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Characterization of bulk materials - Determination of a sizeweighted fine fraction and crystalline silica content - Part 2: Sedimentation method

Charakterisierung von Schüttgütern - Bestimmung einer größengewichteten Feinfraktion und des Anteils an kristallinem Quarz - Teil 2: Sedimentationsverfahren

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Characterization of bulk materials - Determination of a sizeweighted fine fraction and crystalline silica content - Part 2: Sedimentation method

Charakterisierung von Schüttgütern - Bestimmung einer größengewichteten Feinfraktion und des Anteils an kristallinem Quarz - Teil 2: Sedimentationsverfahren

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European foreword

This document (prEN 17289-2:2019) 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 document is currently submitted to the CEN Enquiry.

Introduction

A method was developed in the industrial minerals industry for the purpose of determining the “size weighted relevant fine fraction” within the bulk material. This method provides the necessary information to the users and allows them to compare bulk materials, by measuring the fine fraction, in order for them to select the safest materials. It has been used in the industry and by institutes previously under the acronym SWeRF. EN 17289 (all parts) is based on that industrial method and describes the analytical methods to determine the difference between materials with coarse quartz and fine quartz, e.g. sands versus flour.

As further activities with the material (intentional or otherwise) might change the particle size distribution, the size weighted fine fraction might also change. Therefore, the method reports (in terms of the mass percentages in the bulk material) both, the total CS and the estimated size weighted fine fraction of CS.

Conventions as described in EN 481 can be used as input for this document. However, the output of this document is not related to the respirable fraction and cannot be used for workplace exposure measurements.

EN 17289 (all parts) describes two procedures that can be used to estimate the size weighted fine fraction (SWFF) in bulk materials. It also describes how the SWFF, once separated, can be further analysed to measure the content of crystalline silica ($SWFF_{cs}$). The method can be used for comparing the fine fraction in different bulk samples. EN 17289 (all parts) uses the term fine fraction to indicate that it does not analyse airborne particles, but it evaluates the proportion of particles in a bulk material that, based on their particle size, have a potential to be respirable if they were to become airborne.

EN 17289 (all parts) also allows for the size weighted fine fraction of crystalline silica ($SWFF_{cs}$) particles in bulk materials to be evaluated in terms of mass fraction in percent, if the fraction separated is subsequently analysed by a suitable method.

In a comparison of similar bulk materials, in which the particle size distribution is the only variable, the SWFF can provide useful information to guide material selection. For example, leaving all other factors aside, a bulk material with a lower SWFF value can pose less of a risk in terms of potential occupational exposure. For the actual exposure at the workplace, the handling etc of the material, will play a major role.

Concentrations of respirable dust, or respirable crystalline silica (RCS), in the workplace air, resulting from processing and handling of bulk materials, will depend on a wide variety of factors and these concentrations cannot be estimated using SWFF or $SWFF_{cs}$ values. SWFF and $SWFF_{cs}$ values are not to be used for occupational exposure assessments as they have no relationship with occupational exposure.

The evaluation of bulk materials using SWFF is complementary to determining the dustiness according to EN 15051-1 [1].

The difference between EN 17289 (all parts) and EN 15051-1 is that SWFF quantifies the fine fraction in a bulk material while dustiness quantifies the respirable, thoracic and inhalable dust made airborne from the bulk material after a specific activity (it characterizes the material with relation to the workplace atmosphere when working with the bulk material).

EN 17289 *Characterization of bulk materials — Determination of a size-weighted fine fraction and crystalline silica content* consists of the following parts:

— Part 1: *General information and choice of test methods*;

— Part 2: *Calculation method*;

— Part 3: *Sedimentation method*.

Part 1 gives information on how to choose the most appropriate method as well as a guideline for the determination of crystalline silica. A calculation method based on particle size distribution is described in Part 2. Part 3 describes a method using sedimentation.

1 Scope

This document specifies the determination of the size weighted fine fraction (SWFF) and the size weighted fine fraction of crystalline silica ($SWFF_{CS}$) in bulk materials by calculation. The document also describes the assumptions and preconditions to be fulfilled in order for this method to be valid.

The purpose of this document is to allow users to evaluate bulk materials with regard to their size-weighted fine fraction and crystalline silica content.

The calculation method is applicable only after experiments have shown that the results are accurate and consistently equal or higher than the results from sedimentation, as described in prEN 17289-3:2018, for that particular bulk material.

For preparation of the sample and determination of crystalline silica by XRD and FT-IR see prEN 17289-1:2018.

