SIST

SLOVENSKI STANDARD
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Izpostavljenost na delovnem mestu - Karakterizacija ultrafinih aerosolov/nanoaerosolov - Določevanje številčne koncentracije z uporabo kondenzacijskega števca delcev

Workplace exposure - Characterization of ultrafine aerosols/nanoaerosols - Determination of number concentration using condensation particle counters

Exposition am Arbeitsplatz - Charakterisierung ultrafeiner Aerosole/Nanoaerosole - Bestimmung der Anzahlkonzentration mit Kondensationspartikelzählern

Exposition sur les lieux de travail - Caractérisation des aérosols ultrafins/nanoaérosols - Détermination de la concentration en nombre à l'aide de compteurs de particules à condensation

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Workplace exposure - Characterization of ultrafine aerosols/nanoaerosols - Determination of number concentration using condensation particle counters

Exposition sur les lieux de travail - Caractérisation des aérosols ultrafins/nanoaérosols - Détermination de la concentration en nombre à l'aide de compteurs de particules à condensation

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Contents

Page

European foreword

This document (EN 16897:2017) has been prepared by Technical Committee CEN/TC 137 “Assessment of workplace exposure to chemical and biological agents”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by December 2017, and conflicting national standards shall be withdrawn at the latest by December 2017.

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Introduction

Within occupational hygiene, aerosol concentrations have been traditionally measured in terms of mass concentrations. For ultrafine aerosols and nanoaerosols, other exposure metrics such as the number and surface area concentrations could become important for predicting health effects with some aerosols, depending on their chemical and physical properties. Even if actual occupational exposure metrics have not been established, this European Standard can be used by occupational hygienists and researchers to measure airborne particle concentrations in workplaces.

Recommendations on how to perform an assessment of inhalation exposure to nano-objects and their agglomerates and aggregates (NOAA), including which measurement strategy to adopt, will be provided in prEN 17058:2016 [16].

1 Scope

This European Standard gives guidelines on the measurement of the fine particle fraction of the aerosol, especially for the determination of the number concentration of ultrafine aerosols and nanoaerosols at workplaces by use of condensation particle counters (CPC).

This European Standard deals with the CPC's principle of operation, problems of sampling in the workplace environment, aspects for selecting a suitable instrument, limits of application, use of different working fluids and technologies, calibration, equipment maintenance, measurement uncertainty, and reporting of measurement results. Potential problems and limitations which are of relevance for workplace measurements are described.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 1540, *Workplace exposure - Terminology*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 1540 and the following apply.

3.1
background (particle) measurement
measurement of the particle concentration, at a location or a time not affected by the activity/process under investigation

3.2
emission (particle) measurement
measurement of the particle concentration in direct vicinity of a process or machine

3.3
(particle) (electrical) mobility (equivalent) diameter
diameter of a sphere carrying one elementary electric charge with the same electrical mobility as the particle in question

3.4
exposure (particle) measurement
measurement of the particle concentration close to a worker, preferably in the breathing zone of a worker

Note 1 to entry: Measurements performed outside the breathing zone give only an approximated exposure value.

3.5
nanoaerosol
aerosol comprised of, or consisting of, nano-objects and nanostructured particles

[SOURCE: ISO/TR 27628:2007, definition 2.11] [17]

3.6
nano-object
material with one, two or three external dimensions in the nanoscale below 100 nm

Note 1 to entry: Generic term for all discrete nanoscale objects.

[SOURCE: CEN ISO/TS 80004-1:2015, definition 2.5] [18]

3.7
particle number concentration
c_N
number of particles related to the unit volume of the carrier gas

Note 1 to entry: For the exact particle number concentration indication, information on the gaseous condition (temperature and pressure) is necessary. This can include a comparison of the measured number concentration with the test certificate of a CPC or a correction of the nominal flow with the actual volumetric flow. A frequent check of the instrument including its air flow and response is strongly recommended.

Note 2 to entry: In many cases, depending on make and model, the CPC outputs the particle number concentration based on the assumption that its air flow rate equals the nominal air flow rate determined at a specific testing condition.

Note 3 to entry: The particle number concentration is given as number per cubic centimetre [cm^{-3}].

3.8
ultrafine particle
particle with a nominal diameter (such as geometric, aerodynamic, mobility, projected-area or otherwise) of 100 nm or less

Note 1 to entry: The term is often used in the context of particles produced as a by-product of a process (incidental particles), such as welding fume and combustion fume.

[SOURCE: ISO/TR 27628:2007, definition 2.21]

4 Abbreviations

For the purposes of this document, the following abbreviations apply.

