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Workplace air — Determination of metals and metalloids in airborne particulate matter by inductively coupled plasma atomic emission spectrometry —

Part 1:
Sampling

Air des lieux de travail — Détermination des métaux et métalloïdes dans les particules en suspension dans l'air par spectrométrie d'émission atomique avec plasma à couplage inductif —

Partie 1: Prélèvement d'échantillons

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by was prepared by Technical Committee ISO/TC 146, *Air quality*, Subcommittee SC 2, *Workplace atmospheres*.

This third edition cancels and replaces the second edition (ISO 15202-1:2012), which has been technically revised. The main changes compared to the previous edition are as follows:

- definitions that appear in ISO 18158 have been removed from this document, with ISO 18158 being added as a reference (replacing references to EN 1540);
- references to EN 482 have been replaced with ISO 20581, and references to EN 13890 have been replaced with ISO 21832;
- information regarding sampling pumps has been replaced with ISO 13137;
- the text has been editorially updated.

A list of all parts in the ISO 15202 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The health of workers in many industries is at risk through exposure by inhalation of toxic metals and metalloids. Industrial hygienists and other public health professionals need to determine the effectiveness of measures taken to control workers' exposure, and this is generally achieved by taking workplace air measurements. This document has been published in order to make available a method for making valid exposure measurements for a wide range of metals and metalloids in use in industry. It will be of benefit to: agencies concerned with health and safety at work; industrial hygienists and other public health professionals; analytical laboratories; industrial users of metals and metalloids and their workers, etc.

This document specifies a generic sampling method for subsequent determination of the mass concentration of metals and metalloids in workplace air using inductively coupled plasma atomic emission spectrometry (ICP-AES). Samples obtained using the method described herein can also be subsequently analysed by other instrumental methods, such as atomic absorption spectrometry (AAS) or inductively coupled plasma mass spectrometry (ICP-MS).

This document gives details of relevant International, European and National Standards which specify characteristics, performance requirements and test methods relating to sampling equipment. It augments guidance provided elsewhere on assessment strategy and measurement strategy and specifies a method for collecting samples of airborne particulate matter for subsequent chemical analysis.

ISO 15202-2 describes a number of procedures for preparing sample solutions for analysis by ICP-AES.

ISO 15202-3 gives requirements and test methods for analysis of sample solutions by ICP-AES.

It has been assumed in the drafting of this document the execution of its provisions, and the interpretation of the results obtained, is entrusted to appropriately qualified and experienced people.

Workplace air — Determination of metals and metalloids in airborne particulate matter by inductively coupled plasma atomic emission spectrometry —

Part 1:
Sampling

1 Scope

This document specifies a method for collecting samples of airborne particulate matter for subsequent determination of metals and metalloids using inductively coupled plasma — atomic emission spectrometry (ICP-AES). Samples obtained using the method described herein can also be subsequently analysed for elemental composition by other instrumental methods, such as atomic absorption spectrometry (AAS) or inductively coupled plasma mass spectrometry (ICP-MS).

The method is not applicable to the sampling of mercury, which is present in air in the vapour phase at ambient temperatures; inorganic compounds of metals and metalloids that are permanent gases, e.g. arsine (AsH_3); or inorganic compounds of metals and metalloids that are present in the vapour phase at ambient temperatures, e.g. arsenic trioxide (As_2O_3).

NOTE Although the method does not describe a means of collecting inorganic compounds of metals and metalloids that are present in the vapour phase, in most instances this is relatively easily to achieve by using a back-up filter which has been pre-treated to trap the compound(s) of interest, e.g. a back-up paper pad impregnated with sodium carbonate is suitable for collecting arsenic trioxide (see ISO 11041[2]).

The method is applicable to personal sampling of the inhalable, thoracic or respirable fraction of airborne particles, as defined in ISO 7708, and to static sampling.

This document excludes sampling of surfaces or bulk materials. Guidance on collection of samples for surfaces may be found in ASTM D7659[7].

