BS EN 13205-6:2014

BSI Standards Publication

Workplace exposure — Assessment of sampler performance for measurement of airborne particle concentrations

Part 6: Transport and handling tests

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National foreword

This British Standard is the UK implementation of EN 13205-6:2014. Together with BS EN 13205-1, BS EN 13205-2, PD CEN/TR 13205-3, BS EN 13205-4:2014 and BS EN 13205-6:2014 it supersedes BS EN 13205:2002, which will be withdrawn upon publication of all parts of the series.

The UK participation in its preparation was entrusted to Technical Committee EH/2/2, Work place atmospheres.

A list of organizations represented on this committee can be obtained on request to its secretary.

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English Version

Workplace exposure - Assessment of sampler performance for measurement of airborne particle concentrations - Part 6: Transport and handling tests

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 6: Essais de manipulation et de transport

Exposition am Arbeitsplatz - Beurteilung der Leistungsfähigkeit von Sammlern für die Messung der Konzentration luftgetragener Partikel - Teil 6: Prüfungen zum Transport und zur Handhabung

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Foreword

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of an identical text or by endorsement, at the latest by December 2014 and conflicting national standards shall be withdrawn at the latest by December 2014.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

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

— *Part 6: Transport and handling tests* (the present document).

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

— This part of EN 13205 is partly based on Annex D 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. Almost all definitions are now given either in EN 1540, *Workplace exposure — Terminology* or in Part 1 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 standard gives two methods to determine the dependence of the mass loss from collection substrates due to transport and/or handling, respectively. It is described how to use the test data to calculate the uncertainty due to transport/handling and how this is related to the requirements given in Part 1 of this European Standard.

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.

This part of EN 13205 describes two test methods for determining the uncertainties due to transport errors. The values calculated can directly be compared to the requirements of EN 13205-1:2014 The first method is based on loading collection substrates with particles from a workplace aerosol and delivery by ordinary mail. The second method is based on loading collection substrates with particles from a specified laboratory test aerosol and subsequent exposure of the collection substrates to vibrations using either a laboratory shaker table or a vertical shaker.

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 manufacturers 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 standard give different results.

1 Scope

This European Standard specifies a performance test of loaded collection substrates for samplers for the inhalable, thoracic or respirable aerosol fractions and, as alternative, a handling test, both for testing transport losses of aerosol sampler substrates under prescribed conditions in order to calculate the expanded uncertainty of a measuring procedure according to EN 13205-1:2014, Annex A. The transport test involves shipping loaded substrates with ordinary mail, whereas the handling test uses a shaker.

This part of EN 13205 applies 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 143, *Respiratory protective devices - Particle filters - Requirements, testing, marking*

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*

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

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: respirable fraction, sampling efficiency, personal sampler, static sampler, thoracic fraction, inhalable fraction, measuring procedure, non-random uncertainty, random uncertainty, uncertainty (of measurement), precision and analysis.

4 Symbols and abbreviations

4.1 Symbols

4.1.1 Latin

C_{OEL}	relevant occupational exposure limit (OEL) value, [mg/m^3]
$m_{0,1}$, $m_{0,5}$ and m_2	nominal masses to be loaded onto collection substrates for selected sampling time *t* and nominal flow rate Q^0 at concentrations corresponding to 10 %, 50 % and 200 % of the occupational exposure limit, [mg]
$m_{\mathrm{Handl}_{bn}}$	mass remaining on collection substrate *n* of subset b after the handling test, [mg] –

