SLOVENSKI STANDARD
oSIST prEN 17199-5:2018

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[Not translated]

Workplace exposure - Measurement of dustiness of bulk materials that contain or release nano-objects or submicrometer 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 resuspension des matériaux en vrac contenant des nano-objets et leurs agrégats et agglomérats - Partie 5: Méthode impliquant l'utilisation d'un agitateur vortex

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Workplace exposure - Measurement of dustiness of bulk materials that contain or release nano-objects or submicrometer particles - Part 5: Vortex shaker method

Exposition sur les lieux de travail - Mesurage du pouvoir de resuspension des matériaux en vrac contenant des nano-objets et leurs agrégats et agglomérats - Partie 5: Méthode impliquant l'utilisation d'un agitateur vortex

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

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European foreword

This document (prEN 17199-5:2017) 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 document is currently submitted to the CEN Enquiry.

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

Introduction

Dustiness measurement and characterization provides users (e.g. manufacturers, producers, occupational hygienists and workers) with information on the potential for dust emissions when the bulk material is handled or processed in workplaces. They provide the manufactures of bulk materials containing nanoparticles with information that can help to improve their products and reduce their dustiness. It allows the users of the bulk materials containing nanoparticles 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 size and chemical composition and to thus aid users to evaluate and control the health risk of airborne dust.

This European Standard gives details of the design and operation of the vortex shaker test method that measure the dustiness of bulk materials that contain or release nano-objects or submicrometer particles in terms of dustiness indices or emission rates corresponding to the respirable fraction. 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 solid 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 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 presented in prEN 17199-2:2017 [1], prEN 17199-3:2017 [2] and prEN 17199-4:2017 [3] respectively. The rotating drum and small rotating drum perform, both, repeated pouring or agitation of the same sample nanomaterial while the continuous drop simulates continuous feed of a nanomaterial. The method described in this European Standard, in turn, provides an agitation to a small test sample of powder.

This European Standard 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 nanomaterials as possible in terms of magnitude of dustiness, chemical composition and primary particle size-distribution as indicated by a high range in specific surface area.

1 Scope

This European Standard provides the methodology for measuring and characterizing the dustiness of bulk materials that contain or release nano-objects or submicrometer particles, under standard and reproducible conditions and specifies for that purpose the vortex shaker method.

In addition, this European Standard 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 European Standard enables

a) the measurement of the respirable dustiness mass fraction,

b) the determination of the mass-based dustiness index of respirable particles in the size range from about 10 nm to 1 000 nm;

c) the determination of the number-based dustiness index of respirable particles in the size range from about 10 nm to 1 000 nm;

d) the determination of the number-based emission rate of respirable particles in the size range from about 10 nm to 1 000 nm;

e) the determination of the number size distribution of the released respirable aerosol in the size range from about 10 nm to 10 µm;

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

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

NOTE 2 This comes from the configuration of the vortex shaker apparatus and the small test sample required. Eventually, if future work provides accurate and repeatable data demonstrating that this is possible, the intention is to revise the European Standard and to introduce this application.

NOTE 3 As observed in the pre-normative research Project [4], the vortex shaker method specified in this European Standard provides a more energetic aerosolization than the rotating drum, the continuous drop and the small rotating drum specified in prEN 17199-2:2017 [1], prEN 17199-3:2017 [2] and prEN 17199-4:2017 [3], respectively. It can better simulate high energy dust dispersion operations or processes where vibration 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 te vortex shaker method. Eventually, when a large number of measurement data has been obtained, the intention is to revise the European Standard 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.

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*

prEN 17199-1:2017, *Workplace exposure - Measurement of dustiness of bulk materials that contain or release nano-objects or submicrometer 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 and prEN 17199-1:2017 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
MFC	Mass flow controller
ICP	Inductively coupled plasma
MPPS	Most penetrating particle size
MS	Mass Spectrometry
RH	Relative Humidity
TEM	Transmission Electron Microscopy
XRF	X-ray Fluorescence

5 Principle

The vortex shaker method specified in this European Standard measures the dustiness of bulk materials containing or releasing nano-objects in terms of

— number-based and mass-based dustiness indices of respirable particles in the size range from about 10 nm to 1 000 nm;

— number-based and mass-based emission rates of respirable particles in the size range from about 10 nm to 1 000 nm.

