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Workplace exposure - Assessment of sampler performance for measurement of airborne particle concentrations - Part 1: General requirements

Exposition am Arbeitsplatz - Beurteilung der Leistungsfähigkeit von Sammlern für die Messung der Konzentration luftgetragener Partikel - Teil 1: Allgemeine Anforderungen

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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 1: Exigences générales

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Workplace exposure - Assessment of sampler performance for measurement of airborne particle concentrations - Part 1: General requirements

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Foreword

This document (EN 13205-1:2014) 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of an identical text or by endorsement, at the latest by December 2014 and conflicting national standards shall be withdrawn at the latest by December 2014.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 13205-2, CEN/TR 13205-3, EN 13205-4, EN 13205-5 and EN 13205-6 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* (the present document);

— *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*;

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

— *Part 6: Transport and handling tests.*

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

— This part of EN 13205 is based on Clauses 1 to 8 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.

— The list of definitions has been expanded and many definitions are now given in EN 1540, *Workplace exposure — Terminology*. 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 “overall uncertainty” is no longer used, instead the concept of “expanded uncertainty” is used.

— The list of Requirements (Table 1) has been reformulated/changed for some attributes. The current version of the standard envisages two different types of tests: A test of a candidate aerosol sampler and a test of a complete measuring method based on a candidate sampler, respectively. Two flow charts, one for each type of test, have been included to better demonstrate the relation between the different parts of EN 13205.

— Annex A has been added on how to calculate the expanded uncertainty for a measuring procedure based on aerosol sampling but also consisting of several other stages. This is a complete revision and expansion of Annex E in the previous version. A clause on symbols has been included.

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,

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Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

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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 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 expanded uncertainty (a combination of random and non-random measurement uncertainty) achievable under prescribed laboratory conditions for the methods to be used. The requirements of EN 482 apply to a complete measuring procedure, a combination of the stages consisting of sampling, sample transport/storage and sample preparation/analysis.

This part of EN 13205 gives performance requirements for samplers for the inhalable, thoracic or respirable aerosol fractions. Requirements for the aerosol sampler and transport of loaded collection samplers are stated. Furthermore, the method for calculating the expanded uncertainty for a measuring procedure based on aerosol sampling is described.

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Different test procedures and types of evaluation are described in the other parts of EN 13205 in order to enable application of EN 13205 to a wide variety of instruments. In detail, three different performance tests for sampled concentration and a transport test of loaded collection substrates are described. The three tests differ in the amount of information obtained by the test and its corresponding cost. The first test method determines the sampling efficiency curve of a candidate sampler, the second compares concentrations sampled from three laboratory test atmospheres by a candidate sampler and a (previously) validated sampler, and the third method compares concentrations sampled from a specific workplace by a candidate sampler and a (previously) validated sampler. Additionally a method for determining equivalence between aerosol samplers at specific workplaces and an alternative handling test are presented.

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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 other parts of this European Standard. 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.

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1 Scope

This European Standard specifies performance requirements that are specific to aerosol samplers, primarily inhalable, thoracic and respirable aerosol samplers. These performance requirements, which include conformity with the EN 481 sampling conventions, are applicable 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.

This part of EN 13205 specifies how the performance of aerosol measuring procedures is assessed with respect to the general requirements of EN 482, through the combination of errors arising in the sampling, sample transportation/storage and sample preparation/analysis stages.

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

This part of EN 13205 is not applicable to the determination of analytical errors and factors related to them (for example the bias, precision and limit of detection of the analytical method). Where the aerosol sampler requires the use of an external (rather than integral) pump, the pump is not subject to the requirements of this part of EN 13205.

2 Normative references

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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.