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 7708:1995, *Air quality — Particle size fraction definitions for health-related sampling*

ISO 15202-2, *Workplace air — Determination of metals and metalloids in airborne particulate matter by inductively coupled plasma atomic emission spectrometry — Part 2: Sample preparation*

ISO 15202-3, *Workplace air — Determination of metals and metalloids in airborne particulate matter by inductively coupled plasma atomic emission spectrometry — Part 3: Analysis*

ISO 18158, *Workplace air — Terminology*

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

ISO 21832, *Workplace air — Metals and metalloids in airborne particles — Requirements for evaluation of measuring procedures*

ISO 20581, *Workplace air — General requirements for the performance of procedures for the measurement of chemical agents*

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

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 18158 apply.

ISO and IEC maintain terminological databases for use in standardization at the addresses:

— ISO Online browsing platform: available at http://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

4 Principle

4.1 Airborne particles containing metals and metalloids are collected by drawing a measured volume of air through a collection substrate (e.g. filter or foam) mounted in a sampler designed to collect an appropriate size fraction of airborne particles (see 8.1.1.1).

4.2 The sample and collection substrate are then treated to dissolve the metals and metalloids of interest using one or more of the sample preparation methods prescribed in ISO 15202-2.

4.3 The resultant solution is subsequently analysed for the metals and metalloids of interest using inductively coupled plasma-atomic emission spectrometry, as described in ISO 15202-3.

5 Requirement

The measuring procedure as a whole shall be as covered by this document, ISO 15202-2 and ISO 15202-3, and should consider any relevant International, European or National Standard that specifies performance requirements for procedures for measuring chemical agents in workplace air (e.g. ISO 20581, ISO 21832 and EN 13890).

6 Sampling equipment

6.1 Samplers

6.1.1 Inhalable samplers, designed to collect the inhalable fraction of airborne particles, complying with the provisions of EN 13205-1, for use when the limit value(s) for metals and metalloids of interest apply to the inhalable fraction of airborne particles.

NOTE 1 In general, personal samplers for collection of the inhalable fraction of airborne particles do not exhibit the same size selective characteristics if used for static sampling.

NOTE 2 Some inhalable samplers are designed to collect the inhalable fraction of airborne particles on the collection substrate, and any particulate matter deposited on the internal surfaces of the sampler is not of interest. Other inhalable samplers are designed such that airborne particles which pass through the entry orifice(s) match the inhalable convention, in which case particulate matter deposited on the internal surfaces of the sampler does form part of the sample. For many samplers, particulate matter deposited on the internal surfaces of the sampler or insert is included as part of the sample. For more information on the issue of internal wall deposits, see Annex A.

6.1.2 Thoracic samplers, designed to collect the thoracic fraction of airborne particles, complying with the provisions of EN 13205-1, for use when the limit values for the metals and metalloids of interest apply to the thoracic fraction of airborne particles.

6.1.3 Respirable samplers, designed to collect the respirable fraction of airborne particles, complying with the provisions of EN 13205-1, for use when the limit values for the metals and metalloids of interest apply to the respirable fraction of airborne particles.

NOTE For many samplers, internal wall deposits are included as part of the sample.

6.1.4 Multi-fraction samplers, designed to collect airborne particles and fractionate them so as to enable two or more particle size fractions to be separately determined, complying with the provisions of EN 13205-1, for use as an alternative to collecting multiple samples when limit values for the metals and metalloids of interest apply to more than one particle size fraction.

Multi-fraction samplers sometimes use polyurethane foam to collect larger particles. In such cases, the foam should be compatible with the selected sample preparation method (see ISO 15202-2) and should have the same low metal content specified for filters in 6.2.

6.2 Filters

The filters shall be of a diameter suitable for use with the samplers (6.1), have a collection efficiency of not less than 99,5 % for particles with a 0,3 µm diffusion diameter (see ISO 7708:1995 2.2), have a very low metal content (typically less than 0,1 µg of each metal or metalloid of interest per filter) and be compatible with the selected sample preparation method (see ISO 15202-2).

