SLOVENSKI STANDARD
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Izpostavljenost na delovnem mestu - Ocenjevanje delovnih lastnosti vzorčevalnikov za merjenje koncentracij lebdečih delcev

Workplace exposure - Assessment of sampler performance for measurement of airborne particle concentrations

Exposition am Arbeitsplatz - Beurteilung der Leistungsfähigkeit von Sammlern für die Messung der Konzentration luftgetragener Partikel

Exposition sur les lieux de travail - Évaluation des performances des dispositifs de mesure des concentrations d'aérosols

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13.040.30	Kakovost zraka na delovnem mestu	Workplace atmospheres

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English Version

Workplace exposure - Assessment of sampler performance for measurement of airborne particle concentrations

Exposition sur les lieux de travail - Evaluation des performances des dispositifs de mesure des concentrations d'aérosols

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Contents

Page

Foreword

This document (prEN 13205:2010) 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 13205:2001, which has been technically revised in order to accommodate the revision of EN 482.

Introduction

EN 481 defines sampling conventions for the particle size fractions to be collected from workplace atmospheres in order to assess their impact on human health. Conventions are defined for the inhalable, thoracic and respirable aerosol fractions. These conventions represent target specifications for aerosol samplers, giving the ideal sampling efficiency as a function of particle aerodynamic diameter.

In general, the sampling efficiency of real aerosol samplers will deviate from the target specification, and the aerosol mass collected will therefore differ from that which an ideal sampler would collect. In addition, the behaviour of real samplers is influenced by many factors such as external wind speed. In many cases there is an interaction between the influence factors and fraction of the airborne size distribution of the environment in which the sampler is used.

This standard specifies performance requirements and performance tests for samplers for the inhalable, thoracic and respirable aerosol fractions. Requirements for the aerosol sampler and transport of loaded collection samplers are stated. Three different performance tests for sampled concentration and a transport test of loaded collection substrates are specified. The three tests differ in the amount of information obtained by the test and its corresponding cost. The first test method determines the sampling efficiency curve of a candidate sampler, the second compares concentrations sampled from three laboratory test atmospheres by a candidate sampler and a (previously) validated sampler, and the third method compares concentrations sampled from a specific workplace by a candidate sampler and a (previously) validated sampler. The method for calculating the expanded uncertainty for a measurement procedure based on aerosol sampling is specified. Additionally a method for determining equivalence between aerosol samplers at specific workplaces and an alternative handling test are presented.

1 Scope

This European Standard specifies methods for testing aerosol samplers under prescribed laboratory conditions, and performance requirements that are specific to aerosol samplers. These performance requirements, which include conformity with the EN 481 sampling conventions, apply only to the process of sampling the airborne particles from the air, not to the process of analysing particles collected by the process of sampling. Although analysis of samples collected in the course of testing is usually necessary in order to evaluate the sampler performance, the specified test methods ensure that analytical errors are kept very low during testing and do not contribute significantly to the end result. The determination of analytical errors and factors related to them (for example the bias, precision and limit of detection of the analytical method) is outside the scope of this standard. Where the aerosol sampler requires the use of an external (rather than integral) pump, the pump is not subject to the requirements of this standard.

EN 482 contains general performance requirements for methods used for determining the concentrations of chemical agents in workplace atmospheres. These performance requirements include maximum values of expanded uncertainty (a combination of random and non-random measurement uncertainty) achievable under prescribed laboratory conditions for the methods to be used. The requirements of EN 482 apply to a complete measurement procedure, a combination of the stages consisting of sampling, sample transport/storage and sample preparation/analysis. This standard specifies how the performance of aerosol measurement procedures is assessed with respect to the general requirements of EN 482, through the combination of errors arising in the sampling, sample transportation/storage and sample preparation/analysis stages.

