SLOVENSKI STANDARD
oSIST prEN 13205-5:2012

01-november-2012

Zrak na delovnem mestu - Ocenjevanje lastnosti merilnikov za merjenje koncentracij lebdečih delcev - 5. del: Preskušanje in primerjava vzorčevalnikov za aerosole na delovnem mestu

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

Exposition am Arbeitsplatz - Bewertung der Leistungsfähigkeit von Sammlern für die Messsung der Konzentration luftgetragener Partikel - Teil 5: An Arbeitsplätzen durchgeführte Prüfungen der Leistungsfähigkeit des Aerosolsammlers

Ta slovenski standard je istoveten z: **prEN 13205-5**

ICS:

13.040.30	Kakovost zraka na delovnem mestu	Workplace atmospheres

oSIST prEN 13205-5:2012 **en,fr,de**

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

DRAFT
prEN 13205-5

October 2012

ICS 13.040.30

Will supersede EN 13205:2001

English Version

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

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If this draft becomes a European Standard, CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: Avenue Marnix 17, B-1000 Brussels

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Foreword

This document (prEN 13205-5:2012) 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 13205-4 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 workplace performance test for samplers for the inhalable, thoracic or respirable aerosol fractions described in this document bases on comparing concentrations sampled from a specific workplace (under otherwise identical conditions) by a candidate sampler and a (previously) validated sampler. Additionally, a method is described for determining a correction factor for recalculation of the concentration determined with one sampler into that of the other at specific workplaces.

This method is intended for the user, rather than the manufacturer, of aerosol samplers.

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 prEN 13205-1. 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 determining the performance of an aerosol sampler under prescribed workplace conditions in order to test whether the performance of a candidate sampler fulfils the requirements of prEN 13205-1:2012.

This part of EN 13205 specifies also a simple method to determine how, for a specific workplace aerosol, the concentration measured by the candidate sampler can be recalculated into that of a validated sampler.

This part of EN 13205 is applicable to all samplers used for the health-related sampling of particles in workplace air. Different test procedures and types of evaluation are included to enable application of this part of EN 13205 to a wide variety of instruments.

The methods specified in this part of EN 13205 are not applicable to tests where the performance of personal samplers is related to static samplers or vice versa.

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 atmospheres — General requirements for the performance of procedures for the measurement of chemical agents*

EN 1540, *Workplace exposure — Terminology*

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, prEN 13205-2:2012 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, measuring procedure, non-random uncertainty, random uncertainty, expanded uncertainty, standard uncertainty, combined standard uncertainty, expanded uncertainty, uncertainty (of measurement), coverage factor, precision and analysis.

3.1
correction function
<aerosol sampling> 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

4 Symbols and abbreviations

4.1 Symbols

4.1.1 Latin

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

C_{OEL} — appropriate occupational exposure limit value (OEL) applying to the substances being measured, [mg/m^3]

C_{rtl} — concentration for partial sampling period l in run r, for sampling time t, [mg/m^3]

$\text{twa}_{l1-l2}C_{r3}$ — time-weighted concentration average for candidate sampler for run r, sampling time t=3 extending from partial sampling period $l1$ to partial sampling period $l2$, [mg/m^3]

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

m_{rtl} — average mass collected during partial sampling period l, in run r for sampling time t (where t=1,2,3 represents sampling times T_{exp}, $T_{\text{exp}}/3$ and $T_{\text{exp}}/9$, respectively), [mg]

$\overset{\text{aver}}{\text{Collected}}m_{rtl}$ — average collected mass for partial sampling period l, in run r for sampling time t (where t=1,2,3 represents sampling times T_{exp}, $T_{\text{exp}}/3$ and $T_{\text{exp}}/9$, respectively), [mg]

$\overset{\text{aver}}{\text{InternSep}}m_{rtl}$ — average internally separated mass for partial sampling period l, in run r for sampling time t (where t=1,2,3 represents sampling times T_{exp}, $T_{\text{exp}}/3$ and $T_{\text{exp}}/9$, respectively), [mg]

$\max m_{\text{Collected}}$ — maximum collected mass corresponding to maximum concentration times intended sampling time times nominal flow rate, [mg]

$\max m_{\text{InternSep}}$ — maximum internally separated mass corresponding to difference between maximum total airborne particle (or inhalable fraction) concentration and maximum concentration expected to be sampled by candidate sampler times intended sampling time times nominal flow rate, [mg]

$\text{zero}\, m_{\text{Collected}}$ — collected mass corresponding to approximately zero mass, [mg]

