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

Workplace exposure - Size fraction definitions for measurement of airborne particles

Arbeitsplatzatmosphäre - Feslegung der Größenfraktionen zur Messung luftgetragener Partikel

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

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Workplace exposure - 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 - Feslegung der Größenfraktionen zur Messung luftgetragener Partikel

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European foreword

This document (prEN 481:2024) 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 will supersede EN 481:1993

This document includes the following significant technical changes with regard to EN 481:1993:

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Introduction

The proportion of total particulate matter that 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 the nose or mouth. Inhaled particles can then deposit somewhere in the respiratory tract, or can be exhaled. The site and amount of deposition, or probability of exhalation, depends on properties of the particle, respiratory tract, breathing pattern, and other factors.

Human tissues can absorb liquid particles or soluble components of solid particles wherever they deposit in the respiratory tract. Particles can cause damage close to the deposition site if they are chemically reactive, 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 taken up by cells and tissues and detrimental to health.

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 necessary to define conventions for size selective sampling of airborne particles when the purpose of sampling is health-related, e.g. in compliance sampling.

The respirable and thoracic sampling conventions defined in this document are for the penetration of particles in the inhaled air into deeper regions of the respiratory tract. In this document the penetration is only based on airborne particles depositing onto the enclosing tissue in the respiratory tract due to impaction. The particles are characterized by the aerodynamic diameter. Separation of particles from the inhaled air and deposition onto the enclosing tissue in the respiratory tract by other mechanisms, i.e. mainly diffusion, is disregarded in this document.

These conventions are relationships between particle aerodynamic diameter and the fractions to be collected or measured. These fractions approximate the fraction of particles that penetrate to regions of the respiratory tract under average breathing conditions.

Measurements conducted according to these conventions will yield a better relationship between measured concentration and risk of disease than measurement of the total airborne particle concentration.

Guidance for sampling the defined aerosol fractions is given in CEN/TR 15230 [1]. EN 13205-1 to –6 [2 to 7] describe performance tests for candidate aerosol samplers for any of the sampling conventions defined in this document whereas EN 482 [8] gives general guidance for performance testing of samplers, instruments and analytical methods used in occupational hygiene. A strategy for testing compliance with occupational exposure limits is given in EN 689 [9]. EN ISO 13138 [10] describes sampling conventions for fractions deposited in regions of the respiratory tract.

1 Scope

This document defines sampling conventions for airborne particle size fractions for use in assessing the health relevant exposure from inhalation of particles in the workplace. Conventions are defined for the inhalable, thoracic and respirable fractions. The sampling conventions only describe the inhalation of particles and their penetration in the respiratory tract as governed by inertia (impaction). Deposition in the respiratory tract by other mechanisms, e.g. diffusion, is not considered in this document. The sampling conventions defined in this document apply to both indoor and outdoor workplaces.

The assumptions on which the sampling conventions are defined are given in Clause 6. The convention chosen for a specific application will depend on the region of the health effect of the component of interest in the airborne particles (see Clause 5). The conventions can be used with whatever metric is of interest, including particle count, length, surface area, volume or mass. The metric depends on the kind of particle analysis carried out on the sampled aerosol fraction. The health-related fraction concentrations defined in this document are often expressed in mass of the sampled particles per volume of sampled air in order to compare with mass-based occupational exposure limit values.

The conventions are not applicable in association with limit values expressed in a different metric, e.g. for fibre limit values defined in terms of the length and diameter of airborne fibres and the ratio of the two (aspect ratio), unless a measurement procedure explicitly requires that a specific health related size fraction is to be sampled/collected [13].

The main purpose of this document is to provide agreement on the particle size fractions to sample and their definitions. Sampling is generally carried out using dedicated samplers, for which there is no need to measure the aerodynamic size distribution of the airborne particles to be sampled. Samplers including a separation into one or more relevant sampling conventions(s) are currently available. In general, no assumptions or pre-knowledge are needed on the number of modes, modal diameter(s) or width of the particle aerodynamic size distribution of the airborne particles to be sampled.

Because there is a wide variation from one person to another in the probability of particle inhalation, deposition, reaction to deposition and clearance, this document is not applicable for determining the deposited dose taken up by an individual worker.

The conventions are primarily intended for determining workers' exposure to airborne particles by sampling the *airborne* particles. This document is not applicable to large particles emitted at high speed that are travelling under the momentum from their emission, instead of being carried by the air (airborne) and aspirated into humans and aerosol samplers by their suction (see Annex B).

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 1540:2021, *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.

NOTE The definitions given in EN 1540:2024 are reproduced here for improved readability.