This standard applies to all samplers used for the health-related sampling of particles in workplace air, whatever their mode of operation. Different test procedures and types of evaluation are included to enable application of this standard to a wide variety of instruments. The standard shall enable manufacturers and users of aerosol sampling instruments to adopt a consistent approach to sampler validation, and provide a framework for the assessment of sampler performance with respect to EN 481 and EN 482. It is the responsibility of the manufacturer of aerosol samplers to inform the user of the sampler performance under the laboratory conditions[1)] specified in this European Standard. It is the responsibility of the user to ensure that the sampler complies with the overall uncertainty requirements of EN 482 under the actual conditions of use.

2 Normative references

The following referenced documents are indispensable for the application 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 481:1993, *Workplace atmospheres — Size fraction definitions for measurement of airborne particles*

EN 482:2006, *Workplace atmospheres — General requirements for the performance of procedures for the measurement of chemical agents*

EN 1232:1997, *Workplace atmospheres — Requirements and test methods for pumps used for personal sampling of chemical agents in the workplace*

prEN 1540:2010, *Workplace exposure — Terminology*

EN 12919:1999, *Workplace atmospheres — Pumps for the sampling of chemical agents with a volume flow rate of over 5 l/min — Requirements and test methods*

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1) The inhalable convention is undefined for particle sizes in excess of 100 µm or for wind speeds greater than 4 m/s. The tests required to assess performance are therefore limited to these conditions. Should such large particle sizes or wind speeds actually exist at the time of sampling, it is possible that different samplers meeting this standard may give different results.

EN 13890:2009, *Workplace exposure — Procedures for measuring metals and metalloids in airborne particles — Requirements and test methods*

EN 14530:2004, *Workplace atmospheres — Determination of diesel particulate matter — General requirements*

ISO 15767:2009, *Workplace atmospheres — Controlling and characterising errors in weighing collected aerosols*

ISO 21438-1:2007, *Workplace Air — Determination of inorganic acids by ion chromatography — Part 1: Non-volatile acids (sulfuric acid and phosphoric acid)*

ISO/DIS 21438-3:2009, *Workplace Air — Determination of inorganic acids by ion chromatography — Part 3: Hydrofluoric acid and particulate fluorides*

ISO 24095:2009, *Workplace air — Guidance for the measurement of respirable crystalline silica*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1 Sampling and transport terms

3.1.1
aerosol
airborne particles and the gas (and vapour) mixture in which they are suspended

NOTE The airborne particles can be in or out of equilibrium with their own vapours.

[prEN 1540:2010]

3.1.2
airborne particles
fine matter, in solid or liquid form, dispersed in air

[prEN 1540:2010]

NOTE 1 For the purpose of this standard, the term comprises all particles surrounded by air with a terminal settling speed less than a critical value, whereas the critical value will depend on the application. The idea is to exclude particles that are too large for a specific application.

NOTE 2 For the purpose of this standard, particles surrounded by air but with a terminal velocity exceeding a critical value are not to be considered part of the sample.

3.1.3
candidate sampler
any aerosol sampler that can be used to measure the concentration of aerosol particles and whose performance is *subjected to the performance tests of this standard*

NOTE A candidate sampler that meets the performance criteria will be termed a validated sampler.

3.1.4
collected sample
product of the process of air sampling that consists of the collected chemical and/or biological agents only

[prEN 1540:2010]

NOTE For the purpose of this standard, the term comprises airborne particles collected on the sampling substrate for subsequent analysis. See EN 15051.

3.1.5
collection efficiency
efficiency of collection and retention of sampled particles by the collection substrate

NOTE 1 The collection efficiency can, for example be influenced by the amount of aerosol deposited in the collection substrate.

NOTE 2 The collection efficiency (of a collection substrate) should not be confused with the sampling efficiency (of a sampler).

3.1.6
collection substrate
medium on which airborne chemical and/or biological agents are collected for subsequent analysis

[prEN 1540:2010]

NOTE 1 Filters, internal walls of a sampling cassette, impaction plate or polyurethane/metal foam and polyurethane foams are examples of collection substrates for airborne particles.