CMMD Count Median Mobility Diameter of a particle size distribution

CNC Condensation Nuclei Counter

CPC Condensation Particle Counter

5 Principle

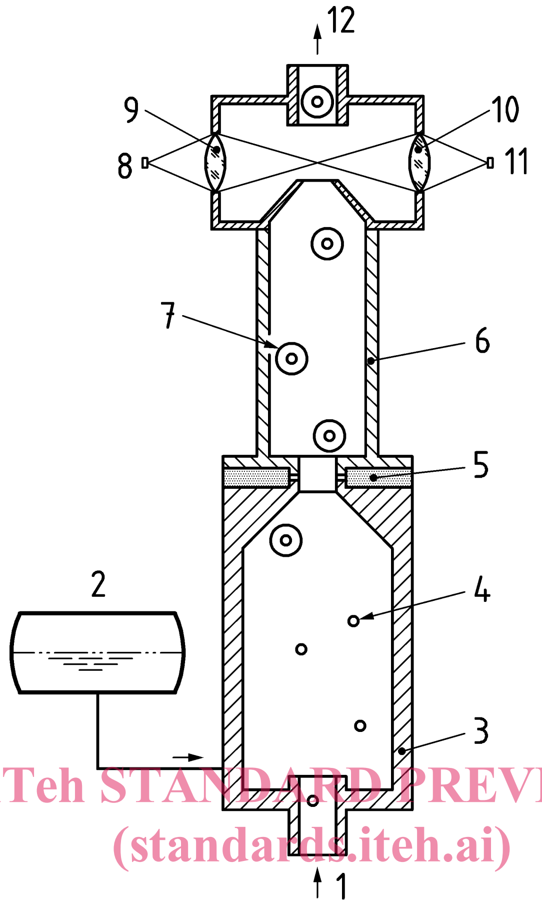
The common principle of all different CPC types is the condensation of supersaturated vapours onto particles. Particles grow to droplets of sizes that can be detected optically [1]. The counting of the droplets is performed via optical light scattering.

A CPC measures, in real-time, airborne particles ranging from few nm up to several µm in size in a limited range of concentration, but does not discriminate between particles of different sizes or origin.

Aerosol particles are drawn into the instrument at the inlet. A pre-separation can be applied to avoid large particles that otherwise would have been trapped in the aerosol transfer tubes of the instrument. A part or the entire air flow is directed into a heated saturator. Commercially available CPCs employ different working fluids to generate the vapour, e.g. butanol, iso-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 and saturation vapour pressure of the working fluid determines the needed heating or cooling steps to initiate condensation and hence the principle design of a laminar flow CPC. The mixture of particles and supersaturated vapour reaches the condensation zone and the vapour condenses onto the particles. The size of the droplets reaches diameters of up to a few micrometres in the condenser zone. The droplet passes through a detection zone 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 a direct determination of particle number concentration (single particle count mode). At higher concentrations some instruments include an evaluation of the total scattered light intensity without single particle counting and thus estimate the number concentration, based on assumptions of final particle size and optical properties (photometric mode).

NOTE Another name given to CPC is condensation nuclei counter (CNC).

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

Figure 1 — Principle of the laminar flow CPC

6 Measurement methods

6.1 General

The CPC measures the number concentration of an aerosol in real-time within a defined range of particle diameters and concentrations. A comparison to mass based occupational limit values of airborne hazardous substances is not possible.

Analytical scanning electron microscopy or transmission electron microscopy can be used for the off-line analysis of airborne particles collected on an appropriate substrate and can provide additional chemical, morphological and size information of the nanoaerosols to data obtained using a CPC or another real-time number concentration instrument (see ISO/TR 27628 [17]) The application of CPCs for environmental measurements is described in [19].

6.2 Exposure measurement

Measurements near to or in the breathing zone of a worker can be carried out to get information on personal exposure. Since CPC instruments are available as static or mobile monitors, a sampling position representative for the personal exposure shall be found. This could e.g. be done with the use of sampling tubes, as specified in 7.4. Workplace air flow pattern characteristics, e.g. direction of air flow relative to particle-emitting source and sampling position, and the presence of multiple particle-emitting sources are essential for either selection of a sampling position or interpretation for worker exposure.

For workers moving around, a different sampling strategy (e.g. time weighted averaging of exposure data from different sampling locations) might be necessary to adopt.

NOTE For some workplace conditions, it is not possible to find a representative sampling position. In these cases, the measured concentrations are less reliable and only estimates of worker's exposure.

General information about measurement strategy in workplaces can be found in EN 689 [20]. Further detailed information on tiered approaches for determining and assessing exposure to manufactured nanomaterials can be found in [2] and [16]. These approaches consist in general of an initial assessment (mainly based on information gathering), a basic exposure measurement, and an expert exposure assessment.

6.3 Emission measurement

The determination of the emission from a task, a process or a machine can be performed by using a CPC at a representative position. Both static and mobile instruments can be used. Differences in the instrument's particle size range and concentration range need to be taken into account. Air flows and emission directions shall be checked prior to the measurement. General information about the use of emission measurements for risk assessment can be found in EN 689.

By changing the position of measurement, an overview of particle-emitting sources in the workplace area or map of particle number concentrations can be achieved [3].

6.4 Background measurement

The influence of several particle-emitting sources of airborne particles (indoor and outdoor sources) on the number concentration at the workplace can be crucial. It is important to know the contribution from those particle-emitting sources (also called background) to the task or process emission or exposure concentration when determining the specific number concentration coming from the task or work process under investigation. External particle-emitting sources often consist of unintentionally created particles and might need to be discriminated from the object of measurement.

In the workplace, the background measurement can be realized with a spatial or a time dependent approach. For the spatial approach, two CPCs are used simultaneously and the number concentrations are compared. One CPC, often referred to near-field instrument, is positioned near or in the breathing zone of the worker or near the task or process. In an ideal condition, the other CPC, often referred as far-field instrument, is placed at a distant location where the nano-object emission source is not detected and where the background signature is the same as the one measured by the near-field CPC. The time dependent approach is realized with one instrument located near or in the breathing zone of the worker or near the task or process and the time periods with and without the nanomaterial related task or process in operation are compared. Details about the assessment of inhalation exposure to nano-objects including the measurement strategy are described in [16].