NOTE 1 See Annex B for guidance on filter selection.

NOTE 2 Besides filters, other types of collection substrates can be suitable, such as foams.

NOTE 3 Commercial products are available that combine a filter and an associated 'shell' that are heat-sealed together to form a sampler insert that primarily collects airborne particles on the filter but also collects on the shell particles that would otherwise be deposited on the internal walls of the sampler.

6.3 Sampling pumps

The sampling pumps shall conform with the requirements of ISO 13137 and be capable of maintaining the selected flow rate (between 1 l/min and 5 l/min for personal sampling pumps, and between 5 l/min and 400 l/min for high-volume sampling pumps) to within ±5 % of the nominal value throughout the sampling period (see 8.1.2). For personal sampling, the pumps shall be capable of being worn by the worker without impeding normal work activity.

6.4 Flowmeter

The flowmeter shall be portable and have an accuracy that is sufficient to enable the volumetric flow rate (see 8.1.1.2) to be measured to within ±5 %.

The calibration of the flowmeter shall be checked against a primary standard, i.e. a flowmeter whose accuracy is traceable to national standards. If appropriate (see 8.1.3), record the atmospheric temperature and pressure at which the calibration of the flowmeter was checked.

It is advisable that the flowmeter used is capable of measuring the volumetric flow rate to within ±2 % or better.

6.5 Ancillary equipment

6.5.1 Flexible tubing, of a diameter suitable for making a leakproof connection from the samplers (6.1) to the sampling pumps (6.3).

6.5.2 Belts or harnesses, to which the sampling pumps can conveniently be fixed for personal sampling (except where the sampling pumps are small enough to fit in workers' pockets).

6.5.3 Flat-tipped forceps, non-metallic (e.g. plastic or plastic-coated) for loading and unloading collection substrates from samplers or from substrate transport cassettes.

6.5.4 Collection substrate transport cassettes or similar, if required (see 8.5.1), in which to transport samples to the laboratory.

6.5.5 Thermometer, 0 °C to 50 °C, graduated in divisions of 1 °C or less, for measurement of atmospheric temperature, if required (see 8.1.3).

6.5.6 Barometer, suitable for measurement of atmospheric pressure, if required (see 8.1.3).

7 Occupational exposure assessment

7.1 General

The scope of this document pertains to the taking of personal and static samples. Refer to relevant International, European or National Standards (e.g. EN 689[3], ASTM E 1370[5]) for guidance on how to develop an appropriate assessment strategy and for general guidance on measurement strategy.

7.2 Personal sampling

Exposure of workers to metals and metalloids shall normally be determined by personal sampling, since the concentration of metals and metalloids in the breathing zone is usually higher than their background levels in the workplace.

7.3 Static sampling

Static sampling may be carried out, if appropriate, to assess the exposure of workers in a situation where personal sampling is not possible (see Note in 8.1.2.1 for an example of such a situation); to characterize the background levels of metals and metalloids in the workplace in order to give an indication of the efficiency of ventilation; or to provide information on the location and intensity of an emission source.

7.4 Selection of measurement conditions and measurement pattern

7.4.1 General

7.4.1.1 Sampling shall be carried out in such a way as to cause the least possible interference with the worker and the normal performance of the job, and to provide samples that are representative of normal working conditions and that are compatible with the analytical method (see ISO 15202-2 and ISO 15202-3).

7.4.1.2 The pattern of sampling shall take into consideration practical issues, such as the nature of the measurement task and the frequency and duration of particular work activities.

7.4.2 Screening measurements of variation of concentration in time/and or space

Screening measurements of variation of concentration in time and/or space may be performed to provide information on the likely pattern of concentration of chemical agents. They can be used to identify locations and periods of elevated exposure and to set the duration and frequency of sampling for measurements for comparison with limit values. Emission sources can be located and the effectiveness of ventilation or other technical measures can be estimated (see ISO 20581).