$\text{zero}\, m_{\text{InternSep}}$ — internally separated mass corresponding to approximately zero mass, [mg]

N_{Run} — number of experimental runs, pairs of (average) validated sampler and candidate sampler concentrations

N_{S_r} — number of candidate samplers used in experimental run r

$N_{S_{rtl}}$	number of candidate samplers used with partial sampling period j in run r for sampling time t
N_{Valid_r}	number of reference samplers (validated samplers) used in experimental run r
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_g	geometric mean of the R_{rs} values, [-]
R_{rs}	ratio of the candidate sampler individual s concentration in experimental run r to the (average) workplace (test) aerosol concentration in experimental run r, [-]
$^{aver}R_r$	ratio of the average candidate sampler concentration to the (average) workplace (test) aerosol concentration in experimental run r, [-]
r_{rtl}	relative concentration (ratio with respect to the time-weighted concentration measured with candidate sampler with the shortest sampling time) for experiment r, sampling time t and partial sampling period l, [-]
s_R	geometric standard deviation of the R_{rs} values, [-]
$s_{ValidConc_{rs}}$	uncertainty of workplace (test) aerosol concentration at position of candidate sampler(s) for experimental run r and candidate sampler individual s, [-]
T_{exp}	experimental sampling time for tests described in Clause 6.5.5 based on estimated average concentration at workplace, [min]
T_{rtl}	actual sampling time of partial sampling period l for set t in experiment r, [min]
$U_{CandSampl}$	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, [-]
$u_{CandSampl\text{-}Bias}$	standard uncertainty (of measurement) due to bias (non-random errors) in relation to the sampling convention of the candidate sampler, [-]
$u_{CandSampler\text{-}CollectedMass}$	standard uncertainty (of measurement) of the sampled concentration (non-random errors) due to mass collected by the candidate sampler, [-]

$u_{\text{CandSampl-Flow}}$ standard uncertainty (of measurement) (random) due to candidate sampler flow excursion from nominal flow rate, [-]

$u_{\text{CandSampler-InternSepMass}}$ standard uncertainty (of measurement) due to internally separated mass (non-random errors) by the candidate sampler, [-]

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

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

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

$u_{\text{ValidConc}}$ standard uncertainty (of measurement) of the reference concentration (random errors) at the position of candidate samplers during experiments, [-]

$u_{\text{ValidSampl-nR}}$ standard uncertainty of the validated sampler (non-random errors), [-]

X_{rs} measured candidate sampler concentration for candidate sampler individual s, for the run (workplace (test) aerosol concentration) r, [mg/m^3]

$^{\text{aver}}X_r$ average of the measured candidate sampler concentrations for the run (workplace (test) aerosol concentration) r, [mg/m^3]

Y_{rs} workplace (test) aerosol concentration (measured with a validated sampler) for the reference sampler individual s, for the run (workplace (test) aerosol concentration) r, [mg/m^3]

Y_{rs}^{*} corrected concentration measured by the candidate sampler individual s, for the run experiment (workplace (test) aerosol concentration) r, [mg/m^3

$^{\text{aver}}Y_r$ average of the concentrations measured with validated samplers for the run (workplace (test) aerosol concentration) r, [mg/m^3]

$Y_{\text{Est-Collected}}$ regression equation for the ratio r_{rtl} as a function of $m_{\text{Collected}} = {}^{\text{aver}}_{\text{Collected}} m_{rtl}$, [-]

$Y_{\text{Est-InternSep}}$ regression equation for the ratio r_{rtl} as a function of $m_{\text{InternSep}} = {}^{\text{aver}}_{\text{InternSep}} m_{rtl}$, [-]

$y = f(x)$ correction function that relates the concentration measured with the candidate sampler to those measured with the (average of) validated sampler(s), [ln(mg/m^3)]

4.1.2 Greek

δ_{Pump} maximum relative change in flow rate allowed by pump flow rate stability, [-]

4.2 Enumerating subscripts

l	for partial sampling periods
$l1$	for first partial sampling period in summation
$l2$	for last partial sampling period in summation
r	for runs
s	for candidate sampler individual
t	for sampling time (where t=1,2,3 represents sampling times T_{exp}, $T_{exp}/3$ and $T_{exp}/9$ respectively)

5 Principle

The test method described in this part of EN 13205 is based on concentrations measured at a specific workplace by the candidate sampler, 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).

The purpose of determining the performance of a candidate sampler at a workplace is to enable the user of the samplers to carry out measurements of dust concentration with samplers that have not been evaluated in laboratory tests according to this part of EN 13205. The validated sampler and candidate sampler shall both be either personal or static samplers.

