SLOVENSKI STANDARD
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Izpostavljenost na delovnem mestu - Ocenjevanje lastnosti merilnikov za merjenje koncentracij lebdečih delcev - 4. del: Preskušanje usposobljenosti laboratorija na podlagi primerjave koncentracij

Workplace exposure - Assessment of sampler performance for measurement of airborne particle concentrations - Part 4: Laboratory performance test based on comparison of concentrations

Exposition am Arbeitsplatz - Bewertung der Leistungsfähigkeit von Sammlern für die Messsung der Konzentration luftgetragener Partikel - Teil 4: Laborprüfung der Leistungsfähigkeit basierend auf dem Vergleich der Konzentrationen

Exposition sur les lieux de travail - Évaluation des performances des dispositifs de prélèvement pour la mesure des concentrations de particules en suspension dans l'air - Partie 4: Essai de performances en laboratoire par comparaison des concentrations

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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 4: Laboratory performance test based on comparison of concentrations

Exposition sur les lieux de travail - Évaluation des performances des dispositifs de prélèvement pour la mesure des concentrations de particules en suspension dans l'air - Partie 4: Essai de performances en laboratoire par comparaison des concentrations

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Foreword

This document (EN 13205-4:2014) 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of an identical text or by endorsement, at the latest by December 2014 and conflicting national standards shall be withdrawn at the latest by December 2014.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, EN 13205-2, CEN/TR 13205-3, 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;*

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

— *Part 4: Laboratory performance test based on comparison of concentrations* (the present document);

— *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 B 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 the used symbols has been added. All definitions are now given either in EN 1540, *Workplace exposure — Terminology* or in Part 1 or Part 2 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.

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.

The laboratory performance test for samplers for the inhalable, thoracic or respirable aerosol fractions described in this document is based on a comparison of concentrations sampled from three laboratory test atmospheres by a candidate sampler and a (previously) validated sampler.

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 that 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. Should such large particle sizes or wind speeds actually exist at the time of sampling, it is possible that different samplers meeting this part of EN 13205 give different results.

1 Scope

This European Standard specifies a method for testing aerosol samplers based on comparison of concentrations under prescribed laboratory conditions in order to verify 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 481, *Workplace atmospheres - Size fraction definitions for measurement of airborne particles*

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*

EN 13205-2:2014, *Workplace exposure — Assessment of sampler performance for measurement of airborne particle concentrations — Part 2: Laboratory performance test based on determination of sampling efficiency*

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 EN 13205-2:2014 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, precision and analysis.

4 Symbols and abbreviations

4.1 Symbols

4.1.1 Latin

c	candidate sampler correction factor for bias correction, either prescribed by sampler manufacturer or measuring procedure, or assigned the value c = 1.00, [-]
N_{A_i}	number of test aerosols for influence variable value ζ_i
N_{IV}	number of values for the other influence variables at which tests were performed

$N_{Q^0_{iar}}$ number of candidate samplers operating at the nominal flow rate at repeat r for test aerosol a at influence variable value ς_i

$N_{Q^+_{iar}}$ number of candidate samplers operating at the higher flow rate at repeat r for test aerosol a at influence variable value ς_i

$N_{Q^-_{iar}}$ number of candidate samplers operating at the lower flow rate at repeat r for test aerosol a at influence variable value ς_i

N_{Valid} number of reference samplers (validated samplers) used per repeat experiment

$N_{Rep_{ia}}$ number of repeats per sampler individual for test aerosol a at influence variable value ς_i

$N_{S_{iar}}$ number of candidate samplers used per experiment at repeat r for test aerosol a at influence variable value ς_i

$N_{S_{rtl}}$ number of candidate samplers used (in the experiment to determine any dependence on sampled mass or internally separated mass) with partial sampling period l in run r for sampling time t

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

Q^+ higher flow rate used for the candidate sampler in the performance test for the effect of flow excursions, [l/min]

Q^- lower flow rate used for the candidate sampler in the performance test for the effect of flow excursions, [l/min]

R_{iars} concentration ratio of the candidate sampler individual s for repeat r of the test aerosol a at influence variable value ς_i to the corresponding test aerosol concentration, defined as $R_{iars} = X_{iars} / Y_{iar}$, [-]

$\overline{R}_{ia}$ average concentration ratio for test aerosol a at influence variable value ς_i, [-]

$s_{ValidConc_{iars}}$ relative uncertainty of test aerosol concentration at position of candidate samplers in test system of test aerosol a at influence variable value ς_i repeat r and candidate sampler individual s, [-]

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

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

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

$u_{CandSampl\text{-}Bias_i}$ 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, [-]

$u_{CandSampl\text{-}Flow_i}$ standard uncertainty (of measurement) of the calculated sampled concentration, due to flow rate deviation at influence variable value ς_i, [-]