NOTE 2 As an example of the converse, the 25-mm or 37-mm plastic filter cassette often used for “total dust” sampling (with gravimetric analysis) in either its closed-face or open-face version is not part of the substrate in the definition above, since it is not weighed.

3.1.7
correction function
mathematical function relating aerosol concentrations measured using a candidate sampler to those measured using a validated sampler, determined by a comparison of the two samplers

3.1.8
inhalable fraction
inhalable aerosol fraction
mass fraction of total airborne particles which is inhaled through the nose and mouth

[prEN 1540:2010]

NOTE 1 The inhalable fraction is specified in EN 481.

NOTE 2 The inhalable fraction depends on the speed and direction of the air movement, on breathing rate and other factors.

3.1.9
inhalable sampler
inhalable aerosol sampler
sampler for the inhalable aerosol fraction
aerosol sampler that is used to collect the inhalable fraction

[prEN 1540:2010]

NOTE An inhalable sampler collects the inhalable fraction or airborne particles, as defined in EN 481, with a performance as stipulated in this document.

3.1.10
nominal flow rate
design flow rate recommended by the sampler manufacturer or measurement procedure

3.1.11
aerodynamic diameter (of a particle)
(particle) aerodynamic diameter
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

[prEN 1540:2010]

NOTE 1 The aerodynamic diameter of a particle depends on the size, density, shape and porosity of the particle.

NOTE 2 For particles of aerodynamic diameter less than 0,5 µm, the particle thermodynamic diameter should be used instead of the particle aerodynamic diameter.

3.1.12
personal sampler
sampler, attached to a person, that collects gases, vapours or airborne particles in the breathing zone to determine exposure to chemical and/or biological agents

[prEN 1540:2010]

NOTE For the purpose of this standard “agent” means airborne particles.

3.1.13
relative concentration
concentration expressed as a fraction of the total airborne concentration

3.1.14
respirable fraction
respirable aerosol fraction
mass fraction of inhaled particles penetrating to the unciliated airways

NOTE The respirable fraction is specified in EN 481.

[prEN 1540:2010]

3.1.15
respirable sampler
respirable aerosol sampler
sampler for the respirable aerosol fraction
aerosol sampler that is used to collect the respirable fraction

[prEN 1540:2010]

NOTE A respirable sampler collects the respirable fraction or airborne particles, as defined in EN 481, with a performance as stipulated in this document.

3.1.16
aerosol sampler
sampler that is used to transport airborne particles to a collection substrate

NOTE The transport can be either active or passive.

[prEN 1540:2010]

3.1.17
sampler inlet efficiency
for each particle aerodynamic diameter, the ratio of aerosol concentration passing through the sampler inlet system, to the corresponding total airborne particle concentration

NOTE The inlet efficiency is the product of the aspiration efficiency, which characterises the aerodynamic behaviour of the sampler orifice, and the size-dependent effects of particle bounce and losses both inside and outside the inlet. The inlet losses can, for some samplers, also depend on external factors such as wind speed and aerosol size distribution.

3.1.18
sampler specimen
sampler individual
single individual of a given type of aerosol sampler

3.1.19
sampling cassette
cassette mounted inside a sampler, designed in such a way that its collection substrate consists of all its interior surfaces (bounding the air-stream with sampled particles), and usually contains a filter or a foam

3.1.20
sampling efficiency (of an aerosol sampler)
(aerosol) sampler efficiency
efficiency curve (of an aerosol sampler)
for each aerodynamic diameter of a particle, the relative fraction of the concentration of airborne particles transported from the undisturbed air to the collection substrate for analysis

NOTE 1 The sampling efficiency is independent of whether the particle concentration is determined by number, surface area or mass.

NOTE 2 For a sampler with internal separation, the sampling efficiency is the product of the inlet efficiency and the separation efficiency.