In addition, this European Standard 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 real-time 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	Symbol	Unit	Aerosol instrument/sampling device	Recommendation
Mass-based dustiness index of respirable particles in the size range from about 10 nm to 1 000 nm	$I_{d,M,\ re}$	mg/kg	25 mm- or 37 mm- air sampling cassette (see 6.2.7) mounted on a respirable cyclone (see 6.2.6)	Mandatory
Number-based dustiness index of respirable particles in the size range from about 10 nm to 1 000 nm	$I_{d,N,\ re}$	1/mg	CPC (see 6.2.8)	Mandatory
Number-based emission rate of respirable particles in the size range from about 10 nm to 1 000 nm	$E_{N,re}$	1/mg.s	CPC (see 6.2.8)	Mandatory
Number of modes of the time-averaged number size distribution in aerodynamic equivalent diameter	N_M	-	Time-resolved size-resolved instrument covering the particle size range from about 10 nm up to about 10 µm (see 6.2.9)	Mandatory
Values of the modal aerodynamic diameters corresponding to the highest mode and to the second highest mode of the time-averaged number size distribution	d_a	µm		Mandatory
Number of modes of the time-averaged mass size distribution in aerodynamic equivalent diameter	N_M	—	Low-pressure cascade impactor covering the particle size range from about 10 nm up to about 10 µm (see 6.2.9)	Optional
Values of the modal aerodynamic diameters corresponding to the highest mode and to the second highest mode of the time-averaged mass size distribution	d_a	µm		Optional
Morphology and chemical composition of the individual released particles and agglomerates/aggregates	—	—	TEM-grid holder (see 6.2.10)	Optional Carbon film can be analysed by transmission electron microscopy (TEM)
Chemical composition of the released particles and agglomerates/aggregates	—	—	25 mm- or 37 mm- air sampling cassette made from conductive material (see 6.2.7) mounted on a respirable cyclone (see 6.2.6)	Optional Filter can be quantitatively analysed by XRF, ICP-AES or ICP-MS.

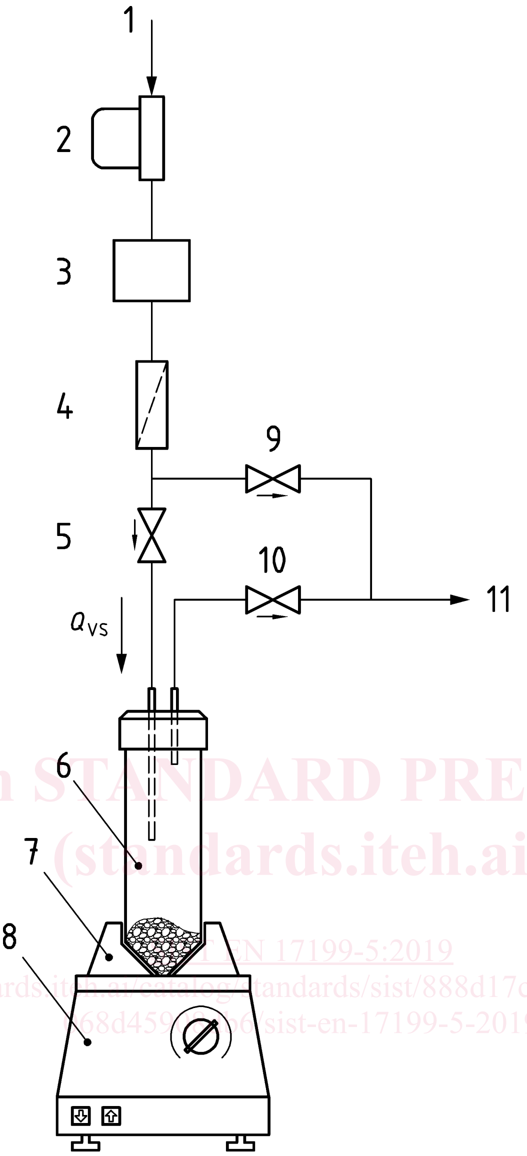
6 Equipment

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.



Key

1 compressed dry air

2 mass flow controller (MFC)

3 humidification system (6.2.3) to deliver 4,2 l/min at (50 ± 5) % RH

4 high-efficiency particle arrestance (HEPA) filter cartridge

5 valve to direct incoming air flow through the cylindrical tube

6 cylindrical container (6.2.2), in which the test sample is poured

7 attachment rubber piece adapted to the design of the bottom of the container

8 vortex shaker apparatus (6.2.1) producing a circular orbital motion

9 valve to direct incoming airflow bypass the cylindrical tube

10 valve to direct outflow to the sampling and measurement section

11 tube to the sampling and measurement section (6.2.5)

NOTE The test bench external dimensions are about 0,6 m × 0,6 m × 0,6 m.

Figure 1 — Overview of the experimental set-up of the vortex shaker test bench