SLOVENSKI STANDARD
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Nadomešča:
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Izpostavljenost na delovnem mestu - Ocenjevanje lastnosti merilnikov za merjenje koncentracij lebdečih delcev - 2. del: Preskušanje usposobljenosti laboratorija na osnovi učinkovitosti vzorčenja

Workplace exposure - Assessment of sampler performance for measurement of airborne particle concentrations - Part 2: Laboratory performance test based on determination of sampling efficiency

Exposition am Arbeitsplatz - Bewertung der Leistungsfähigkeit von Sammlern für die Messsung der Konzentration luftgetragener Partikel - Teil 2: Laborprüfung der Leistungsfähigkeit basierend auf der Bestimmung des Probenahmewirkungsgrades

Exposition sur les lieux de travail - Évaluation des performances des dispositifs de prélèvement pour le mesurage des concentrations d'aérosols - Partie 2 : Essai de performances en laboratoire par détermination de l'efficacité de prélèvement

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ICS:

13.040.30	Kakovost zraka na delovnem mestu	Workplace atmospheres

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EUROPEAN STANDARD

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English Version

Workplace exposure - Assessment of sampler performance for measurement of airborne particle concentrations - Part 2: Laboratory performance test based on determination of sampling efficiency

Exposition sur les lieux de travail - Évaluation des performances des dispositifs de prélèvement pour le mesurage des concentrations de particules en suspension dans l'air - Partie 2: Essai de performances en laboratoire par détermination de l'efficacité de prélèvement

Exposition am Arbeitsplatz - Beurteilung der Leistungsfähigkeit von Sammlern für die Messung der Konzentration luftgetragener Partikel - Teil 2: Laborprüfung der Leistungsfähigkeit basierend auf der Bestimmung des Probenahmewirkungsgrads

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This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

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COMITÉ EUROPÉEN DE NORMALISATION
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Foreword

This document (EN 13205-2:2014) 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 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 December 2014 and conflicting national standards shall be withdrawn at the latest by December 2014.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document together with EN 13205-1, CEN/TR 13205-3, EN 13205-4, EN 13205-5 and EN 13205-6 supersedes EN 13205:2001.

EN 13205, *Workplace exposure — Assessment of sampler performance for measurement of airborne particle concentrations*, consists of the following parts:

— *Part 1: General requirements;*

— *Part 2: Laboratory performance test based on determination of sampling efficiency* (the present document);

— *Part 3: Analysis of sampling efficiency data* [Technical Report];

— *Part 4: Laboratory performance test based on comparison of concentrations;*

— *Part 5: Aerosol sampler performance test and sampler comparison carried out at workplaces;*

— *Part 6: Transport and handling tests.*

Significant technical changes from the previous edition, EN 13205:2001:

— This part of EN 13205 is based on Annex A of the previous edition, EN 13205:2001.

— The scope has been limited to aerosol samplers, and the current version of the standard is not (directly) applicable to other types of aerosol instruments.

— As this is now a standard in its own right, a clause on symbols used has been added. Almost all definitions are now given either in EN 1540, *Workplace exposure — Terminology* or in Part 1 of this standard.

— The method of calculating the uncertainty of a sampler or a measuring procedure has been revised in order to comply with ENV 13005. The concept of "accuracy" is no longer used, instead the concept of "expanded uncertainty" is used.

— The five major sources of uncertainty due to aspects of the sampling performance of an aerosol sampler (calibration of sampler test system, estimation of sampled concentration, bias relative to the sampling convention, individual sampler variability and excursion from nominal flow rate) are described with equations on how to incorporate these uncertainties into the expanded uncertainty of a sampler. CEN/TR 13205-3 gives recommendations how these entities may be calculated from measured sampling efficiency data.

— The list of the particle size distributions (per sampling convention) to be used for the evaluation of sampler performance has been restricted at the lower end to reflect that particles with an aerodynamic diameter less than 0,5 µm are not sampled due to aerodynamic forces. In the current version, an additional requirement on the size distributions is that at least 84 % of the aerosol mass consists of particles exceeding 0,5 µm.

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

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 particle size distribution of the environment in which the sampler is used.

EN 13205 (all parts) enables manufacturers and users of aerosol samplers 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 part of EN 13205. It is the responsibility of the user to ensure the actual conditions of intended use are within what the manufacturer specifies as acceptable conditions according to the performance test.

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. If such large particle sizes or wind speeds actually existed at the time of sampling, it is possible that different samplers meeting this document give different results.

1 Scope

This European Standard specifies a laboratory performance test for samplers for the inhalable, thoracic and respirable aerosol fractions, based on determining the sampling efficiency curve of a candidate sampler at a minimum of nine particle sizes. It specifies methods for testing aerosol samplers under prescribed laboratory conditions in order to test whether the performance of a candidate sampler fulfils the requirements of EN 13205-1:2014.