7.4.3 Screening measurements of time-weighted average concentration and reasonable worst-case measurements

7.4.3.1 Screening measurements of time-weighted average concentration may be performed to obtain relatively crude information on the exposure level in order to decide whether an exposure problem exists at all, and, if so, to appraise its possible seriousness. They can also be used to determine if the exposure is well below or well above the limit value (see ISO 20581).

7.4.3.2 Screening measurements of time-weighted average concentration are typically carried out in the initial stages of a survey to assess the effectiveness of control measures. Sampling may be carried out during representative work episodes to obtain clear information about the level and pattern of exposure, or reasonable worst-case measurements may be made.

NOTE Screening measurements of time-weighted average concentration made to clearly identify work episodes during which highest exposure occurs are typically referred to as "reasonable worst-case measurements" (see EN 689[3]).

7.4.4 Measurements near an emission source

Measurements may be performed near an emission source to provide information on the location and intensity of the source. In association with other information, they can allow the elimination of a suspected source as a significant contributor to exposure (see ISO 20581).

7.4.5 Measurements for comparison with limit values and periodic measurements

7.4.5.1 Measurements for comparison with limit values

7.4.5.1.1 Measurements for comparison with limit values are performed to provide accurate and reliable information on, or allow the prediction of, the time-weighted average concentration of a specific chemical agent in the air that could be inhaled (see ISO 20581).

7.4.5.1.2 For metals and metalloids with short-term limit values, the sampling time shall be as close as possible to the reference period, which is typically 15 min, but can be anything between 5 min and 30 min.

7.4.5.1.3 For metals and metalloids with long-term limit values, samples shall be collected for the entire working period, if possible, or during a number of representative work episodes (see 8.1.2.1 for the minimum sampling time).

NOTE The best estimate of long-term exposure is obtained by taking samples for the entire working period, but this is often not practicable (e.g. because of the possibility of overloading the collection substrate).

7.4.5.2 Periodic measurements

Periodic measurements are performed to determine whether exposure conditions have changed since measurements for comparison with limit values were made, or whether control measures remain effective (see ISO 20581).

8 Sampling method

8.1 Preliminary considerations

8.1.1 Selection and use of samplers

8.1.1.1 Select samplers (6.1) designed to collect the inhalable, thoracic or respirable fraction of airborne particles, as defined in ISO 7708, according to which particle size fraction is applicable to the limit values for the metals and metalloids of interest. If more than one particle size fraction is of interest, collect multiple samples or use a multi-fraction sampler.

Limit values for individual metals and metalloids can apply to either the inhalable, thoracic or respirable fraction of airborne particles, or combination. The samplers used should therefore be selected to meet the requirements of the governing jurisdiction.

If possible, the samplers selected should be manufactured from conducting material, since samplers manufactured in non-conducting material have electrostatic properties that can influence representative sampling.

8.1.1.2 Use the samplers at their design flow rate, and in accordance with the instructions provided by the manufacturer, so that they collect the intended fraction(s) of airborne particles. See Reference [4] for further guidance.

8.1.2 Sampling period

8.1.2.1 Select a sampling period that is appropriate for the measurement task (see 7.4), but ensure that it is long enough to enable the metals and metalloids of interest to be determined with acceptable uncertainty at levels of industrial hygiene significance. For example, consider the metal or metalloid of interest with the lowest limit value, and estimate the minimum sampling time required to ensure that the amount collected is above the lower limit of the working range of the analytical method when the metal or metalloid concerned is present in the test atmosphere at an appropriate multiple of its limit value, using the following Formula (1):

$$t_{\text{min}} = \frac{m_{\text{min}}}{q_V \times F \times \rho_{\text{LV}}} \qquad (1)$$

where

t_{min}	is the minimum sampling time, in minutes;
m_{min}	is the lower limit of the analytical range, in micrograms, for the metal or metalloid interest with the lowest limit value;
q_V	is the design flow rate of the sampler, in litres per minute;
F	is an appropriate multiple of the limit value (e.g. 0,1 times for an 8 h time-weighted average limit value or 0,5 times for a short-term limit value);
ρ_{LV}	is the limit value, in milligrams per cubic metre, for the metal or metalloid of interest with the lowest limit value.