	Clause 6
$m_{\text{Load}_{bn}}$	mass loaded onto collection substrate *n* of subset b, [mg]
$m_{\text{Transp}_{bn}}$	mass remaining on collection substrate *n* of subset b after the transport test, [mg] – Clause 5
N_{ML_b}	number of mass loaded collection substrates in subset *b*
Q^0	nominal flow rate of sampler, [l/min]
s_{Handl}	standard deviation of handling losses of loaded collection substrates, [mg] – Clause 6
s_{Handl_b}	standard deviation of handling losses of loaded collection substrates for subset *b*, [mg] – Clause 6
s_{Transp}	standard deviation of transport losses of loaded collection substrates, [mg] – Clause 5
s_{Transp_b}	standard deviation of transport losses of loaded collection substrates for subset *b*, [mg] – Clause 5
t	selected sampling time in the range from the minimum to the maximum sampling time according to the measurement procedure, [min]
$t_{0,1}$, $t_{0,5}$ and t_2	estimated sampling times for obtaining nominal mass loadings of collection substrates, $m_{0,1}$, $m_{0,5}$ and m_2, respectively, with nominal flow rate Q^0 at actual workplace concentration, [min]
t_x	minimum sampling period at the concentration equal to χC_{OEL} mg/m^3, [min]
$u_{\text{t-nR}}$	non-random measurement error due to transport/handling losses, [-]
$u_{\text{t-R}}$	random measurement error due to transport/handling losses, [-]

4.1.2 Greek

$\Delta m_{\text{Handl}_{bn}}$	mass loss due to the handling test for collection substrate *n* of subset b, [mg] – Clause 6
$\Delta m_{\text{Transp}_{bn}}$	mass loss due to the transport test for collection substrate *n* of subset b, [mg] – Clause 5
$^{\text{aver}}\Delta m_{\text{Handl}_b}$	average relative handling losses of loaded collection substrates for subset *b*, [mg] – Clause 6
$^{\text{aver}}\Delta m_{\text{Transp}_b}$	average transport losses of loaded collection substrates for subset *b*, [mg] – Clause 5
λ_χ	requirement for the transport loss (see 5.1) at the concentration equal to χC_{OEL} mg/m^3, [-]
χ	proportionality constant that takes the values 0,1, 0,5 and 2,0, respectively, for the concentrations corresponding to 10 %, 50 % and 200 %, respectively, of C_{OEL}, [-]
χ_n	ratio of the calculated concentration from mass load *n* and the limit value, [-]

4.2 Enumerating subscripts

b	for subset of collection substrate mass loads
n	for collection substrate mass load

5 Transport test based on weighing samples before and after shipping by mail

5.1 Principle

The transport test is carried out as laboratory test to simulate rough handling that collection substrates, either mounted or unmounted in their aerosol samplers, can be subjected to while transported by mail. Rough handling can result in the movement of collected particles between collection substrate and the internal walls of the sampler or between collection substrate and a special container for transport of the collection substrate to the laboratory. This can be important for all samples being transported from the sampling site to a laboratory.

5.2 Test procedure

5.2.1 General

The purpose of this test is estimate mass measurement errors due to either material loss or substrate contamination during the transport of samples between field and laboratory. This test is relevant to both complete samplers (i.e. with mounted collection substrates) and collection substrates removed from the samplers and placed in special containers for transport to a laboratory.

It is expected that the errors increase with median particle geometric size of the test aerosols, and that the errors for inhalable aerosol samplers would be larger than those for respirable aerosol samplers. This test can be performed for several different aerosols. For a test that is intended to be representative of a range of aerosols possibly encountered by the sampler, it is necessary to perform the test with a test aerosol consisting of as large particles as relevant.

This test is applicable to any suitable analytical method. Gravimetric determination (weighing) is used throughout this part of EN 13205 as a surrogate term for any suitable analytical method. If the test described in this clause is to be used with a different analytical method, the procedure needs to be modified accordingly.

If the normal mode of transport is to place the dust-laden collection media in special tins or containers, the transport test shall be carried out in this manner.

This test applies to both personal and static samplers.

5.2.2 Test equipment

At least five (but preferably seven) samplers, with collection substrates, shall be used in the test. The samplers need to be exposed to identical concentrations.