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

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
airborne particle
chemical or biological agent, in solid or liquid form, dispersed in air

Note 1 to entry: Smoke, fume, mist and fog consist of airborne particles.

Note 2 to entry: This term describes a class of particles with a specific property, namely those that are airborne while being measured or sampled. The document is not applicable to particles that are not airborne, whether they have been airborne in the past or will be airborne in the future.

Note 3 to entry: Particle projectiles are a specific class of particles that move through air under its own momentum, which they obtained when they were ejected into air. A typical example is particles generated by using grinding wheels. In order to be able to travel a long distance under its own momentum, a particle projectile needs to be large (much larger than 100 μm) and have been emitted at high speeds (exceeding 5 m/s to 10 m/s). Once drag has consumed all the original momentum of a particle projectile, it moves in the air as any other airborne particle, under the influence of air currents, air suction, drag and external forces, e.g. gravity.

3.2
alveolar region
compartment of the human respiratory tract consisting of respiratory bronchioles, alveolar ducts, alveolar sacs and alveoli

Note 1 to entry: The American Conference of Governmental Industrial Hygienists uses the term Gas-Exchange region and the (US) National Commission on Radiological Protection uses the term Pulmonary region [12].

3.3
cut-size of a sampler
$d_{\mathrm{ae,p=0,50}}$
particle size corresponding to the sampling efficiency of a sampler being equal to 0,50

3.4
cut-size of sampling convention X
$d_{\mathrm{ae,X,p=0,50}}$
particle size corresponding to sampling convention X being equal to 0,50, where X is either the thoracic or the respirable sampling convention

3.5
inhalability
ratio of the concentration of particles entering the respiratory tract (by inhalation through the nose or mouth) to the corresponding concentration in the air before the particles are affected by the presence of the exposed individual and inhalation (i.e., the total airborne particle concentration)

Note 1 to entry: For the definition of “total airborne particle composition”, see 3.15.

Note 2 to entry: The numerical definition of inhalability is given as a function of the aerodynamic particle diameter.

3.6
inhalable convention
inhalable sampling convention
E_I
sampling convention describing the ratio of the concentration of particles entering the respiratory tract (by inhalation through the nose or mouth) to the corresponding concentration in the air before the particles are affected by the presence of the exposed individual and inhalation (i.e., the total airborne particle concentration) as a function of the aerodynamic particle diameter (i.e., inhalability)

Note 1 to entry: For the definition of "inhalability", see 3.5.

Note 2 to entry: The mathematical definition of the inhalable convention is given in 7.1.1.

Note 3 to entry: The mathematical definition of the inhalable convention depends on the wind speed range at the actual workplace, see 7.1.1.

Note 4 to entry: The concentration can be related to the number, surface area or mass of the airborne particles.

3.7
inhalable fraction concentration
inhalable aerosol fraction concentration
inhalable dust fraction concentration
concentration of the sub-set of the total airborne particle concentration collected by an ideal sampler with a sampling efficiency perfectly matching the inhalable sampling convention

Note 1 to entry: For any specific worker, the actual inhaled fraction depends on the speed and direction of the air movement, on breathing rate and other factors. This fraction of an individual person can deviate from the measured inhalable fraction concentration.

Note 2 to entry: For the definition of "total airborne particle concentration", see 3.15.

Note 3 to entry: The concentration obtained using a validated sampler is an approximation to this concentration.

Note 4 to entry: The inhalable fraction is sometimes called inspirable; the terms are equivalent.

Note 5 to entry: The inhalable fraction concentration is also applicable to liquid particles.

3.8
particle aerodynamic diameter
d_{ae}
diameter of a sphere of 1 g/cm^3 density with the same terminal settling velocity in calm air as the particle, under the prevailing conditions of temperature, pressure and relative humidity

Note 1 to entry: The particle aerodynamic diameter depends on the size, density and shape of the particle and, to a small degree, on the mean free path of the air carrying the particles.

Note 2 to entry: In the human respiratory tract, the separation of particles from the inhaled air for particles of aerodynamic diameter less than 0,5 µm does not primarily depend on aerodynamics (impaction or settling by gravity). For these particles, the separation mechanism is instead mainly governed by diffusion, and the size of these particles is best described by the particle diffusive (equivalent) diameter. The particle diffusive (equivalent) diameter equals the diameter of a sphere with the same diffusion coefficient as the particle under the prevailing conditions of temperature, pressure and relative humidity.

Note 3 to entry: This document disregards the influence of diffusion on the penetration of particle sizes ($d_{ae} \leq 0,5$ µm) in the human respiratory tract.