NOTE If the minimum sampling time is too long, consider the possibility of using a sampler designed to be used at a higher flow rate or of using an alternative more sensitive analytical technique (e.g. ICP-MS).

8.1.2.2 When high concentrations of airborne particles are anticipated, select a sampling period that is not so long as to risk overloading the collection substrate with particulate matter.

8.1.3 Temperature and pressure effects

Refer to the manufacturer's instructions to determine if the indicated volumetric flow rate of the flowmeter (6.4) is dependent upon temperature and pressure. Consider whether the difference between the atmospheric temperature and pressure at the time of calibration of the flowmeter and during sampling is likely to be great enough to justify making a correction to take this into account, e.g. if the error could be greater than ±5 %. If a correction is necessary, measure and record the atmospheric temperature and pressure at which the calibration of the flowmeter was checked (see 6.4) and measure and record the atmospheric temperature and pressure at the start and at the end of the sampling period (see 8.4.1 and 8.4.2).

NOTE An example of temperature and pressure correction for the indicated volumetric flow rate is given in Annex C for a constant pressure drop, variable area flowmeter.

8.1.4 Handling of collection substrates

To minimize the risk of damage or contamination, handle collection substrates carefully (e.g. filters using flat-tipped forceps), in a clean area, where the concentration of airborne particles is as low as possible.

8.2 Preparation for sampling

8.2.1 Cleaning of samplers

Unless disposable filter cassettes are used, clean the samplers (6.1) before use. Disassemble the samplers, soak in detergent solution, rinse thoroughly with water, wipe with absorptive tissue and allow to dry before reassembly. Alternatively, use a laboratory washing machine to clean the samplers.

8.2.2 Loading the samplers with collection substrates

Load clean samplers (see 8.2.1) with suitable collection substrates (e.g. filters described in 6.2), label each sampler so that it can be uniquely identified, and seal with its protective cover or plug to prevent contamination.

NOTE Alternatively, commercially available pre-loaded filter cassettes can be used.

8.2.3 Setting the volumetric flow rate

Perform the following in a clean area, where the concentration of airborne particles is low.

Connect each loaded sampler (see 8.2.2) to a sampling pump (6.3) using flexible tubing (6.5.1), ensuring that no leaks can occur. Remove the protective cover or plug from each sampler, switch on the sampling pump, attach the flowmeter (6.4) to the sampler so that it measures the flow through the sampler inlet orifice(s), and set the required volumetric flow rate (see 8.1.1.2). Switch off the sampling pump and seal the sampler with its protective cover or plug to prevent contamination during transport to the sampling position.

If necessary, allow the sampling pump operating conditions to stabilize before setting the volumetric flow rate.

NOTE For additional information, see ISO 13137.

8.2.4 Field blanks

Select one unused loaded sampler or cassette from each batch of ten prepared as blanks, subject to a minimum of three. Treat these in the same manner as those used for sampling with respect to storage and transport to and from the sampling position, but do not draw air through the collection substrate.

8.3 Sampling position

8.3.1 Personal sampling

8.3.1.1 The sampler shall be positioned in the worker's breathing zone, as close to the mouth and nose as is reasonably practicable, e.g. fastened to the worker's lapel. Attach the sampling pump to the worker in a manner that causes minimum inconvenience, e.g. to a belt (6.5.2) around the waist, or place it in a convenient pocket.

8.3.1.2 Give consideration to whether the nature of the process is likely to result in a significant difference between the actual exposure of the worker and the concentration of metals and metalloids measured by a sampler mounted on the lapel. If this is the case, make special arrangements to mount the sampler as close as possible to the worker's nose and mouth.

NOTE Examples of the need to make special arrangements to mount the sampler as close as possible to the worker's nose and mouth are:

- in welding and allied processes, when the use of a welder's face shield provides a degree of protection by physically deflecting the plume of welding fume away from the breathing zone, and sampling on the lapel could overestimate exposure (see ISO 10882-1[1]); and
- in soldering, when sampling on the lapel could significantly underestimate exposure because the characteristic plume of solder fume rises up past the nose and mouth.