[prEN 1540:2010]

3.1.21
sampling method
part of the measurement procedure that describe the overall process of sampling, including sampler preparation and sample transport

3.1.22
sampling process
physical mechanisms by which particles are selectively aspirated into a sampler inlet, graded by means of inertial or other forces, transported to the collection substrate or to other internal surfaces, or lost from the collection substrate

3.1.23
penetration
internal penetration
for each particle aerodynamic diameter, the ratio of the sampling efficiency to the inlet efficiency

NOTE This describes the efficiency with which particles pass through the stage of inertial separation, as e.g. foams, cyclones, impactors.

3.1.24
static sampler
sampler, not attached to a person, that collects gases, vapours or airborne particles at a particular location

[prEN 1540:2010]

3.1.25
total airborne particle concentration
concentration of aerosol particles present in the air before the particles are affected by the presence of the sampler, or in the case of a personal sampler by the presence of the person wearing the sampler

NOTE See prEN 1540:2010 for the definition of total airborne particles.

3.1.26
thoracic fraction
thoracic aerosol fraction
mass fraction of inhaled particles penetrating beyond the larynx

NOTE The thoracic fraction is specified in EN 481.

[prEN 1540:2010]

3.1.27
thoracic sampler
thoracic aerosol sampler
sampler for the thoracic aerosol fraction
aerosol sampler that is used to collect the thoracic fraction

[prEN 1540:2010]

NOTE A thoracic sampler collects the thoracic fraction or airborne particles, as defined in EN 481, with a performance as stipulated in this document.

3.1.28
validated sampler (Annex A)
sampler that has previously been tested using the methods described in Annex A of this document resulting in a performance as required by this document

NOTE In a performance test according to Annex A, the sampling efficiency curve of the candidate sampler will be determined as a function of particle size (and possibly other influencing factors).

3.1.29
validated sampler (Annex B)
sampler that has previously been tested using the methods described in Annex B of this document resulting in a performance as required by this document

NOTE In a performance test according Annex B, the concentration sampled by the candidate sampler will be compared with the concentration sampled by a validated reference sampler, for at least three test aerosols.

3.1.30
validated sampler (Annex C)
sampler that has previously been tested using the methods described in Annex C of this document resulting in a performance as required in this document

NOTE In a performance test according Annex C, the concentration sampled by the candidate sampler at a workplace will be compared with the concentration sampled by a validated reference sampler.

3.2 Performance terms

3.2.1
bias
difference between the expectation of a test result or measurement result and a true value

[ISO 3534-2:2006]

NOTE 1 Bias is the total systematic error as contrasted to random error. There may be one or more systematic error components contributing to the bias. A larger systematic difference from the true value is reflected by a larger bias value.

NOTE 2 In practice, the accepted reference value is substituted for the true value. The accepted reference value (for definition see ISO 3534-2) can be, for example, the certified value of a reference material, the concentration of a standard test atmosphere or the target value of an interlaboratory comparison.

NOTE 3 In this European Standard the true value of the concentration of a chemical agent in air will be the concentration calculated to be sampled by an ideal sampler with a sampling efficiency identical to the sampling convention or sampled by a validated sampler.

3.2.2
combined standard uncertainty
u_c
standard uncertainty of the result of measurement when that result is obtained from the values of a number of other quantities, equal to the positive square root of a sum of terms, the terms being the variances or covariances of these other quantities weighted according to how the measurement result varies with changes in these quantities

[ENV 13005:1999]

3.2.3
coverage factor
k
numerical factor used as a multiplier of the combined standard uncertainty in order to obtain an expanded uncertainty

[ENV 13005:1999]

NOTE 1 A coverage factor, k , is typically in the range from 2 to 3.

NOTE 2 EN 482 specifies $k = 2$.