Twenty-one (21) collection substrates, plus blanks are required. Divide the collection substrates into three sets of seven substrates.

This test is preferentially carried out at workplaces, using workplace aerosols.

An analytical balance reading to 0,01 mg (or better) is required for weighing the collection substrates.

5.2.3 Test aerosol and method of loading collection media

The test shall be performed with a polydisperse test aerosol of suitable composition.

There are several requirements on the test aerosol when possible transport errors for unspecified aerosols are investigated: The test aerosol shall consist of non-volatile, non-reactive, non-sticky and non-hygroscopic particles. For samplers of the respirable or thoracic aerosol fraction, the ratio of the sampled fraction to the total airborne particle concentration shall be less than 40 %. For sampler of the inhalable aerosol fraction, the mass median of the test aerosol shall exceed 20 µm.

NOTE In the case that the test is to be applied to a specific aerosol that is sticky, the results cannot be generalized.

Unless the relevant measuring procedure states an upper (and/or lower) mass loading of the collection substrates, the range of masses loaded onto the collection substrates shall approximately correspond to that sampled from concentrations in the range one tenth to twice the occupational exposure limit value of a relevant substance, with one sampling time, t, in the range from the minimum to the maximum sampling time according to the measuring procedure and using the nominal flow rate. Determine the three nominal collection substrate mass loads, $m_{0,1}$, $m_{0,5}$ and m_2, respectively, that for the selected sampling time, t, and nominal flow rate, Q^0, corresponds to concentrations equal to 0,1 times, 0,5 times and 2 times the relevant occupational exposure limit. The actual masses loaded shall exceed 90 % of the corresponding nominal value.

5.2.4 Test method

The procedure involves the following steps:

a) condition the collection media (including at least three blanks) in a balance room atmosphere until the weight is stable;

b) weigh the collection substrates according to the relevant measuring procedure;

c) clean the samplers before each new sampling period;

d) load collection substrates into the samplers;

e) at the workplace, determine the approximate concentration, and from it estimate the approximate sampling times, $t_{0,1}$, $t_{0,5}$ and t_2, respectively, for loading the collection substrates with nominal masses $m_{0,1}$, $m_{0,5}$ and m_2, respectively.

NOTE These sampling times can be longer than 8 h if the actual workplace concentration is considerably lower than the OEL.

f) mount collection substrates into the samplers and run the samplers during the estimated sampling time(s) in order to load the collection substrates with the calculated nominal mass, $m_{0,1}$, $m_{0,5}$ or m_2;

g) after each run the loaded collection substrates are either placed in their transportation containers, or, if the collection substrates are transported mounted in the used samplers, the collection substrates are left in the samplers;

h) repeat from c) until a subset of seven collection substrates has been obtained per nominal load mass, $m_{0,1}$, $m_{0,5}$ or m_2;

i) transport the loaded collection substrates back to the laboratory, taking great care to avoid that the sample particles which are most easily lost have already been lost when the samples arrive at the laboratory;

j) weigh the loaded substrates and blanks according to the relevant measurement procedure;

k) pack the loaded substrates (or uncleaned samplers with loaded substrates, whichever is relevant) according to the relevant measurement procedure, and dispatch the transport containers by mail, consigned delivery system or by the end-user's own vehicle (whatever is most common/ appropriate) to a trusted addressee/consignee at a remote location; ask the addressee/ consignee to return the package containing the test substrates, with the same transport system without opening it;

l) upon return of the collection substrates (incl. blanks) weigh them according to the relevant measurement procedure.

ISO 15767 gives recommendations for proper weighing of aerosol collection substrates.