This part of EN 13205 is applicable to all samplers used for the health-related sampling of particles in workplace air.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 1540, *Workplace exposure — Terminology*

EN 13205-1:2014, *Workplace exposure — Assessment of sampler performance for measurement of airborne particle concentrations — Part 1: General requirements*

CEN/TR 13205-3:2014, *Workplace exposure — Assessment of sampler performance for measurement of airborne particle concentrations — Part 3: Analysis of sampling efficiency data*

EN 13205-5:2014, *Workplace exposure — Assessment of sampler performance for measurement of airborne particle concentrations — Part 5: Aerosol sampler performance test and sampler comparison carried out at workplaces*

EN ISO 13137, *Workplace atmospheres — Pumps for personal sampling of chemical and biological agents - Requirements and test methods (ISO 13137)*

3 Terms and definitions

For the purpose of this document, the terms and definitions given in EN 1540, EN 13205-1:2014 and the following apply.

NOTE With regard to EN 1540, in particular, the following terms are used in this document: total airborne particles, respirable fraction, sampling efficiency, static sampler, thoracic fraction, inhalable fraction, measuring procedure, non-random uncertainty, random uncertainty, expanded uncertainty, standard uncertainty, combined standard uncertainty, uncertainty (of measurement), coverage factor and precision.

3.1
relative concentration
concentration expressed as a fraction of the total airborne concentration

3.2
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

4 Symbols and abbreviations

4.1 Symbols

4.1.1 Latin

$A\left(D_{\mathrm{A}},\sigma_{\mathrm{A}},D\right)$ relative lognormal aerosol size distribution, with mass median aerodynamic diameter D_{A} and geometric standard deviation σ_{A}, [1/µm]

NOTE The word “relative” means that the total amount of particles is unity [-], *i.e.* $\int_{0}^{\infty} A\left(D_{\mathrm{A}},\sigma_{\mathrm{A}},D\right)\mathrm{d}D = 1$.

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, [-]

$\bar{C}_i$ mean sampled relative aerosol concentration, expressed as a fraction of the total airborne aerosol concentration, calculated to be obtained when using the candidate sampler, for aerosol size distribution A at influence variable value ς_i, [-]

c candidate sampler correction factor for bias correction, either prescribed by sampler manufacturer or measuring procedure, or assigned the value c = 1.00, [-]

D aerodynamic diameter, [µm]

D_{A} mass median aerodynamic diameter of a lognormal aerosol size distribution A, [µm]

D_{A_a} mass median aerodynamic diameter a of a lognormal aerosol size distribution A, [µm]

D_{max} diameter of the end of the integration range of the sampled aerosol, [µm]

D_{min} diameter of the beginning of the integration range of the sampled aerosol, [µm]

D_p aerodynamic diameter of test particle p (p = 1 to N_P), [µm]

$\bar{E}_i\left(D_p\right)$ mean sampling efficiency of the candidate sampler for test particle size p at influence variable value ς_i, [-] – (polygonal approximation method)

$\bar{E}_i\left(Q,D_p\right)$ mean sampling efficiency curve of the candidate sampler at flow rate Q for test particle size p at influence variable value ς_i, [-] – (polygonal approximation method)

${}^{\mathrm{est}}E_{is}(D)$ fitted sampling efficiency curve of the candidate sampler individual s at influence variable value ς_i, [-] – (curve-fitting method)

${}^{\mathrm{est}}E_{is}(Q,D)$ fitted sampling efficiency curve of the candidate sampler individual s at flow rate Q for influence variable value ς_i, [-] – (curve-fitting method)

$e_{ipr[s]}$ and $e_{ips[r]}$ experimentally determined efficiency value, with notation for polygonal approximation and curve-fitting methods, respectively. The subscripts are for influence variable value ς_i, particle size F (p = 1 to N_P), sampler individual s (s = 1 to N_S) and repeat r (r = 1 to N_R), [-] – (notation for polygonal approximation and curve-fitting methods, respectively)

$F(D)$ target sampling convention, [-]

$g_{ipr[s]}$ and $g_{ips[r]}$ aerosol concentration sampled by the candidate sampler. The subscripts are for influence variable value ς_i, particle size p (p = 1 to N_P), sampler individual s (s = 1 to N_S) and repeat r (r = 1 to N_R), [mg/m³] or [1/m³] – (notation for polygonal approximation and curve-fitting methods, respectively)

h_{ipr} and $h_{ips[r]}$ corresponding total airborne aerosol concentration estimated from the sharp-edged probe values. The subscripts are for influence variable value i (i = 1 to N_{IV}), particle size p (p = 1 to N_P), sampler individual s (s = 1 to N_S) and repeat r (r = 1 to N_R), [mg/m³] or [1/m³] – (notation for polygonal approximation and curve-fitting methods, respectively)

$m_i\left(D_A, \sigma_A, Q\right)$ mean sampled aerosol mass, expressed as a fraction of the total airborne aerosol mass, calculated to be obtained when using the candidate sampler with flow rate Q, to sample aerosol size distribution A at influence variable value ς_i, [-]

N_{IV} number of values for the other influence variables at which tests were performed,

N_P number of test particle sizes

N_{Rep} number of repeats at particle size p for candidate sampler individual s at influence variable value ς_i – (in the polygonal approximation method N_{Rep} equals the number of repeats, whereas in the curve-fitting method it equals the number of repeats per candidate sampler individual)

N_S number of candidate sampler individuals – (In the polygonal approximation method N_S equals the number of sampler individuals tested per repeat, whereas in the curve-fitting method it equals the total number of sampler individuals tested.)