8.3.2 Static sampling

8.3.2.1 If static sampling is carried out to assess the exposure of a worker in a situation where personal sampling is not possible (e.g. due to the need to sample at a volumetric flow rate higher than the design flow rate of available personal samplers), the sampling position shall be in the immediate vicinity of the worker and at breathing height. If in doubt, the sampling position shall be taken as the point where the risk of exposure is considered to be greatest.

8.3.2.2 If static sampling is carried out to characterize the background level of metals and metalloids in the workplace, select a sampling position that is sufficiently remote from the work processes, such that results will not be directly affected by airborne particles from emission sources.

8.4 Collection of samples

8.4.1 When ready to begin sampling, remove the protective cover or plug from the sampler and switch on the sampling pump. Record the time and volumetric flow rate at the start of the sampling period. If the sampling pump is fitted with an integral timer, check that this is reset to zero. If appropriate (see 8.1.3), measure the atmospheric temperature and pressure at the start of the sampling period using the thermometer (6.5.5) and barometer (6.5.6), and record the measured values.

NOTE If the temperature or pressure at the sampling position is different from that where the volumetric flow rate was set (see 8.2.3), the volumetric flow rate could change and it might need to be re-adjusted before sampling.

8.4.2 At the end of the sampling period (see 8.1.2), record the time and calculate the duration of the sampling period. Check the malfunction indicator and/or the reading on the integral timer, if fitted, and consider the sample to be invalid if there is evidence that the sampling pump was not operating properly throughout the sampling period. Measure the volumetric flow rate at the end of the sampling period using the flowmeter (6.4), and record the measured value. If appropriate (see 8.1.3), measure the atmospheric temperature and pressure at the end of the sampling period using the thermometer (6.5.5) and barometer (6.5.6), and record the measured values.

8.4.3 Carefully record the sample identity and all relevant sampling data (see 9.1). Calculate the mean volumetric flow rate by averaging the volumetric flow rates at the start and at the end of the sampling period and, if appropriate (see 8.1.3), calculate the mean atmospheric temperature and pressure. Calculate the volume of air sampled, in litres, at atmospheric temperature and pressure, by multiplying the mean flow rate in litres per minute by the duration of the sampling period in minutes. The mean volumetric flow rate shall comply with the requirements of ISO 13137.

8.5 Transportation

8.5.1 For samplers that collect airborne particles on the collection substrate (see Note 2 in 6.1.1), remove the substrate from each sampler and place it in a labelled transport container (e.g. filter in a transport cassette described in 6.5.4). Take particular care to prevent the collected sample from becoming dislodged from heavily loaded collection substrates. Alternatively, transport samples to the laboratory in the samplers in which they were collected. The sampler shall be sent to the laboratory when sampler wall deposits are to be evaluated as part of the sample.

8.5.2 For samplers that have an internal filter cassette (see Note 2 in 6.1.1), remove the filter cassette from each sampler and fasten with its lid or transport clip.

8.5.3 For samplers of the disposable cassette type, transport samples (collected on filters or by using inserts) to the laboratory in the samplers in which they were collected.

8.5.4 Transport the samples (8.5.1 to 8.5.3) to the laboratory in a container which has been designed to prevent damage to the samples in transit and which has been labelled to ensure proper handling.

8.5.5 Ensure that the documentation which accompanies the samples is suitable for a “chain of custody” to be established (see, for example, ASTM D 4840[6]).