5.3 Calculations

For each of the three sets $(b = 1,2,3)$ of nominal collection substrate mass loads, $m_{0,1}$, $m_{0,5}$ or m_2, calculate the loaded mass on each $(n = 1,2,..,N_{\mathrm{ML_b}})$ collection substrate, before and after the transport test, respectively. Calculate the mass loss due to the transport test for each collection substrate from Formula (1):

$$\Delta m_{\mathrm{Transp}_{bn}} = m_{\mathrm{Load}_{bn}} - m_{\mathrm{Transp}_{bn}} \tag{1}$$

where

$m_{\mathrm{Load}_{bn}}$ is the mass loaded onto collection substrate n of subset b, [mg];

$m_{\mathrm{Transp}_{bn}}$ is the mass remaining on collection substrate n of subset b after the transport, [mg]; and

$\Delta m_{\mathrm{Transp}_{bn}}$ is the mass loss due to the transport test for collection substrate n of subset b, [mg].

Plot the mass loss versus the initially loaded substrate mass, $m_{\mathrm{Load}_{bn}}$.

NOTE It is expected that the relative transport losses in many cases will be less than 0,05, except for very small sample masses. However, in the latter circumstances it might be considerably larger than the analytical uncertainty.

For each of the three subsets $(b = 1,2,3)$ of nominal collection substrate mass loads, $m_{0,1}$, $m_{0,5}$ or m_2, calculate the average and standard deviation of the transport losses from Formula (2):

$$\begin{cases} {}^{\mathrm{aver}}\Delta m_{\mathrm{Transp}_b} = \dfrac{1}{N_{\mathrm{ML}_b}} \displaystyle\sum_{n=1}^{N_{\mathrm{ML}_b}} \Delta m_{\mathrm{Transp}_{bn}} \\ s_{\mathrm{Transp}_b}{}^2 = \dfrac{1}{N_{\mathrm{ML}_b} - 1} \displaystyle\sum_{n=1}^{N_{\mathrm{ML_b}}} \left(\Delta m_{\mathrm{Transp}_{bn}} - {}^{\mathrm{aver}}\Delta m_{\mathrm{Transp}_b} \right)^2 \end{cases} \tag{2}$$

where

N_{ML_b} is the number of mass loaded collection substrates in subset b;

s_{Transp_b} is the standard deviation of transport losses of loaded collection substrates for subset b, [mg];

$\Delta m_{\mathrm{Transp}_{bn}}$ is the mass loss due to the transport test for loaded collection substrate n of subset b, [mg]; and

$^{aver}\Delta m_{Transp_b}$ is the average transport losses of loaded collection substrates for subset b, [mg].

Pool the standard deviation of transport losses of loaded collection substrates for all three subsets according to Formula (3):

$$s_{Transp}{}^2 = \frac{\sum_{n=1}^{N_{ML_b}} N_{ML_b} s_{Transp_b}{}^2}{\sum_{n=1}^{N_{ML_b}} N_{ML_b}} \quad (3)$$

The non-random uncertainty due to transport losses, $u_{t\text{-}nR}$, is set equal to zero. The random uncertainty due to transport losses, $u_{t\text{-}R}$, is calculated as the standard deviation of the sample mass losses, $\Delta m_{Transp_{bn}}$ divided by the loaded mass, and is a function over the range of loaded samples, $m_{Load} \in \left[\min\left(m_{Load_{bn}}\right) \max\left(m_{Load_{bn}}\right) \right]$,

$$\begin{cases} u_{t\text{-}nR} = 0 \\ u_{t\text{-}R}\left(m_{Load}\right) = \dfrac{s_{Transp}}{m_{Load}} \end{cases} \quad (4)$$

where

m_{Load} is the mass loaded onto the collection substrate in the range investigated, $\min\left(m_{Load_{bn}}\right)$ to $\max\left(m_{Load_{bn}}\right)$, [mg];

s_{Transp} is the standard deviation of transport losses of loaded collection substrates, [mg];

$u_{t\text{-}nR}$ is the non-random measurement error due to transport losses, [-]; and

$u_{t\text{-}R}$ is the random measurement error due to transport losses, [-].

