SLOVENSKI STANDARD
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Zrak na delovnem mestu - Definicije velikostnih razredov za merjenje lebdečih delcev

Workplace atmospheres - Size fraction definitions for measurement of airborne particles

Arbeitsplatzatmosphäre - Festlegung der Teilchengrößenverteilung zur Messung luftgetragener Partikel

Atmospheres des lieux de travail - Définition des fractions de taille pour le mesurage des particules

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Workplace atmospheres - Size fraction definitions for measurement of airborne particles

Atmosphères des lieux de travail - Définition des fractions de taille pour le mesurage des particules en suspension dans l'air

Arbeitsplatzatmosphäre - Festlegung der Teilchengrößenverteilung zur Messung luftgetragener Partikel

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Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

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CEN

European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

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Foreword

This European Standard was drawn up by the Technical Committee CEN/TC 137 "Assessment of workplace exposure" of which the secretariat is held by DIN.

This standard was submitted for Formal Vote, and the result was positive.

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of an identical text or by endorsement, at the latest by January 1994, and conflicting national standards shall be withdrawn at the latest by January 1994.

According to the CEN/CENELEC Internal Regulations, the following countries are bound to implement this European Standard: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom.

0 Introduction

The proportion of total particulate matter which is inhaled into a human body depends on properties of the particles, on the speed and direction of air movement near the body, on breathing rate, and whether breathing is through nose or mouth. Inhaled particles can then deposit somewhere in the respiratory tract, or can be exhaled. The site of deposition, or probability of exhalation, depends on properties of the particle, respiratory tract, breathing pattern, and other factors.

Liquid particles or soluble components of solid particles can be absorbed by the tissues wherever they deposit. Particles can cause damage close to the deposition site if they are corrosive, radioactive, or capable of initiating some other type of damage. Insoluble particles can be transported to another part of the respiratory tract or body, where they can be absorbed or cause a biological effect.

There is a wide variation from one person to another in the probability of particle inhalation, deposition, reaction to deposition, and clearance. Nevertheless, it is possible to define conventions for size selective sampling of airborne particles when the purpose of sampling is health-related. These conventions are relationships between aerodynamic diameter and the fractions to be collected or measured, which approximate to the fractions penetrating to regions of the respiratory tract under average conditions. Measurement conducted according to these conventions will probably yield a better relationship between measured concentration and risk of disease.

Note:
For further information on the factors affecting inhalation and deposition, and their application in standards, see [8], [9], [10], [11], [12] and [13].

Workplace atmospheres - Size fraction definitions for measurement of airborne particles

1 Scope

This standard defines sampling conventions for particle size fractions which are to be used in assessing the possible health effects resulting from inhalation of airborne particles in the workplace. They are derived from experimental data for healthy adults. Conventions are defined for the inhalable, thoracic and respirable fractions; extrathoracic and tracheobronchial conventions may be calculated from the defined conventions. (The inhalable fraction is sometimes called inspirable - the terms are equivalent. The nomenclature of the fractions is discussed in annex A). Assumptions are given in clause 4. The convention chosen will depend on the region of effect of the component of interest in the airborne particles (see clause 3). Conventions are stated in terms of mass fractions, but they may also be used when the intention is to evaluate the total surface area or the number of particles in the collected material.

In practice, the conventions will often be used to specify instruments to sample airborne particles for the purpose of measuring concentrations corresponding to

the defined fractions. It should be noted that experimental error in the testing of instruments, and possible dependence on factors other than aerodynamic diameter, mean that it is only possible to make a statement of probability that an instrument's performance falls within a certain range, and that different instruments will fall within an acceptable range.

Note:
The problem of comparing instruments with the conventions is to be dealt with in another standard.

One application is the comparison of mass concentration of airborne size fractions with limit values. It should be noted with respect to relevant European Directives that the use of other methods is allowed provided that they yield the same or stricter conclusion. One important example is the respirable convention in relation to compliance with the limit value. Equipment matching the Johannesburg convention [2] will in practical circumstances give the same or a higher mass concentration (by up to about 20 %) than equipment matching the respirable convention given in 5.3, so the use of equipment matching the Johannesburg convention will be consistent with the European Directive.

The conventions should not be used in association with limit values defined in completely different terms, for example for fibre limit values defined in terms of the length and diameter of fibres.

2 Definitions

For the purposes of this standard, the following definitions apply.

2.1 Sampling convention

A target specification for sampling instruments which approximates to, for each particle aerodynamic diameter:

- in the case of inhalable convention, the ratio of the mass concentration of particles entering the respiratory tract to the corresponding mass concentration in the air before the particles are affected by the presence of the exposed individual and inhalation;

- in the case of the other conventions, the ratio of the mass concentration of particles entering the specified region of the respiratory tract to the mass concentration of particles entering the respiratory tract. (These other conventions can also be expressed as ratios to the mass concentration of total airborne particles).