Q actual flow rate of candidate sampler, [l/min]

Q^0 nominal flow rate of sampler, [l/min]

q_0 parameter expressing whether the nominal or actual flow rate is used for the calculation of sampled respirable and thoracic aerosol fractions, [-]

$q_i\left(D_A, \sigma_A\right)$ flow rate dependence of sampled mass for aerosol size distribution A at influence variable value ς_i, [-]

$s_{\text{CandSampl-Flow}_{ia}}$ non-random uncertainty (of measurement) of the calculated sampled concentration, due to excursion from nominal flow and/or deviation from initial flow, for the a^{th} aerosol size distribution A at influence variable value ς_i, [-]

$s_{\left(\delta_{\text{FlowSet}} + \delta_{\text{Pump}}\right)}$ random uncertainty for combined rectangular distribution based on allowed initial flow deviation from nominal flow rate and pump flow deviation, [-]

$U_{\text{CandSampl}}$ expanded uncertainty (of measurement) of the calculated sampled concentration due to the candidate sampler, [-]

$u_{\text{CandSampl}}$ combined uncertainty (of measurement) of the calculated sampled concentration due to the candidate sampler, [-]

$u_{\text{CandSampl}_i}$ combined uncertainty (of measurement) of the candidate sampler, at influence variable value ς_i, [-]

$u_{\text{CandSampl-Bias}_i}$ standard uncertainty (of measurement) due to bias (non-random errors) in relation to the sampling convention of the candidate sampler at influence variable value ς_i, [-]

$u_{\text{CandSampl-Calibr}_i}$ standard uncertainty (of measurement) (non-random and random errors) of the

	calculated sampled concentration, due to the calibration uncertainty of the experiment, calculated as the RMS of the corresponding relative uncertainties over all N_{SD} aerosol size distributions A at influence variable value ς_i, [-]
$u_{\text{CandSampl-Flow}_i}$	standard uncertainty (of measurement) of the calculated sampled concentration, due to flow rate deviation at influence variable value ς_i, [-]
$u_{\text{CandSampl-ModelCalc}_i}$	standard uncertainty (of measurement) of the calculated sampled concentration (random errors), due to the uncertainty of the fitted model, calculated as the RMS of the corresponding relative uncertainties over all N_{SD} aerosol size distributions A at influence variable value ς_i, [-]
$u_{\text{CandSampl-nR}}$	combined uncertainty (of measurement) of the sampled concentration (non-random errors) due to the candidate sampler, [-]
$u_{\text{CandSampl-nR}_i}$	combined uncertainty (of measurement) of the sampled concentration (non-random errors) due to the candidate sampler, at influence variable value ς_i, [-]
$u_{\text{CandSampl-R}}$	combined uncertainty (of measurement) of the sampled concentration (random errors) due to the candidate sampler, [-]
$u_{\text{CandSampl-R}_i}$	combined uncertainty (of measurement) of the sampled concentration (random errors) due to the candidate sampler, at influence variable value ς_i, [-]
$u_{\text{CandSampl-Variability}_i}$	standard uncertainty (of measurement) of the sampled concentration (random errors) due to differences among candidate sampler individuals at influence variable value ς_i, [-]
W_p	weighted average of integration of aerosol size distribution A between two particle sizes, [-] – (polygonal approximation)

4.1.2 Greek

Δ_i	bias or relative error in the aerosol concentration measured using the candidate sampler, for aerosol size distribution A, at influence variable value ς_i, [-]
δ_{FlowSet}	maximum relative error allowed in setting the flow rate, [-]
δ_{Pump}	maximum relative change in flow rate allowed by pump flow rate stability, [-]
$\varepsilon_{ipr[s]}$ and $\varepsilon_{ips[r]}$	Random experimental error at particle size p, repeat r and candidate sampler s at influence variable value ς_i, [-] – (notations for polygonal approximation and curve-fitting methods, respectively)
ς	value of other influence variable values, as for example wind speed and mass loading of sampler, with values for i = 1 to N_{IV}, [various dimensions]
ς_i	i^{th} value of any other influence variable NOTE The dimension of each ς_i depends on the influence variable. The dimension selected, however, is not critical, as the values are never part in any calculation.
σ_A	geometric standard deviation of a lognormal aerosol size distribution A from Table A.2 [-]
σ_{A_a}	geometric standard deviation a of a lognormal aerosol size distribution A, [µm] –

4.2 Enumerating subscripts

a for test aerosols