SLOVENSKI STANDARD
SIST EN 13205:2002

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Zrak na delovnem mestu - Ocenjevanje lastnosti merilnikov za merjenje koncentracij lebdeļ ih delcev

Workplace atmospheres - Assessment of performance of instruments for measurement of airborne particle concentrations

Arbeitsplatzatmosphäre - Bewertung der Leistungsfähigkeit von Geräten für die Messung der Konzentration luftgetragener Partikel

Atmospheres des lieux de travail - Evaluation des performances des intruments de mesurage des concentrations d'aérosol

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Workplace atmospheres - Assessment of performance of instruments for measurement of airborne particle concentrations

Atmosphères des lieux de travail - Evaluation des performances des intruments de mesurage des concentrations d'aérosols

Arbeitsplatzatmosphäre - Bewertung der Leistungsfähigkeit von Geräten für die Messung der Konzentration luftgetragener Partikel

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
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Management Centre: rue de Stassart, 36 B-1050 Brussels

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Foreword

This European Standard has been prepared by Technical Committee CEN/TC 137 "Assessment of workplace exposure", 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of an identical text or by endorsement, at the latest by June 2002, and conflicting national standards shall be withdrawn at the latest by June 2002.

This document contains annexes A, B, D, E, that are normative and annexes C and F that are informative.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland 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, that depend on the environment in which the sampler is used.

1 Scope

This European Standard specifies methods for testing aerosol sampling instruments under prescribed laboratory conditions, and performance requirements that are specific to aerosol sampling instruments. 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 sampling instrument 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 overall uncertainty (a combination of precision and bias) achievable under prescribed laboratory conditions for the methods to be used. The requirements of EN 482 apply to the combined results of sampling airborne particles and analysing collected particles. This standard specifies how the performance of aerosol measurement methods is assessed with respect to the general requirements of EN 482, through the combination of sampling and analytical errors.

This standard applies to all instruments 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 should 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

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text, and the publications are listed here. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated reference the latest edition of the publication referred to applies (including amendments).

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

EN 1540, *Workplace atmospheres — 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.*

[1)] The inhalable convention is undefined for particle sizes in excess of 100 µm or for windspeeds greater than 4 $m \cdot s^{-1}$. 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.

3 Terms and definitions

For the purposes of this European Standard the following terms and definitions apply.

3.1
accuracy
accuracy is the upper confidence limit of the bias or relative error in *sampling* the aerosol, which provides an estimate of the range around the ideal or true concentration in which 95 % of the sampled concentrations can be expected to lie

NOTE 1 Details of calculation methods for accuracy suited to different test methods are given in annexes A and B.

NOTE 2 Accuracy is generally defined as 'The closeness of agreement between a test result and the accepted reference value' (see ISO 3534-1).

3.2
ambient aerosol 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

3.3
bias
in accordance with EN 482

3.4
candidate instrument (for use in comparisons)
any kind of instrument, including a sampling instrument, that can be used to measure the concentration of aerosol particles and whose performance is to be determined

3.5
correction function
mathematical function relating aerosol concentrations measured using a candidate instrument to those measured using a reference sampler, determined by a comparison of the two instruments

3.6
personal sampler
in accordance with EN 1540

3.7
precision
in accordance with EN 482

3.8
reference sampler (for use in comparisons)
sampler that has previously been tested using the methods described in annex A of this standard, and whose accuracy is estimated to be less than or equal to 30 % under the environmental conditions of the comparison

3.9
sampler inlet efficiency; entry efficiency
for each particle aerodynamic diameter, the ratio of aerosol concentration passing through the sampler inlet system, to the corresponding ambient aerosol 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.

3.10
sampler, sampling instrument; (generic term)
apparatus for separating aerosol particles from their carrier gas (normally air)

3.11
sampler specimen (specific term)
single individual of a given type of sampling instrument

3.12
sampling efficiency
for each particle aerodynamic diameter, the ratio of aerosol concentration collected for measurement by the sampling process, to the corresponding ambient aerosol concentration

3.13
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

3.14
separation efficiency
for each particle aerodynamic diameter, the ratio of the sampling efficiency to the inlet efficiency

3.15
static sampler
in accordance with EN 1540

4 Requirements

4.1 Summary of requirements

Table 1 —Summary of aerosol sampler performance requirements

Attribute	Requirement	Test method	Notes
Accuracy	See 4.2	Annex A Annex B	
Specimen variability	Variations in sampled mass <5 %, for a group of 6 identically exposed specimens	Annex A	[1])
Air flow stability (for samplers with integral pumps)	Relevant clauses of EN 1232 and EN 12919	Relevant clauses of EN 1232 and EN 12919 (modified if necessary)	[2])
Transportation and handling	For 10 test substrates, No weight change > 5 %	Annex D	
Sample identification	Suitable area for sample identification provided	Visual check	
Instructions for use	Contents as in clause 7	Visual check	
Design safety	Relevant clauses of EN 1232 and EN 12919	Relevant clauses of EN 1232 and EN 12919	
Electrical safety	Relevant clauses of EN 1232 and EN 12919	Relevant clauses of EN 1232 and EN 12919	
Temperature stability	Response does not deviate from the mean by more than 5 %	Annex B	[3])
Time stability	Response does not deviate from the mean by more than 5 %	Annex B	[3])
[1]) Tests are unnecessary where manufacturers can demonstrate that dimensional tolerances are sufficiently stringent to reduce specimen variability below measurable levels. [2]) If necessary, any more stringent requirements for air flow stability shall be specified in the manufacturers information for use for the instrument. [3]) These requirements only apply to direct-reading instruments.			