For three simulated sampled concentrations, equal to 10 %, 50 % and 200 % of the relevant limit value, determine the minimum sampling time needed in order that the random uncertainty component due to transport loss is within the requirements stated in EN 13205-1:2014, 5.1, see Formula (5):

$$t_\chi = 1000 \frac{s_{Transp}}{\lambda_\chi Q^0 \chi C_{OEL}} \quad (5)$$

where

C_{OEL} is the relevant limit value, [mg/m^3];

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

s_{Transp} is the standard deviation of transport losses of loaded collection substrates, [mg];

t_x is the minimum sampling time at the concentration equal to χC_{OEL}, [min];

χ takes the values 0,1, 0,5 and 2,0, respectively, for the concentrations corresponding to 10 %,

50 % and 200 %, respectively, of C_{OEL} , [-]; and

λ_{χ} is the requirement for the transport loss (see EN 13205–1:2014, 5.1) at the concentration equal to χC_{OEL} , [-].

5.4 Test Report

5.4.1 General

The test report shall be divided into sections as described.

5.4.2 Testing laboratory details and sponsoring organisation

— Name and address of testing laboratory, personnel carrying out the tests and date of the work;

— name of the organisation sponsoring the test.

5.4.3 Description of candidate sampler and collection substrate

— Sampler name and type (i.e. static or personal, size selection method if present, nominal flow rate);

— sampling times employed for the test;

— aerosol fraction measured;

— type and definition of collection substrate, e.g. filter, foam, greased plate; whether medium is held in a cassette;

— transport containers if used;

— number, age and origin of specimens tested.

5.4.4 Description of test methods and materials

Describe the methods used for the test in detail. The report shall normally include:

— transportation system and package for transport containers;

— description of test aerosol, incl. concentration and ratio of aerosol fraction of interest to total airborne particle concentration;

— details (diagram if necessary) of the system used to generate the test aerosols and load the collection substrates.

5.4.5 Results

Tabulate and plot the initial collected masses and the corresponding transport losses.

Tabulate, or express mathematically, random uncertainty due to transport mass loss of the sampler/collection substrate for the test aerosol used.

For three simulated sampled concentrations, equal to 10 %, 50 % and 200 % of the relevant limit value, state the minimum sampling time, t_x, for which the measurement error due to transport loss is within the requirements stated in EN 13205-1:2014, 5.1.

5.4.6 Summary

Give a summary of the test report, explaining the scope of the tests and the main findings. Describe any practical difficulties the test has highlighted with the routine use of the sampler, especially the transport of dust-laden samples. Describe any restrictions on the transportation of collection substrates that are necessary in order for the requirements stated in EN 13205-1:2014, 5.1 to be met.

6 Handling test for loaded samplers or collection substrates using a shaker

6.1 Principle

The handling test is carried out as a laboratory test to simulate rough handling that aerosol samplers can be subjected to in practical use. Rough handling can result in the movement of collected particles between collection substrate and the internal walls of the sampler or between collection substrate and a special container for transport of the collection substrate to the laboratory. This can be especially important for personal samplers when removed from the wearer, and for all samples being transported from sampling site to laboratory. Turning a sampler with size selective stages upside-down can also cause contamination of fine particle fractions with coarse particles, or vice-versa, depending on the sampler.

This test is applicable to any suitable analytical method. Gravimetric determination (weighing) is used throughout this part of EN 13205 as a surrogate term for any suitable analytical method. If the test described in this clause is to be used with a different analytical method, the procedure needs to be modified accordingly.

6.2 Test procedure

6.2.1 General

This test is relevant to both complete samplers and collection media removed from the samplers and either protected by being shielded with transport lids and/or placed in special containers for transport to a laboratory. If the complete sampler is too large to be tested the part containing the collection medium shall be dismantled from the sampler before testing. Depending on the size of the samplers, the required number of results can be obtained either sequentially or simultaneously.