3.2.4
expanded uncertainty
U
quantity defining an interval about a result of a measurement, expected to encompass a large fraction of the distribution of values that could reasonably be attributed to the measurand

[ENV 13005:1999]

3.2.5
(occupational exposure) limit value
limit of the time-weighted average of the concentration of a chemical agent in the air within the breathing zone of a worker in relation to a specified reference period

[Council Directive 98/24/EC Art. 2 d)]

3.2.6
measurand
particular quantity subject to measurement

[ENV 13005:1999]

3.2.7
measuring procedure
measurement procedure
set of operations described specifically for the sampling and analysis of chemical or biological agents in air

NOTE A measuring procedure usually includes preparation for sampling, sampling, transportation and storage, preparation of samples for analysis and analysis.

[prEN 1540:2010]

3.2.8
non-random uncertainty
uncertainty associated with systematic errors

[prEN 1540:2010]

3.2.9
precision
closeness of agreement between independent test/measurement results obtained under stipulated conditions

[ISO 3534-2:2006]

3.2.10
random uncertainty
uncertainty associated with random errors

[prEN 1540:2010]

3.2.11
sampler bias
bias of the sampling method

3.2.12
specified measuring range
the set of values of the concentration for which the uncertainty of measurement is intended to lie within specified limits

3.2.13
standard uncertainty
uncertainty of the result of a measurement expressed as a standard deviation

[ENV 13005:1999]

3.2.14
uncertainty (of measurement)
parameter, associated with the results of a measurement, that characterizes the dispersion of the values that could reasonably be attributed to the measurand

[ENV 13005:1999]

3.3 Analysis terms

3.3.1
analysis
all operations carried out after sample preparation to determine the amount or concentration of the analyte(s) of interest present in the sample

[prEN 1540:2010]

3.3.2
analytical method
all steps of the measuring procedure that describe the overall process of sample preparation and analysis

[prEN 1540:2010]

4 Symbols and abbreviations

NOTE The letter for each Annex in which the symbol is used is shown after each symbol,

4.1 Symbols

4.1.1 Latin

$A(D_\text{A}, \sigma_\text{A}, D)$ Relative lognormal aerosol size distribution, with mass median aerodynamic diameter D_A and geometric standard deviation σ_A, [1/µm] – Annex A and H

NOTE The word "relative" means that the total amount of particles is unity [-], *i.e.* $\int_0^\infty A(D_\text{A}, \sigma_\text{A}, D)\,\mathrm{d}D = 1$.

A_p Integration of aerosol size distribution A between two particle sizes, [-] – Annex H (polygonal approximation method)

$A_{t,p}$ Integration of aerosol size distribution A between two particle sizes, calculated using set t of the simulated test particle sizes, [-] – Appendix H (polygonal approximation method)

$b_{ip}, b_{ip}^\text{left}, b_{ip}^\text{right}, b_{ip}^\text{top}, b_{ip}^\text{front}$ Coefficients in Equation [.92] to estimate the test aerosol concentration at a specific sampler position e.g. in a wind tunnel based on nearby concentrations (to the left, right, above and in front of) the sampler measured by thin-walled sharp-edged probes, [-] – Annex H

$C_{\text{amb inhale}_{rtl}}$ Average total airborne particle (or inhalable aerosol fraction) concentration for partial sampling period l in run r for sampling time t, [mg/m^3] – Annex C

C_{is} Sampled relative aerosol concentration, calculated to be obtained when using the candidate sampler individual s, for aerosol size distribution A at influence variable value ς_i, [-] – Annex H (curve-fitting method)

$C_{is,t}$ Sampled relative aerosol concentration, calculated to be obtained when using the candidate sampler individual s, for aerosol size distribution A at influence variable value ς_i, using simulated set t of test particle sizes, [-] – Annex H (curve-fitting method)

C_n Calculated concentration corresponding to the mass load n, selected sampling period T and nominal flow rate Q^0, [mg/m^3] – Annex F

C_{rtl} Concentration for partial sampling period l in run r, for sampling time t, [mg/m^3] – Annex C

C_std Target sampled relative aerosol concentration, expressed as a fraction of the total airborne aerosol concentration, that would have been sampled using an ideal sampler with a sampling efficiency identical to the sampling convention, $F(D)$, for aerosol size distribution A, [-] – Annex A