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 on-random and random sources of error are also determined, for example, individual sampler variability, excursion from nominal flow rate and experimental errors.

Analysis of the field data is carried out to determine the performance of the candidate sampler. The performance will be specific to the workplace activities included in the performance test and cannot be assumed to apply to different circumstances.

The criteria for accepting the performance of the sampler is identical to those for a laboratory test for performance evaluation. If the performance is poor, this will probably be due to either that the inherent variability at the workplace is exceedingly large, or by including too wide a range of workplace activities in the test, rather than to poor performance by the sampler. In the first case the large variability can only be reduced by averaging over several sampler individuals, which can be difficult with personal samplers. In the second case the performance test shall be repeated for a more narrowly-defined group of exposed persons or workplace activities, until an adequate degree of equivalence is established. In some workplaces the nature or organisation of the work can make this impossible.

NOTE The variability of the concentration at many workplaces can prove to be so large that it becomes impossible to determine a performance (expanded uncertainty) within the bounds specified by EN 482. To try to determine the (hopefully low) combined standard uncertainty of the sampler in the midst of an inherently large variability at the workplace can, however, prove to be very cumbersome. Such an endeavour would need an extensive experimental design in order to extract the information needed for the calculations described in this part of EN 13205.

6 Test method

6.1 General

Pairs of measurements are obtained with both validated sampler individual(s) and candidate sampler individual(s) (preferably more than one individual for both the validated sampler and the candidate sampler), exposed to the same aerosol. The number of pairs of measurements (experimental runs) obtained shall be as large as possible and never less than ten. The measurements shall cover the range of aerosol properties, concentrations and environmental conditions occurring at the sampling sites, and be obtained over a period of at least five days (although a larger number of days is preferred).

Both the validated and the candidate sampler(s) shall be operated in accordance with the instructions given in the manufacturer's instruction manual for the sampler types. Any deviations from these instructions shall be documented in the performance test report. Only those samples obtained in accordance with documented operating procedures shall be regarded as valid and included in the data analysis.

In order for the candidate sampler to be termed a validated sampler (type C) its performance shall meet the requirements of prEN 13205-1:2012, 5.2 c).

6.2 Performance test of personal samplers for the inhalable aerosol fraction

For each person selected, both the validated and candidate samplers shall be worn, positioned at their normal sites of use (e.g. shaller/lapel/collar bone). Both samplers shall be positioned as closely together as possible without mutual interference or deviation from their normal positions. It is important to assign the validated sampler and candidate sampler randomly to the measurement positions to avoid positional bias in the results.

Personal samplers for the inhalable aerosol fraction can be compared using a life-size mannequin located close to a worker, but not disturbing his/her work. CALTOOL is an example of such a designed mannequin[2]. The use of a mannequin makes it easier to perform a test based on several validated sampler individuals and candidate sampler individuals, whose concentrations may be averaged for each measured concentration.

6.3 Performance test of static samplers

The inlets of the validated sampler and the candidate sampler shall be positioned as closely together as possible without mutual interference. In the case of samplers with directional inlets, the position with respect to external air currents shall be the same for all samplers.

Reference aerosol concentrations at the inlet of the candidate sampler can be obtained by averaging the results of several validated samplers. An example of this approach is to place the candidate sampler at the centre of an equilateral triangle, and to place three validated samplers at the vertices. If tests are carried out using pairs of samplers placed at various sites, then each test shall be repeated with the positions of the samplers reversed, to avoid positional bias.

6.4 Performance test of personal samplers for the respirable or thoracic aerosol fractions

Candidate personal samplers for the respirable or thoracic aerosol fractions may be tested as static samplers as the particle size distribution of these two fractions only varies very slowly with the distance from the worker. A static test has the advantage that several candidate samplers (and validated samplers) can easily be exposed to a very similar concentration. A way to do this is by mounting the candidate and validated samplers inside a vertically mounted barrel/canister that shields the candidate samplers/validated samplers from the spatially varying concentration at a workplace. The entrance to the barrel/canister shall face vertically and be small enough that the concentration across the inlet would be spatially homogeneous. The inlet orifices of the candidate samplers shall all be at the same height inside the barrel/canister and at the same radial distance from the axis. No extra suction is required apart from that sustained from the samplers in the test. For such a barrel/canister it shall be verified that the aerosol aspiration/transport losses from the outside to the inlets of

[2] See Bibliography, references [1] to [3].