6.2.2 Test equipment

At least five (but preferably seven) samplers, with collection substrates, shall be used in the test. The samplers need to be exposed to identical concentrations.

Twenty-one (21) collection substrates, plus blanks are required. Divide the collection substrates into three sets of seven substrates.

The apparatus used to simulate handling and transport stresses is either a laboratory shaker table or a vertical shaker. An orbital shaker moves with circular motions in the horizontal plane. EN 143 describes a vertical shaker. The apparatus used shall have a peak-to-peak distance between 19 mm and 25 mm and a frequency of 50/min to 300/min. The weight capacity of the shaker shall be at least 10 kg.

An aerosol chamber/wind tunnel and suitable dust generator to disperse an agglomerate-free test aerosol, such as a rotating table generator or rotating brush generator, are required to load the collection media prior to testing.

An analytical balance reading to 0,01 mg (or better) is required for weighing the collection substrates.

6.2.3 Mounting of the samplers

To simulate potential particle movement during handling, personal samplers shall be mounted on stands on the platform in the orientation that they take during sampling (i.e. samplers pointing downwards when on the body shall be mounted pointing downwards during the test. This test is only applied to personal samplers.

To simulate particle movement during handling of samples from workplace to laboratory, samplers containing dust-laden collection media shall be positioned with their dusty surfaces pointing in the same direction as when they are handled (normally upwards). If the normal mode of handling is to place the dust-laden collection media in special tins or containers, the handling test shall be carried out in this manner. This test applies to both personal and static samplers.

6.2.4 Test aerosol and method of loading collection media

The test aerosol shall be generated from a well-mixed powder composed of equal mass fractions of different grades of aluminium oxide powder:

— for samplers for the inhalable fraction, the grades F1200, F800 and F400;

— for sampler for the thoracic fraction, the grades F1200 and F800; and

— for samplers for the respirable fraction, only the grade F1200.

The powder shall be pre-heated overnight in an oven at 60 °C to drive off any moisture.

Unless the relevant measuring procedure states an upper (and/or lower) mass loading of the collection substrates, the range of masses loaded onto the collection substrates shall approximately correspond to that sampled from concentrations in the range one tenth to twice the occupational exposure limit value of a relevant substance, with one sampling time, *t*, in the range from the minimum to the maximum sampling time according to the measuring procedure and using the nominal flow rate. Determine the three nominal collection substrate mass loads, $m_{0,1}$, $m_{0,5}$ and m_2, respectively, that for the selected sampling time, t, and nominal flow rate, Q^0, corresponds to concentrations equal to 0,1 times, 0,5 times and 2 times the relevant occupational exposure limit. The actual masses loaded shall exceed 90 % of the corresponding nominal value.

6.2.5 Test method

The procedure involves the following steps:

a) condition the collection substrates (including at least three blanks) in a balance room atmosphere until the weight is stable;

b) weigh the collection substrates according to the relevant measuring procedure;

c) clean the samplers before each new sampling period;

d) load collection substrates into the samplers;

e) mount the samplers in the aerosol chamber/wind tunnel, expose them to the test aerosol, for a time and flow rate sufficient to give the required particle mass on the collection substrate;

f) clean the outside of the samplers only;

g) remove the collection substrates;

h) repeat from c) until a subset of seven collection substrates has been obtained per nominal load mass, $m_{0,1}$, $m_{0,5}$ or m_2;

i) condition the collection substrates in a balance room atmosphere until the weight is stable;

j) reweigh the collection media;

k) reload the weighed collection media carefully into the dirty samplers or mount the transport lids onto the collection media and/or place them in special transport containers (depending on how samples are handled);

l) place the samplers or transport containers onto the shaker table or vertical shaker and shake for at least 20 min or 2 000 rotations;

m) remove the collection media, recondition until the weight is stable and reweigh according to the relevant measurement procedure.

ISO 15767 gives recommendations for proper weighing of aerosol collection substrates.