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EN 481, *Workplace atmospheres — Size fraction definitions for measurement of airborne particles*

EN 482:2012, *Workplace exposure — General requirements for the performance of procedures for the measurement of chemical agents*

EN 1540:2011, *Workplace exposure — Terminology*

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*

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

EN 13205-4:2014, *Workplace exposure — Assessment of sampler performance for measurement of airborne particle concentrations — Part 4: Laboratory performance test based on comparison of concentrations*

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 13205-6:2014, *Workplace exposure — Assessment of sampler performance for measurement of airborne particle concentrations — Part 6: Transport and handling tests*

EN 13890, *Workplace exposure — Procedures for measuring metals and metalloids in airborne particles — Requirements and test methods*

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EN 14530, *Workplace atmospheres — Determination of diesel particulate matter — General requirements*

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

ISO 15767, *Workplace atmospheres — Controlling and characterizing uncertainty in weighing collected aerosols*

ISO 21438 (all parts), *Workplace atmospheres — Determination of inorganic acids by ion chromatography*

ISO 24095, *Workplace air — Guidance for the measurement of respirable crystalline silica*

3 Terms and definitions

For the purpose of this document, the terms and definitions given in EN 1540 and the following apply.

3.1 Terms related to sampling and transportation

NOTE In addition to the terms and definitions given by entry numbers 3.1.1 to 3.1.21, in particular, the following general terms, terms related to the physical and chemical process of air sampling and terms related to the analytical method of EN 1540 are used in this document as well: respirable fraction, inhalable fraction, sampling efficiency, thoracic fraction, measuring procedure, analysis, analytical method, measurand and occupational exposure limit value.

3.1.1
airborne particles
fine matter, in solid or liquid form, dispersed in air

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Note 1 to entry: Smoke, fume, mist and fog consist of airborne particles.

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[SOURCE: EN 1540:2011, 2.2.3]

3.1.2
aerosol
airborne particles and the gas (and vapour) mixture in which they are suspended

Note 1 to entry: The airborne particles can be in or out of equilibrium with their own vapours.

Note 2 to entry: In occupational hygiene, the carrier gas is air, possibly contaminated by other gases and vapours.

[SOURCE: EN 1540:2011, 2.2.4, modified – Note 2 to entry has been added.]

3.1.3
aerosol sampler
(airborne) particle sampler
(airborne) particulate sampler
sampler that is used to transport airborne particles to a collection substrate

Note 1 to entry: The term aerosol sampler is commonly used although it is not in line with the definition of aerosol given in EN 1540:2011, 2.2.4.

Note 2 to entry: The transport can be either active or passive.

Note 3 to entry: For the purpose of this document, a sampler is not a pump or an air mover, but can include either of them in specific cases.

[SOURCE: EN 1540:2011, 3.2.1.5, modified – Note 3 to entry has been added.]

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3.1.4
candidate sampler
any aerosol sampler that can be used to collect airborne particles in order to determine their concentration and whose performance is subjected to performance tests

Note 1 to entry: A candidate sampler that meets the performance criteria will be termed a validated sampler.

3.1.5
collected sample
product of the process of air sampling that consists of the collected chemical and/or biological agents only

Note 1 to entry: For the purpose of this document the collected sample comprises of airborne particles collected and retained on the sampling substrate for subsequent analysis.

[SOURCE: EN 1540:2011, 3.1.2, modified – Note 1 to entry has been added.]

3.1.6
collection substrate
sampling substrate
collection medium
sampling medium
medium on which airborne chemical and/or biological agents are collected for subsequent analysis

Note 1 to entry: Filters, polyurethane foams and sampling cassettes are examples of collection substrates for airborne particles.

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Note 2 to entry: Activated carbon, silica gel and reagent impregnated filters are examples of collection substrates for gases and vapours.

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Note 3 to entry: Agar media are examples of collection substrates for bioaerosols.

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Note 4 to entry: The 25-mm or 37-mm plastic filter cassette often used for “total dust” sampling (with gravimetric analysis) in either its closed-face or open-face version is not part of the substrate in the definition above, since it is not weighed. On the other hand, some analytical methods for elements in samples collected with 25-mm or 37-mm plastic filter cassette require that particles deposited onto the internal surfaces of the filter cassette upstream of the filter to be included in the analysis, and in this case the internal surfaces of the filter cassette is part of the collection substrate.

[SOURCE: EN 1540:2011, 3.3.6, modified – Note 4 to entry has been added.]

3.1.7
collection efficiency
efficiency of collection and retention of sampled particles by the collection substrate

Note 1 to entry: The collection efficiency can, for example be influenced by the amount of particles deposited in the collection substrate.