9 Documentation

9.1 Sampling information

The following information shall be recorded by the person carrying out the sampling. It shall be passed to the person responsible for completing the test report, if this is someone different:

a) a statement to indicate the confidentiality of the information supplied, if appropriate;

b) a complete identification of the air sample, including the date of sampling, the place of sampling, the type of sample (personal or static), either the identity of the individual whose breathing zone was sampled (or other personal identifier) or the location at which the general occupational environment was sampled (for a static sample), a brief description of the work activities that were carried out during the sampling period, and a unique sample identification code;

c) the make, type, lot number and diameter of collection substrate used;

d) the make and type of sampler used, including information about the target size fraction of airborne particles that the sampler is designed to collect;

e) the make and type of sampling pump used, and its identification;

f) the make and type of flowmeter used, the primary standard against which the calibration of the flowmeter was checked, the range of flow rates over which the calibration of the flowmeter was checked, and the atmospheric temperature and pressure at which the calibration of the flowmeter was checked, if appropriate (see 8.1.3);

g) the time at the start and at the end of the sampling period, and the duration of the sampling period in minutes;

h) the pre-and post-sampling flowrate measurements, and the mean flow rate during the sampling period, in litres per minute;

i) the mean atmospheric temperature and pressure during the sampling period, if appropriate (see 8.1.3);

j) the volume of air sampled, in litres, at ambient conditions;

k) the name of the person who collected the sample.

9.2 Information to accompany the request for analytical services

The following information shall be supplied to the laboratory analysing the sample(s):

a) the unique sample identification code(s);

b) the type(s) of collection substrate or sampler insert used;

c) a list(s) of the metals to be determined and the associated data quality objectives;

d) details of the person to whom the results shall be returned;

e) any special requirements (e.g. quality control protocols to be followed).

Annex A
(informative)

Sampler wall deposits

A.1 General

This annex provides information on the necessity for accounting for deposits of particulate matter on the interior walls of a transport cassette or sampler. Information on the methods for accounting for deposits of particulate matter on the interior walls can be found in ISO 15202-2.

A.2 Samplers

Samplers for aerosols typically consist of a filter supported in a holder, though other collection substrates are also used, e.g. impaction plates and foams. The entire device is considered to be an aerosol sampler. The sampling efficiency of an aerosol sampler is considered to be the air concentration calculated from the particles collected by the sampler compared to their concentration in undisturbed air. All aerosol samplers exhibit a decrease in sampling efficiency with increasing particulate aerodynamic diameter. Size-selective samplers are designed for a specific sampling efficiency over a range of aerodynamic diameters, known as a sampling convention (see ISO 7708), and the sampling efficiency of the sampler is considered with reference to the relevant sampling convention. In some sampler designs, e.g. cyclones, there is an internal separator to achieve the required size selection.

A.3 Collection efficiency

The collection efficiency of an aerosol sampler has four components:

- the aspiration efficiency;
- the transfer efficiency within the sampler (either from sampler inlet to the collection substrate or, if an internal separator is present, both from the sampler inlet to the internal separator and from the internal separator to the collection substrate);
- the penetration efficiency (through the internal separator, if present); and
- the capture efficiency of the collection substrate (e.g. filtration efficiency, when the collection substrate is a filter).

For any given sampler design, the various components depend on the particle aerodynamic size and air flow rate through the sampler. The aspiration efficiency also depends on wind speed and direction, while the sampler's angle to the vertical influences both aspiration and transport efficiency. Part of the sample will deposit on internal surfaces of the sampler as a result of losses during passage within the sampler. In addition, if the sampler is transported after sampling, particles deposited on the substrate can become dislodged and add to deposits already on the internal surfaces of the sampler (although this is likely of lesser importance, except when the collection substrate is overloaded with sample). If the design specification for the sampler is to include all aspirated particles, these losses need to be taken into account. Table A.1 provides examples of median values of deposits on the walls for two commercially available samplers in common use, taken from data in References [8], [9], [10], [11] and [12]. No pattern can be discerned from these data that would allow the use of correction factors.

For some samplers, the sample deposited on the collection substrate is considered to be the entire sample, i.e. wall deposits are not considered to be part of the sample. For other samplers, it is recommended that the wall deposits are evaluated[13]. Other relevant information regarding particle deposits on the interior walls of sampler and particle losses during the transportation of samples is available in [14], [15] and [16].

A.4 Contribution to the uncertainty budget

Where an air sampling and analytical method includes a specific procedure for recovering and analysing wall deposits, this needs to be taken into account when estimating the expanded uncertainty of the method.