6.3 Calculations

For each of the three sets $(b = 1,2,3)$ of nominal collection substrate mass loads, $m_{0,1}$, $m_{0,5}$ or m_2, calculate the loaded mass on each $(n = 1,2,..,N_{\mathrm{ML_b}})$ collection substrate, before and after the handling test, respectively. Calculate the mass loss due to the handling test for each collection substrate from Formula (6):

$$\Delta m_{\mathrm{Handl}_{bn}} = m_{\mathrm{Load}_{bn}} - m_{\mathrm{Handl}_{bn}} \tag{6}$$

where

$m_{\mathrm{handl}_{bn}}$ is the mass loaded onto collection substrate n of subset b, [mg];

$m_{\mathrm{Handl}_{bn}}$ is the mass remaining on collection substrate n of subset b after the handling test, [mg]; and

$\Delta m_{\mathrm{Handl}_{bn}}$ is the mass loss due to the handling test for collection substrate n of subset b, [mg].

Plot the mass loss versus the initially loaded substrate mass, $m_{\mathrm{Handl}_{bn}}$.

NOTE It is expected that the relative handling losses in many cases will be less than 0,05, except for very small sample masses. However, in the latter circumstances it might be considerably larger than the analytical uncertainty.

For each of the three subsets $(b = 1,2,3)$ of nominal collection substrate mass loads, $m_{0,1}$, $m_{0,5}$ or m_2, calculate the average and standard deviation of the handling losses from Formula (7):

$$\begin{cases} {}^{\mathrm{aver}}\Delta m_{\mathrm{Handl}_b} = \dfrac{1}{N_{\mathrm{ML}_b}} \displaystyle\sum_{n=1}^{N_{\mathrm{ML}_b}} \Delta m_{\mathrm{Handl}_{bn}} \\ s_{\mathrm{Handl}_b}{}^2 = \dfrac{1}{N_{\mathrm{ML}_b} - 1} \displaystyle\sum_{n=1}^{N_{\mathrm{ML}_b}} \left(\Delta m_{\mathrm{Handl}_{bn}} - {}^{\mathrm{aver}}\Delta m_{\mathrm{Handl}_b} \right)^2 \end{cases} \tag{7}$$

where

N_{ML_b} is the number of mass loaded collection substrates in subset *b*;

s_{Handl_b} is the standard deviation of handling losses of loaded collection substrates for subset b, [mg];

$\Delta m_{\mathrm{Handl}_{bn}}$ is the mass loss due to the handling test for loaded collection substrate *n* of subset b, [mg]; and

$^{\mathrm{aver}}\Delta m_{\mathrm{Handl}_b}$ is the average handling losses of loaded collection substrates for subset b, [mg].

Pool the standard deviation of handling losses of loaded collection substrates for all three subsets according to Formula (8):

$$s_{\mathrm{Handl}}{}^2 = \frac{\sum_{n=1}^{N_{\mathrm{ML_b}}} N_{\mathrm{ML}_b} s_{\mathrm{Handl}_b}{}^2}{\sum_{n=1}^{N_{\mathrm{ML_b}}} N_{\mathrm{ML}_b}} \tag{8}$$

The non-random uncertainty due to handling losses, $u_{\mathrm{t\text{-}nR}}$, is set equal to zero. The random uncertainty due to handling losses, $u_{\mathrm{t\text{-}R}}$, is calculated as the standard deviation of the sample mass losses, $\Delta m_{\mathrm{Handl}_{bn}}$ divided by the loaded mass, and is a function over the range of loaded samples, $m_{\mathrm{Load}} \in \left[\min\left(m_{\mathrm{Load}_{bn}}\right) \max\left(m_{\mathrm{Load}_{bn}}\right)\right]$, see Formula (9):

$$\begin{cases} u_{\mathrm{t\text{-}nR}} = 0 \\ u_{\mathrm{t\text{-}R}}\left(m_{\mathrm{Load}}\right) = \dfrac{s_{\mathrm{Handl}}}{m_{\mathrm{Load}}} \end{cases} \tag{9}$$

where

m_{Load} is the mass loaded onto the collection substrate in the range investigated, $\min\left(m_{\mathrm{Load}_{bn}}\right)$ to $\max\left(m_{\mathrm{Load}_{bn}}\right)$, [mg];

s_{Handl} is the standard deviation of handling losses of loaded collection substrates, [mg];