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

$u_{CandSampl\text{-}nR_i}$ combined uncertainty (of measurement) of the sampled concentration (non-random errors) due to the candidate sampler, at influence variable value ς_i, [-]

$u_{CandSampl\text{-}R}$ 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, [-]
$u_{\text{ValidConc}_i}$	standard uncertainty (of measurement) of test aerosol concentration (random errors) at the position of candidate samplers in test system, at influence variable value ς_i, [-]
$u_{\text{ValidSampl-nR}}$	standard uncertainty of the validated sampler (non-random errors), [-]
X_{iarm}	concentration of the candidate sampler individual m operated either at the nominal flow rate (Q^0) or the higher or lower flow rates (Q^+ and Q^-, respectively), for repeat r of the test aerosol a, at influence variable value ς_i, [mg/m^3]
X_{iars}	concentration of the candidate sampler individual s, for repeat r of the test aerosol a, at influence variable value ς_i, [mg/m^3]
Y_{iar}	aerosol concentration (measured with a validated sampler) for the repeat r of test aerosol a, at influence variable value ς_i, [mg/m^3]

4.1.2 Greek

δ_{FlowSet}	maximum relative error allowed in setting the flow rate, [-] – Annex A and B
δ_{Pump}	maximum relative change in flow rate allowed by pump flow rate stability, [-]
ς	other influence variable, 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 another 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.

4.2 Enumerating subscripts

a	for test aerosols
I	for selected value of distinguishable values of an influence variable
i	for influence variable values, ς,
$i0$	for selected value of non-distinguishable values of an influence variable which causes the largest combined standard uncertainty for the candidate sampler
m	for the candidate sampler individuals operating at the nominal, lower, and higher flow rate, respectively, in the test for the effect of flow excursions
s	for candidate sampler individual

4.3 Abbreviations

RMS	Root Mean Square

5 Principle

The test method described in this part of EN 13205 is based on measured concentrations by the candidate sampler for at least three different test aerosols, whether all aspirated particles are part of the sample (as for most inhalable samplers) or if a particle size-dependent penetration occurs between the inlet and the collection substrate (as for thoracic and respirable samplers). A candidate aerosol sampler is tested by comparison with a validated sampler. Both samplers are exposed to the same test aerosols in a wind tunnel or aerosol chamber, and tests repeated under specified conditions relevant to the practical application of the candidate sampler. The concentrations collected by both samplers are then compared. The test assumes that the sampling efficiencies of both the candidate sampler and the reference sampler are independent of the aerosol concentration. The candidate sampler results shall agree with the validated sampler (type A) results within specified limits.

The bias versus the sampling convention is determined by comparing the concentrations determined with the candidate sampler and a validated sampler. Other sampling errors due to non-random and random sources of error are also determined, for example, individual sampler variability, excursion from nominal flow rate and experimental errors.

The principal difference with the type A test method is that in this laboratory comparison the sampler efficiency curve is not determined, and the candidate sampler cannot therefore be compared directly to the EN 481 sampling conventions. This means that following this test it is not possible to calculate the expanded uncertainty of the candidate sampler for any arbitrary aerosol size distribution that was not applied in the tests. The choice of test aerosols and test conditions is particularly important as these will limit the field of application of the candidate sampler.

6 Test method

6.1 General

Aerosol concentration values measured using the candidate sampler are divided by aerosol concentration values measured using a validated (type A) sampler. An experimental design shall be devised that gives due attention to randomization and to estimation of the main effects. The design, and its associated statistical model, shall be explained in the test report.

6.2 Test conditions

Aerosol tests shall be carried out in a wind tunnel or aerosol chamber with a suitable aerosol source[2)]. The aerosol concentration shall be homogeneous at the measuring site where the samplers are situated. The facility shall be able to vary the test variables as required in 6.3. Candidate personal samplers for the inhalable particle fraction intended for use outdoors or in environments with forced ventilation (i.e. wind speeds in excess of 0,5 m/s) shall be compared with a validated sampler (type A) which has been shown to meet the requirements under these conditions. Samplers (candidate and validated sampler) need not to be mounted on a life-size mannequin. For wind tunnel tests a bluff body simulating a mannequin (or a mannequin) shall be used. The size and nature of the bluff body (mannequin) used shall be described in the test report. Alternative test methods may be used if they have been shown to give equivalent results[3)]. If a sampler is tested as a personal sampler in moving air, the results do not apply to its use as a static sampler for use in environments with strong wind speeds and vice versa.

2) Useful guidance on the generation of suitable test aerosols is given by VDI 2066, VDI 3489 and VDI 3491.

3) For examples of performance evaluations of personal inhalable samplers, see Bibliography, references [1] to [4].