SLOVENSKI STANDARD
oSIST prEN 13205-4:2012

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Zrak na delovnem mestu - Ocenjevanje lastnosti merilnikov za merjenje koncentracij lebdečih delcev - 4. del: Preskušanje usposobljenosti laboratorija na osnovi 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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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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Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

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Contents

Page

Foreword

This document (prEN 13205-4:2012) 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 together with prEN 13205-1, prEN 13205-2, FprCEN/TR 13205-3, prEN 13205-5 and prEN 13205-6 supersedes prEN 13205:2010 and will supersede 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;*

— *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.*

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.

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

EN 13205 enables 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 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 Eurpean 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 prEN 13205-1:2012.

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 482, *Workplace exposure — General requirements for the performance of procedures for the measurement of chemical agents*

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

EN 1540, *Workplace exposure — Terminology*

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

prEN 13205-1:2012, *Workplace exposure — Assessment of sampler performance for measurement of airborne particle concentrations — Part 1: General requirements*

prEN 13205-2:2012, *Workplace exposure — Assessment of sampler performance for measurement of airborne particle concentrations — Part 2: Laboratory performance test based on determination of sampling efficiency*

3 Terms and definitions

For the purpose of this document, the term and definitions given in EN 1540, prEN 13205-1:2012 and prEN 13205-2:2012 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, measuring procedure, non-random uncertainty, random uncertainty, expanded uncertainty, standard uncertainty, combined standard uncertainty, expanded 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 ζ_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 ζ_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 ζ_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 ζ_i

$N_{S_{iar}}$ number of candidate samplers used per experiment at repeat r for test aerosol a at influence variable value ζ_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 ζ_i to the corresponding test aerosol concentration, defined as $R_{iars} = X_{iars} / Y_{iar}$, [-]

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

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

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

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

$u_{CandSampl\text{-}Variability_i}$ standard uncertainty (of measurement) of the sampled concentration (random errors) due to differences among candidate sampler individuals at influence variable value ζ_i, [-]

$u_{ValidConc_i}$ standard uncertainty (of measurement) of test aerosol concentration (random errors) at the position of candidate samplers in test system, at influence variable value ζ_i, [-]

$u_{ValidSampl\text{-}nR}$ 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 ζ_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 ζ_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 ζ_i, [mg/m^3]

4.1.2 Greek

$\delta_{FlowSet}$ 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 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 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 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 randomisation 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.

6.3 Test variables

6.3.1 General

The comparison shall include those influence variables which the critical review indicates are important for the candidate sampler. Table 1 lists the most important influence variables and identifies those for which testing is compulsory (C), compulsory for some candidate samplers or uses only (C*), or optional (O). Excluded variables shall be clearly identified in the section of the test report that describes the scope of the test.

Table 1 also summarises the ranges of values for which the selected variables shall be tested, and the number of values within these ranges. In general, the values chosen need not include the extremes of the range, although specific requirements are stated in some cases. Where the experimental design requires a choice to be made, for example materials used to generate the test aerosols, the critical review shall consider the effect of the choices made on the applicability of the test results to routine sampling.

This document only gives specific information on how to calculate the uncertainty component, and how to add it into the expanded uncertainty, for uncertainty components pertaining to compulsory test influence variables. For optional test influence variables, the user will need to specify the tests, how they are evaluated and how the corresponding uncertainty components are added into the expanded uncertainty.

Based on the critical review, tests for particle size dependence may be carried out for several values of any influence variable, but with all other variables fixed (for example, at one wind speed only, chosen to be most representative of the conditions of use).

Six replicate results shall be obtained for each combination of experimental conditions. The six replicate test results may be obtained either by conducting the tests sequentially, or where the size of test facility and samplers allows (see 7.4), by simultaneous testing of a group of specimens.

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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].