A specific method for the evaluation of the SWFF for diatomaceous earth bulk materials is given in Annex A. Due to the internal porosity of diatomaceous earth, the general instructions given in this document are adapted in order to take into account the material's effective density.

This document is applicable for bulk materials which have been fully investigated and validated. The criteria for the materials are described in this document and prEN 17289-3:2018. This includes industrial minerals which can contain crystalline silica such as quartz, clay, kaolin, talc, feldspar, mica, cristobalite, vermiculite, diatomaceous earth, barite, andalusite, iron ore, chromite etc.

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 1540:2011, *Workplace exposure - Terminology*

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

prEN 17289-1:2019, *Characterization of bulk materials – Determination of a size-weighted fine fraction and crystalline silica content — Part 1: General information and choice of test methods*

prEN 17289-3:2019, *Characterization of bulk materials – Determination of a size-weighted fine fraction and crystalline silica content — Part 3: Sedimentation method*

ISO 1183-1, *Plastics* — Methods for determining the density of non-cellular plastics — Part 1: Immersion method, liquid pyknometer method and titration

ISO 13317-1, *Determination of particle size distribution by gravitational liquid sedimentation methods — Part 1: General principles and guidelines*

ISO 13317-2, *Determination of particle size distribution by gravitational liquid sedimentation methods — Part 2: Fixed pipette method*

ISO 13320, *Particle* size analysis — Laser diffraction methods

3 Terms and definitions

For the purposes of this document, tthe terms and definitions given in in EN 1540:2011 and prEN 17289-1:2019 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

CS	Crystalline Silica
DE	Diatomaceous Earth
PSD	Particle Size Distribution
PSDD	Particle Size Density Distribution
SWFF	Size Weighted Fine Fraction
$SWFF_{CS}$	Size Weighted Fine Fraction of crystalline silica

5 Assumptions

The calculation method is based on the following assumptions:

a) The dynamic form factor is neglected in the determination of the particle size distribution with methods other than methods based on sedimentation;

b) The precondition is that in a mixture the different materials have the same particle size distribution. If this is not the case a separation using the sedimentation method shall be used;

c) The subsample is representative of the bulk material.

6 Determination of SWFF and $SWFF_{CS}$ by calculation

The SWFF of a sample is calculated by first determining its particle size distribution by laser diffraction according to ISO 13320 or gravitational liquid sedimentation by X-ray method according to ISO 13317-1 and ISO 13317−2.

A size weighting is then applied, based on the probability function given in EN 481, i.e. the probability function for particles reaching the alveoli when inhaled, see Formula (1).

$$SWFF = \int_{D_{ae}=0}^{D_{ae}=\infty} PSDD\left(D_{ae}\right) \times P\left(D_{ae}\right) dD_{ae} \quad (1)$$

where

$PSDD\left(D_{ae}\right)$ is the density function describing the particle size distribution for aerodynamic diameter Dae;

$P\left(D_{ae}\right)$ is the probability of reaching the alveoli for particles of aerodynamic diameter Dae, according to EN 481.

D_{ae} is the aerodynamic diameter Stokes law that can be used to calculate the aerodynamic diameter from the size distribution according to Formula (2) as follows:

$$D_{ae} = D_{eq} \times \sqrt{\rho_p / \rho_0} \quad (2)$$

where

D_{eq} is the diameter as used in the particle size distribution measurement;

ρ_0 is the unit density (1000 kg/m³), as defined in EN 481;

ρ_p is the particle density, in kg/m³.

A standardized method shall be used to determine the density, e.g. by using a He or liquid pyknometer in accordance with ISO 1183-1.

A more detailed explanation of the derivation of Formula (1) is given in prEN 17289-3:2019.

The $SWFF_{cs}$ is calculated by multiplying the SWFF of the sample with the fraction of crystalline silica in the sample, see Formula (3). It is assumed that the particle size distribution of the sample and of the crystalline silica in the sample are the same.

$$SWFF_{cs} = SWFF \times \varphi_{cs} \quad (3)$$

where

φ_{cs} is the mass fraction of crystalline silica in the bulk sample

The content of crystalline silica of the sample shall be determined using techniques such as X-ray Powder Diffractometry (XRD) or Infrared Spectroscopy (IR) as described in prEN 17289-1:2019, Clause 5 and Annex A.

For non-spherical particles such as needles and platelets, laser diffraction will tend to overestimate their diameter and additionally, because of their shape, these particles behave as smaller particles in air. As a consequence, laser diffraction shall not be used for these kinds of particles because it will result in a SWFF that is too low. Instead gravitational liquid sedimentation is best used in these cases.