Note 4 to entry: The particle aerodynamic equivalent diameter is an equivalent diameter, because it is not a real diameter. It is based on particles with equivalent diameters have equal amount of some property, in this case settling speed in air.

3.9
relative inhalable, thoracic or respirable fraction
sum of all amount, according to selected metric, of (relevant) particle sizes of a normalised particle size distribution weighted by the selected sampling convention

Note 1 to entry: The relative (health-related) fraction can be determined for any of the defined sampling conventions; inhalable in the low wind speed range, inhalable in the medium wind speed range, thoracic and respirable, respectively.

3.10
respirable convention
respirable sampling convention
E_{R}
sampling convention describing the ratio of the concentration of particles penetrating to the alveolar region (for average breathing conditions and light to moderate physical activity) to the corresponding concentration in the air before the particles are affected by the presence of the exposed individual and inhalation (i.e., the total airborne particle concentration)

Note 1 to entry: These experiments were carried out with humans often inhaling radioactive particles [13].

Note 2 to entry: For the definition of “total airborne particle concentration”, see 3.15.

Note 3 to entry: The numerical definition of the respirable convention is given as a function of the aerodynamic particle diameter (see 7.1.3).

Note 4 to entry: The workload and breathing parameters are those defined for the ACGIH “Reference worker” [15].

3.11
respirable fraction concentration
respirable aerosol fraction concentration
respirable dust fraction concentration
concentration of the sub-set of the total airborne particle concentration collected by an ideal sampler with a sampling efficiency perfectly matching the respirable sampling convention

Note 1 to entry: For any specific worker, the actual fraction that penetrates to the alveolar region depends both on the breathing rate and other factors, and on speed and direction of the air movement. This fraction of an individual person can deviate from the measured respirable fraction concentration.

Note 2 to entry: For the definition of “total airborne particle concentration”, see 3.15.

Note 3 to entry: The concentration obtained using a validated sampler is an approximation to this concentration.

Note 4 to entry: The respirable fraction concentration is also applicable to liquid particles.

3.12
sampling convention
collection efficiency function of the ratio of particle concentrations, describing the probability (as a function of particle aerodynamic diameter) of the total airborne concentration that constitutes the health-related fraction in question

Note 1 to entry: In the case of the inhalable convention, this probability is defined as the ratio of the concentration of particles entering the respiratory tract to the corresponding homogeneous total airborne particle concentration in the air before the particles are affected by the presence of the exposed individual and inhalation.

Note 2 to entry: In the case of the other conventions, this probability is defined as the ratio of the concentration of particles entering the specified region of the respiratory tract to the corresponding homogeneous total airborne particle concentration in the air before the particles are affected by the presence of the exposed individual and inhalation.

Note 3 to entry: This definition specifies how the inhalability and penetration data, upon which the collection efficiency functions are based, originally were determined.

Note 4 to entry: This document defines four sampling conventions; the inhalable in the low wind-speed range, the inhalable in the medium wind-speed range, the thoracic and the respirable.

3.13
thoracic convention
thoracic sampling convention
E_{T}
sampling convention describing the ratio of the concentration of particles penetrating beyond the larynx (for average breathing conditions and light to moderate physical activity) to the corresponding concentration in the air before the particles are affected by the presence of the exposed individual and inhalation (i.e., the total airborne particle concentration)

Note 1 to entry: These experiments were carried out with humans, often inhaling radioactive particles [13].

Note 2 to entry: For the definition of “total airborne particle concentration”, see 3.15.

Note 3 to entry: The numerical definition of the thoracic convention is given as a function of the aerodynamic particle (see 7.1.2).

Note 4 to entry: The workload and breathing parameters are those defined for the ACGIH “Reference worker” [15].

Note 5 to entry: The thoracic convention approximates to the thoracic fraction during oral breathing. During nose breathing, the fraction of particles penetrating the larynx is lower due to deposition in the nose.

3.14
thoracic fraction concentration
thoracic aerosol fraction concentration
thoracic dust fraction concentration
concentration of the sub-set of the total airborne particle concentration collected by an ideal sampler with a sampling efficiency perfectly matching the thoracic sampling convention

Note 1 to entry: For any specific worker, the actual fraction that penetrates the larynx depends both on the breathing rate and other factors, and on the speed and direction of the air movement. This fraction of an individual person can deviate from the measured thoracic fraction concentration.

Note 2 to entry: For the definition of “total airborne particle concentration”, see 3.15.

Note 3 to entry: The concentration obtained using a validated sampler is an approximation to this concentration.

Note 4 to entry: The thoracic fraction concentration is also applicable to liquid particles.