$u_{\mathrm{t\text{-}nR}}$ is the non-random measurement error due to handling losses, [-]; and

$u_{\mathrm{t\text{-}R}}$ is the random measurement error due to handling losses, [-].

For three simulated sampled concentrations, equal to 10 %, 50 % and 200 % of the relevant limit value, determine the minimum sampling time needed according to Formula (10) in order that the random uncertainty component due to handling loss is within the requirements stated in EN 13205-1:2014 5.1.

$$t_\chi = 1000 \frac{s_{\mathrm{Handl}}}{\lambda_\chi Q^0 \chi C_{\mathrm{OEL}}} \tag{10}$$

where

C_{OEL} is the relevant limit value, [mg/m^3];

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

s_{Handl} is the standard deviation of handling losses of loaded collection substrates, [mg];

t_X is the minimum sampling time at the concentration equal to χC_{OEL}, [min];

χ takes the values 0,1, 0,5 and 2,0, respectively, for the concentrations corresponding to 10 %, 50 % and 200 %, respectively, of C_{OEL}, [-]; and

λ_χ is the requirement for the handling loss (see EN 13205–1:2014, 5.1) at the concentration equal to χC_{OEL}, [-].

6.4 Test Report

6.4.1 General

The test report shall be divided into sections as described.

6.4.2 Testing laboratory details and sponsoring organisation

— Name and address of testing laboratory, names of personnel carrying out the tests and date of the work;

— name of the organisation sponsoring the test.

6.4.3 Description of candidate sampler and collection substrate

— Sampler name and type (i.e. static or personal, size selection method if present, nominal flow rate);

— aerosol fraction measured;

— type and definition of collection substrate, e.g. filter, foam, greased plate; whether medium is held in a cassette;

— transport containers if used;

— number, age and origin of specimens tested.

6.4.4 Description of test methods and materials

Describe the apparatus and methods used for test in detail. The report shall normally include:

— specification of the shaker;

— description of test aerosol, incl. concentration and ratio of aerosol fraction of interest to total airborne particle concentration;

— details (diagram if necessary) of the system used to generate the test aerosols and load the collection substrates.

6.4.5 Results

Tabulate and plot the initial collected masses and the corresponding handling losses.

Tabulate, or express mathematically, random uncertainty due to handling mass loss of the sampler/collection substrate for the test aerosol used.

For three simulated sampled concentrations, equal to 10 %, 50 % and 200 % of the relevant limit value, state the minimum sampling time, t_x, for which the measurement error due to handling loss is within the requirements stated in EN 13205-1:2014, 5.1.

6.4.6 Summary

Give a summary of the test report, explaining the scope of the tests and the main findings. Describe any practical difficulties the test has highlighted with the routine use of the sampler, especially the handling of dust-laden samples. Describe any restrictions on the means of transport or handling that are necessary in order for the requirements stated in EN 13205-1:2014, 5.1 to be met.

Bibliography

[1] EN 481, *Workplace atmospheres - Size fraction definitions for measurement of airborne particles*

[2] EN 482, *Workplace exposure - General requirements for the performance of procedures for the measurement of chemical agents*

[3] CEN/TR 13205-3:2014, Workplace exposure — Assessment of sampler performance for measurement of airborne particle concentrations — Part 3: Analysis of sampling efficiency data

[4] 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*

[5] 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*

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