2.2 Particle aerodynamic diameter

The diameter of a sphere of density 1 g cm^{-3} with the same terminal velocity due to gravitational force in calm air, as the particle, under the prevailing conditions of temperature, pressure and relative humidity (see clause 4).

Note:
For particles of aerodynamic diameter less than 0,5 μm, the particle diffusion diameter should be used instead of the particle aerodynamic diameter. The particle diffusion diameter means the diameter of a sphere with the same diffusion coefficient as the particle under the prevailing conditions of temperature, pressure and relative humidity.

2.3 Inhalable fraction

The mass fraction of total airborne particles which is inhaled through the nose and mouth.

Note:
The inhalable fraction depends on the speed and direction of the air movement, on breathing rate and other factors.

2.4 Inhalable convention

A target specification for sampling instruments when the inhalable fraction is the fraction of interest.

2.5 Extrathoracic fraction

The mass fraction of inhaled particles failing to penetrate beyond the larynx.

2.6 Extrathoracic convention

A target specification for sampling instruments when the extrathoracic fraction is of interest.

2.7 Thoracic fraction

The mass fraction of inhaled particles penetrating beyond the larynx.

2.8 Thoracic convention

A target specification for sampling instruments when the thoracic fraction is of interest.

2.9 Tracheobronchial fraction

The mass fraction of inhaled particles penetrating beyond the larynx, but failing to penetrate to the unciliated airways.

2.10 Tracheobronchial convention

A target specification for sampling instruments when the tracheobronchial fraction is of interest.

2.11 Respirable fraction

The mass fraction of inhaled particles penetrating to the unciliated airways.

2.12 Respirable convention

A target specification for sampling instruments when the respirable fraction is of interest.

2.13 Total airborne particles

All particles surrounded by air in a given volume of air.

Note:
Because all measuring instruments are size-selective to some extent, it is often impossible to measure the total airborne particle concentration.

3 Principle of conventions

The sampling conventions recognise that only a fraction of the airborne particles which are near to the nose and mouth is inhaled. This fraction is called the inhalable fraction (see 2.3). For some substances, the sub-fractions of this which penetrate beyond the larynx, or to the unciliated airways are of special significance for health. This standard presents conventionalised curves approximating to the fraction inhaled and the sub-fractions reaching beyond the larynx or to the unciliated airways. These curves are called the inhalable convention (see 2.4), the thoracic convention (see 2.8) and the respirable convention (see 2.12).

Extrathoracic (see 2.6) and tracheobronchial (see 2.10) conventions may be calculated from these. Instruments used for sampling need to conform with the sampling convention appropriate to the region of the respiratory tract where deposition of the substance being measured might lead to biological effect. For example, the inhalable convention would be chosen if the substance might lead to a biological effect wherever it deposited, the thoracic convention would be chosen if the region was the bronchi, and the respirable convention if the region was the alveoli.

Instruments can be used to collect individual fractions according to the conventions, or to collect several fractions simultaneously. For example, an instrument could collect particles from the air according to the inhalable convention, and then separate this material into portions according to thoracic, tracheobronchial and respirable conventions. Alternatively, an instrument might just collect the respirable fraction from the air. In this case, the design would have to ensure that selection at the entry due to aerodynamic effects, and subsequently within the instrument, was such that the overall selection was in accordance with the conventions.

4 Assumptions and approximations

Approximations and assumptions are unavoidable in simulating by sampling conventions the very complex interaction of variables that governs respiratory tract entry and penetration.

The conventions are necessarily only approximations to respiratory tract behaviour, and the following assumptions are particularly important:

- The inhalable fraction depends on air movement - speed and direction - on breathing rate, and on whether breathing is by nose or mouth. The values given in the inhalable convention are for representative values of breathing rate, and averaged for all wind directions. This is appropriate for an individual uniformly exposed to all wind directions or predominantly to wind from the side or from behind. The convention usually under-estimates the inhalable fraction of larger particles for an individual who usually faced the wind, particularly in windspeeds greater than 4 m s^{-1}.

- The respirable and thoracic fractions vary from individual to individual and with breathing pattern, and the conventions are necessarily approximations to the average case.

- Each convention approximates to the fraction penetrating to a region, not to the fraction depositing there. In general, particles must deposit to have a biological effect. In this respect, the conventions will lead to an over-estimate of the potential biological effect. The most important example is that the respirable convention over-estimates the fraction of very small