Note 2 to entry: The collection efficiency (of a collection substrate) should not be confused with the sampling efficiency (of a sampler). For the definition of sampling efficiency see EN 1540:2011, 3.3.10.

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3.1.8
inhalable fraction
mass fraction of total airborne particles which is inhaled through the nose and mouth

Note 1 to entry: The inhalable fraction is specified in EN 481.

Note 2 to entry: The inhalable fraction depends on the speed and direction of the air movement, on breathing rate and other factors.

[SOURCE: EN 1540:2011, 2.3.1.1, modified – Note 2 to entry has been added.]

3.1.9
inhalable sampler
aerosol sampler that is used to collect the inhalable fraction

Note 1 to entry: An inhalable sampler collects the inhalable fraction of airborne particles, as defined in EN 481, with a performance as stipulated in this document.

[SOURCE: EN 1540:2011, 3.2.1.5.1, modified – Note 1 to entry has been added.]

3.1.10
nominal flow rate
design flow rate recommended by the sampler manufacturer or measuring procedure

3.1.11
particle aerodynamic diameter
diameter of a sphere of 1 g cm^{-3} density with the same terminal settling velocity in calm air as the particle, under the prevailing conditions of temperature, pressure and relative humidity

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Note 1 to entry: The particle aerodynamic diameter depends on the size, density and shape of the particle.

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Note 2 to entry: For particles of aerodynamic diameter less than 0,5 µm, the particle thermodynamic diameter should be used instead of the particle aerodynamic diameter.

[SOURCE: EN 1540:2011, 2.3.2, modified – Note 2 to entry has been added.]

3.1.12
sampler inlet efficiency
for each particle aerodynamic diameter the ratio of aerosol concentration passing through the sampler inlet to the corresponding total airborne particle concentration

Note 1 to entry: The sampler 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.

3.1.13
penetration
internal penetration
for each particle aerodynamic diameter the ratio of the sampling efficiency to the sampler inlet efficiency

Note 1 to entry: The penetration describes the efficiency with which particles pass through the stage of internal aerodynamic separation, as for example in foams, cyclones, impactors or elutriators.

3.1.14
personal sampler
sampler, attached to a person, that collects gases, vapours or airborne particles in the breathing zone to determine exposure to chemical and/or biological agents

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Note 1 to entry: For the purpose of this document “agent” means airborne particles.

[SOURCE: EN 1540:2011, 3.2.2, modified – Note 1 to entry has been added.]

3.1.15
respirable sampler
aerosol sampler that is used to collect the respirable fraction

Note 1 to entry: A respirable sampler collects the respirable fraction or airborne particles, as defined in EN 481, with a performance as stipulated in this document.

[SOURCE: EN 1540:2011, 3.2.1.5.3 modified – Note 1 to entry has been added.]

3.1.16
sampler specimen
sampler individual
single individual of a given type of aerosol sampler

3.1.17
sampling cassette
cassette mounted inside a sampler, designed in such a way that its collection substrate consists of all its interior surfaces (bounding the air-stream with sampled particles), and usually containing a filter or another suitable collection substrate

3.1.18
sampling method
part of the measuring procedure that describe the overall process of sampling, including sampler preparation and sample transport

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3.1.19
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

Note 1 to entry: The losses from the collection substrate referred to here regard losses occurring during sampling and not during transport and/or storage.

3.1.20
thoracic sampler
aerosol sampler that is used to collect the thoracic fraction

Note 1 to entry: A thoracic sampler collects the thoracic fraction or airborne particles, as defined in EN 481, with a performance as stipulated in this document.

[SOURCE: EN 1540:2011, 3.2.1.5.2 modified – Note 1 to entry has been added.]

3.1.21
validated sampler
sampler that has been tested under specified conditions to comply with a required performance

Note 1 to entry: This European Standard distinguishes between three types of validated samplers. See below.

Note 2 to entry: A validated sampler which has previously been tested using the methods described in EN 13205–2 to comply with the requirements given in EN 13205–1 is designated as “validated sampler (type A)”. In a performance test according to EN 13205–2, the sampling efficiency curve of the candidate sampler will be determined as a function of particle size (and possibly other influencing factors).