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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