SLOVENSKI STANDARD
SIST EN 17199-5:2019

01-september-2019

Izpostavljenost na delovnem mestu - Meritve prašnosti razsutih materialov, ki vsebujejo ali sproščajo respirabilne nanopredmete ter njihove agregate in aglomerate (NOAA) in druge respirabilne delce - 5. del: Metoda s krožnim mešalnikom

Workplace exposure - Measurement of dustiness of bulk materials that contain or release respirable NOAA or other respirable particles - Part 5: Vortex shaker method

Exposition am Arbeitsplatz - Messung des Staubungsverhaltens von Schüttgütern, die Nanoobjekte oder Submikrometerpartikel enthalten oder freisetzen - Teil 5: Verfahren mit Vortex-Schüttler

Exposition sur les lieux de travail - Mesurage du pouvoir de résuspension des matériaux en vrac contenant ou émettant des nano-objets et leurs agrégats et agglomérats (NOAA) ou autres particules en fraction alvéolaire - Partie 5: Méthode impliquant l'utilisation d'un agitateur vortex

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13.040.30	Kakovost zraka na delovnem mestu	Workplace atmospheres

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EUROPEAN STANDARD

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English Version

Workplace exposure - Measurement of dustiness of bulk materials that contain or release respirable NOAA or other respirable particles - Part 5: Vortex shaker method

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This European Standard was approved by CEN on 8 February 2019.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

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European foreword

This document (EN 17199-5:2019) 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of an identical text or by endorsement, at the latest by September 2019 and conflicting national standards shall be withdrawn at the latest by September 2019.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association.

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Introduction

Dustiness measurement and characterization provide users (e.g. manufacturers, producers, occupational hygienists and workers) with information on the potential for dust emissions when bulk material is handled or processed in workplaces. They provide the manufactures of bulk materials containing NOAA with information that can help to improve their products and reduce their dustiness. It allows the users of the bulk materials containing NOAA to assess the controls and precautions required for handling and working with the material and the effects of pre-treatments (e.g. modify surface properties or chemistry). It also allows the users to select less dusty products, if available. The particle size distribution of the aerosol and the morphology and chemical composition of its particles can be used by occupational hygienists, scientists and regulators to further characterize the aerosol in terms of particle size distribution and chemical composition and to thus aid users to evaluate and control the health risk of airborne dust.

This document gives details on the design and operation of the vortex shaker test method that measures the dustiness of bulk materials that contain or release respirable NOAA or other respirable particles in terms of dustiness indices or emission rates. Dustiness indices as well as emission rates can be determined number- or mass-based. In addition the test method characterizes the released aerosol by measuring the particle size distribution using direct-reading aerosol instruments and collects samples for off-line analysis (as required) for their morphology and their chemical composition.

The vortex shaker method is useful for addressing the ability of bulk materials including nanomaterials (in powder form), to release airborne particles (aerosol) during agitation, the so-called dustiness.

The vortex shaker method provides a simulation of operation or processes where the agitation mechanism delivering energy to the powder to release airborne particles is the vibration or shaking mechanism. Vibration and shaking are mechanisms that are often found in industry, either voluntarily or involuntarily. Many surfaces receiving powders are vibrating or shaking, as for example during powder transportation by belt feeder or vibrating conveyor. Moreover, by providing an energetic aerosolization, the vortex shaker method provides even a simulation of the worst-case scenario in a workplace, as for example the (non-recommended) practice of cleaning contaminated worker coveralls and dry work surfaces with compressed air.

The vortex shaker method presented here differs from the rotating drum, the continuous drop and the small rotating drum methods presented in EN 17199-2 [1], EN 17199-3 [2] and EN 17199-4 [3] respectively. The rotating drum and small rotating drum methods perform, both, repeated agitation of the same sample nanomaterial while the continuous drop method simulates continuous feed of a nanomaterial. The method described in this document, in turn, provides an agitation to a small test sample of powder.