4.2 Accuracy

The candidate sampler is in conformity with the relevant EN 481 convention when the accuracy is less than or equal to 30 %:

a) for type 1 test (see annex A): for at least 85 % of the relevant particle size distributions (see Table A.2) and for all compulsory tests according to Table A.1 or resulting from the critical review;

b) for type 2 test (see annex B): for all the particle size distributions tested, and for all compulsory tests according to Table B.1 or resulting from the critical review.

This requirement shall be fulfilled for any wind speed in the intended range for practical use. The maximum tested wind speed in which the sampler meets the accuracy requirement determines the upper limit for practical use.

NOTE Even where the sampler is not generally in conformity with the EN 481 convention, it can be used for the health-related sampling of airborne particles provided it meets the overall uncertainty requirements of EN 482, for the specific conditions (e.g. particle size distributions, measurement tasks, analytical errors) in which the measuring procedure will be applied.

5 Test methods

5.1 Choice of laboratory tests to be used

The critical review forms the first stage of the sampler performance evaluation and determines the design of the laboratory tests (see annexes A and B). Its purpose is to identify which environmental and other variables are likely to affect the sampling efficiency. The critical review shall explain the evidence for the inclusion or exclusion of variables from the tests, making reference where possible to published results. The review shall consider the environments in which the sampler will be used and decide the wind conditions, aerosols and other parameters to be used in the tests. The critical review shall be documented in the test report, drawing attention to any limitations in the scope of the performance evaluation arising from the decisions made.

Table 2 — Principal factors influencing the performance of aerosol samplers

Factor	Nature of effect	Sampler types affected
Particle size	Size-dependent selection of particles	All sampler types
Wind speed	Wind speed at inlet affects aspiration, especially for high winds, large particles	Any sampler not having an isokinetic inlet
Wind direction	Wind orientation at inlet affects aspiration	Any sampler not having an omnidirectional inlet
Aerosol composition	Particle bounce and re-entrainment; breakdown of agglomerates	E.g. Cyclones, impactors
Sampled aerosol mass	Collection efficiency changes as surfaces are heavily loaded	E.g. impactors, porous foam filters
Aerosol charge	Attraction to and repulsion from surfaces	All samplers, particularly non-conducting samplers
Specimen variability	Small dimensional differences cause large aerodynamic effects	E.g. Cyclones, impactors
Flow rate variations	Particle separation mechanism strongly flow-dependent	E.g. Cyclones, elutriators, impactors
Surface treatments	Collection efficiency depends on e.g. greases used to coat collection surfaces	E.g. Impactors, impingers

Table 2 gives an informative checklist of the principal variables known to influence aerosol sampling instruments, and examples of the instruments for which they can cause measurable effects. The critical review shall consider these variables, and also the potential effects of temperature, pressure, humidity, vibration, movement, orientation, sample transportation and electromagnetic susceptibility. The following common problems with sampling instruments should also be addressed:

- whether the sampling process can lead to the breakdown of agglomerates, i.e. alter the size distribution of the aspirated aerosol;
- whether the sampler inlet can collect particles flying towards it or sedimenting into it, as well as those entering under the influence of air suction alone;
- whether there can be interaction between sampler flow rate and external wind speed, if the pressure drop across the sampler is small;
- whether the samplers may behave differently with liquid or solid particles, or particles having different bounce characteristics.

5.2 Overview of test methods

Annex A specifies a laboratory test method for determining how closely an aerosol sampling instrument matches the target sampling convention. Annex A describes how the data obtained from the test shall be treated in order to calculate the performance characteristics of the sampler. The test method in annex A is suited to samplers intended to follow the conventions laid down in EN 481, and which physically separate particles from their carrier gas by aerodynamic processes[2)].

Annex B describes procedures for comparing the results of a candidate instrument with a reference sampler, in a laboratory test. These comparison tests are suited to samplers that physically separate particles from their carrier gas by aerodynamic processes, or additionally to any other kind of instrument intended for measuring the concentration of aerosol particles in a gas. In the laboratory comparison test, the sampling characteristics of the candidate instrument are indirectly compared with the EN 481 sampling conventions.

Annex C (informative) suggests a procedure for establishing the equivalence of two aerosol concentration measurement methods by means of a field comparison. The outcome of a field comparison is dependent both on the circumstances existing in the workplace, and on the performances of the instruments included. The purpose of the procedure is to allow the use of non-standard aerosol measuring instruments where equivalence with reference samplers has been established by means of a standardised test.

Annex D describes a test procedure to assess the usability of aerosol samplers and potential errors introduced during handling and transport of samples.

During subsequent use of the tested aerosol sampler, the consideration of analytical errors is very important for the user of the sampler. This is because the general performance requirements of EN 482 apply to all parts of a measurement process, including both sampling and analysis of the sample. Annex E describes how the overall uncertainty of an aerosol measuring process is calculated for assessment according to the requirements of EN 482, by the combination of analytical and sampling errors.

6 Types of evaluation

There are two different types of evaluation. These types are defined as follows:

- Type 1: clause 5 + annex A + annex D.
- Type 2: clause 5 + annex B + annex D.

These types are ranked in order of the quality of information available to the user of the sampling instrument following testing. The type 1 test gives the user more information from which to assess the likely performance of the

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[2)] An example of a device for measuring aerosol concentrations, which does not physically separate the particles from air using aerodynamic processes, is an instrument that selectively senses particles by means of light scattering.