Table A.1 — Median wall deposits for closed-face cassette (CFC) and Institute of Occupational Medicine (IOM) samplers

Industry	Analyte	CFC samplers		IOM samplers	
		Median wall deposit (%)	*n*	Median wall deposit (%)	*n*
Copper smelter	Cu	21	18	16	17
Lead ore mill	Pb	19	9	19	8
Solder manufacture	Pb	29	30		
Solder manufacture	Pb	45	50		
Solder manufacture	Sn	56	47		
Battery production	Pb	28	16	8	11
Welding	Cr (VI)	5	10		
Welding	Al			3	18
Plating	Cr (VI)	12	12		
Paint spray	Cr (VI)	7	29		
Foundry	Zn	53	9		
Zinc plating	Zn	27	18		
Cast iron foundry	Fe	22	18	8	18
Grey iron foundry	Fe	24	18	5	18
Bronze foundry	Cu, Pb, Sn, Zn	19, 13, 0, 15	6	0, 0, 0, 3	6
Cuproberyllium foundry	Cu, Be	31, 12	4		

Annex B
(informative)

Guidance on filter selection

NOTE The following guidance is intended to help the user choose the most suitable filter or sampler insert for a particular application. It is not an exhaustive treatise on the subject, and covers only the basics of those matters that merit consideration. In many instances, similar considerations apply to the selection of other sampling substrates, such as polyurethane foams.

B.1 Collection efficiency

B.1.1 Most filters that are typically used for sampling airborne particulate matter have the required collection efficiency (see 6.2) for sampling the respirable, thoracic and the inhalable fractions of airborne particles. Such filters include depth filters (e.g. glass or quartz fibre filters) and membrane filters [e.g. mixed cellulose ester membrane filters and membrane filters made from polymers such as polyvinyl chloride (PVC) or polytetrafluoroethylene (PTFE)]. Results of the collection efficiencies of commonly used membrane air sampling filters for respirable size-selective sampling were reported in Reference [17].

B.1.2 Cellulose (paper) filters can have a collection efficiency below 99 %, and are generally unsuitable for sampling airborne particles. However, they are sometimes treated with a reagent, e.g. sodium carbonate, and used as a secondary medium to collect inorganic gases or vapours, e.g. arsenic trioxide.

B.1.3 Certain processes carried out at elevated temperatures can produce ultrafine airborne particles condensed from the vapour phase, known as fume. Filters used to sample airborne particulate matter can have a reduced collection efficiency for these very small particles, which are significantly less than 1 µm in diameter. However, the particles usually agglomerate soon after formation to produce larger particles that are efficiently collected. In general, filters that have a collection efficiency that meets the specification given in 6.2 are therefore suitable for sampling fume.

B.2 Dust-loading capacity

B.2.1 Membrane filters are manufactured from a variety of polymeric materials by a number of different processes. In each case, the result is a thin, flexible disc of microporous material. Retention of particles takes place on the surface of membrane filters, which results in them having a relatively low dust-loading capacity in comparison with depth filters. If an excessive amount of dust is collected on a membrane filter, this can result in blockage of the pores, and failure of the sampling pump. In addition, sample can be lost from the filter during handling or in transport. Sampling times should therefore be kept reasonably short when sampling with membrane filters in a dusty environment, or depth filters should be used.

B.2.2 Depth filters consist of fibres that have been pressed together to form an irregular three-dimensional mesh. Particles are not only retained at the surface, but also within the structure of the filter, in its depths. This gives them a significantly higher dust loading capacity than membrane filters. In this respect, depth filters are a better choice than membrane filters when sampling for long periods in a dusty environment. However, depth filters tend to have a higher metal content than membrane filters, particularly in the case of certain metals, and this also needs to be considered when selecting the filter to be used.

B.2.3 Sampler inserts (see 6.2, Note 3) consisting of plastic material with a filter attached usually have a higher dust load capacity than in cases B.2.1 and B.2.2 above.