This document was developed based on the results of pre-normative research [4]. This project investigated the dustiness of ten bulk materials (including nine bulk nanomaterials) with the intention to test as wide a range of bulk materials as possible in terms of magnitude of dustiness, chemical composition and primary particle size distribution as indicated by a large range in specific surface area.

1 Scope

This document describes the methodology for measuring and characterizing the dustiness of bulk materials that contain or release respirable NOAA or other respirable particles, under standard and reproducible conditions and specifies for that purpose the vortex shaker method.

This document specifies the selection of instruments and devices and the procedures for calculating and presenting the results. It also gives guidelines on the evaluation and reporting of the data.

The methodology described in this document enables

a) the measurement of the respirable dustiness mass fraction,

b) the measurement of the number-based dustiness index of respirable particles in the particle size range from about 10 nm to about 1 µm,

c) the measurement of the number-based emission rate of respirable particles in the particle size range from about 10 nm to about 1 µm,

d) the measurement of the number-based particle size distribution of the released respirable aerosol in the particle size range from about 10 nm to 10 µm,

e) the collection of released airborne particles in the respirable fraction for subsequent observations and analysis by electron microscopy.

This document is applicable to the testing of a wide range of bulk materials including nanomaterials in powder form.

NOTE 1 With slightly different configurations of the method specified in this document, dustiness of a series of carbon nanotubes has been investigated ([5] to [10]). On the basis of this published work, it can be assumed that the vortex shaker method is also applicable to nanofibres and nanoplates.

This document is not applicable to millimetre-sized granules or pellets containing nano-objects in either unbound, bound uncoated and coated forms.

NOTE 2 The restrictions with regard to the application of the vortex shaker method on different kinds of nanomaterials result from the configuration of the vortex shaker apparatus as well as from the small size of the test sample required. Eventually, if future work will be able to provide accurate and repeatable data demonstrating that an extension of the method applicability is possible, the intention is to revise this document and to introduce further cases of method application.

NOTE 3 As observed in the pre-normative research project [4], the vortex shaker method specified in this document provides a more energetic aerosolization than the rotating drum, the continuous drop and the small rotating drum methods specified in EN 17199-2 [1], EN 17199-3 [2] and EN 17199-4 [3], respectively. The vortex shaker method can better simulate high energy dust dispersion operations or processes where vibration or shaking is applied or even describe a worst case scenario in a workplace, including the (non-recommended) practice of cleaning contaminated worker coveralls and dry work surfaces with compressed air.

NOTE 4 Currently no classification scheme in terms of dustiness indices or emission rates has been established according to the vortex shaker method. Eventually, when a large number of measurement data has been obtained, the intention is to revise the document and to introduce such a classification scheme, if applicable.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

CEN ISO/TS 80004-2, *Nanotechnologies - Vocabulary - Part 2: Nano-objects (ISO/TS 80004-2)*

EN 481, *Workplace atmospheres - Size fraction definitions for measurement of airborne particles*

EN 1540, *Workplace exposure - Terminology*

EN 13205-2, *Workplace exposure - Assessment of sampler performance for measurement of airborne particle concentrations - Part 2: Laboratory performance test based on determination of sampling efficiency*

EN 15051-1, *Workplace exposure - Measurement of the dustiness of bulk materials - Part 1: Requirements and choice of test methods*

EN 17199-1, *Workplace exposure - Measurement of dustiness of bulk materials that contain or release respirable NOAA or other respirable particles - Part 1: Requirements and choice of test methods*

EN 16897, *Workplace exposure - Characterization of ultrafine aerosols/nanoaerosols - Determination of number concentration using condensation particle counters*

ISO 15767, *Workplace atmospheres - Controlling and characterizing uncertainty in weighing collected aerosols*

ISO 27891, *Aerosol particle number concentration - Calibration of condensation particle counters*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 1540, EN 15051-1, CEN ISO/TS 80004-2 and EN 17199-1 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

4 Symbols and abbreviations

AES	Atomic Emission Spectroscopy
CPC	Condensation Particle Counter
ELPI®[1)]	Electrical Low Pressure Impactor
EM	Electron Microscopy
HEPA	High Efficiency Particulate Arrestance
ICP	Inductively coupled plasma
MFC	Mass flow controller
MS	Mass Spectrometry
NOAA	Nano-objects, and their aggregates and agglomerates > 100 nm
RH	Relative Humidity
TEM	Transmission Electron Microscopy
VS	Vortex Shaker
XRF	X-ray Fluorescence

5 Principle

The vortex shaker method (see Annex A and Annex C) specified in this document measures the dustiness of bulk materials in terms of

— the respirable dustiness mass fraction,

— the number-based dustiness index, and

— the number-based emission rate.

In addition, this document describes the procedures by which the aerosols can be further characterized in terms of their particle size distributions and the morphology and chemical composition of their airborne particles.

The sampling for the purpose of and the execution of qualitative or quantitative analysis of the morphology and chemical composition of the collected airborne nanostructured particles are described. Performing these analyses is optional but can provide confirmation of the sizes of the particles generated and complementary information to the time- and size-resolving instruments.

Table 1 provides

— an overview of the different measurands, their symbols and units,

— information on whether determining these measurands is mandatory or not, and

— the aerosol instruments and sampling devices needed to determine a measurand.

1) ELPI® is the trade name or trademark of a product supplied by Dekati. This information is given for the convenience of users of this European Standard and does not constitute an endorsement by CEN of the product named. Equivalent products may be used if they can be shown to lead to the same results.

Table 1 — Measurands, aerosol instruments/sampling devices and associated recommendations for the vortex shaker method

Measurand (unit)	Method/ device specific to measurand	Mandatory/Optional
Respirable dustiness mass fraction (mg/kg)	25 mm- or 37 mm- air sampling cassette (see 6.2.8) mounted on a respirable cyclone (see 6.2.7)	Mandatory
Number-based dustiness index of respirable particles in the particle size range from about 10 nm to about 1 µm (1/mg)	Condensation Particle Counter (CPC) (see 6.2.9)	Mandatory
Number-based average emission rate of respirable particles in the particle size range from about 10 nm to about 1 µm (1/mg·s)		Mandatory
Number of modes of the time-averaged number-based particle size distribution as $dN/dlogD_i$ (-)	Time- and size-resolving instrument covering the particle size range from about 10 nm up to about 10 µm (see 6.2.10)	Mandatory
Modal aerodynamic equivalent diameters corresponding to the highest mode ($M1_N$) and to the second highest mode ($M2_N$) of the time-averaged number-based particle size distribution as $dN/dlogD_i$ (µm)		Mandatory
Number of modes of the time-averaged mass-based particle size distribution as $dM/dlogD_i$ (-)	Cascade impactor covering the particle size range from about 10 nm up to about 10 µm (see 6.2.10)	Optional
Modal aerodynamic equivalent diameters corresponding to the highest mode ($M1_M$) and to the second highest mode ($M2_M$) of the time-averaged mass-based particle size distribution as $dM/dlogD_i$ (µm)		Optional
Morphological and chemical characterization of the particles including NOAA (-)	TEM-grid holder equipped with porous carbon film TEM-grid (see 6.2.11)	Optional Carbon film may be analysed by transmission electron microscopy (TEM)
Chemical characterization of the particles including NOAA (-)	25 mm- or 37 mm- air sampling cassette made from conductive material (see 6.2.8) mounted on a respirable cyclone (see 6.2.7)	Optional Filters may be quantitatively analysed by XRF, ICP-AES or ICP-MS.
NOTE The particle size range described above is based on the equipment used during the prenormative research.		

6 Equipment

6.1 General

The test apparatus consists of an especially designed cylindrical container (see 6.2.2), in which a small volume (0,5 cm^3) of the test sample is placed that is continuously shook according a circular orbital motion generated by the vortex shaker apparatus (see 6.2.1).

HEPA filtered air, controlled at (50 ± 5) % RH, passes through the cylindrical container at a flow rate Q_{VS} = 4,2 l/min in order to transfer the released aerosol inside the container to the sampling or measurement section.

An overview of the experimental set-up of the vortex shaker test bench is given in Figure 1.