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Indoor air —

Part 37:
Measurement of $PM_{2,5}$ mass concentration

Air intérieur —

Partie 37: Mesure de la concentration massique en $PM_{2,5}$

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Foreword

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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).

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For an explanation on 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 the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 146, *Air quality*, Subcommittee SC 6, *Indoor air.*

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.

A list of all parts in the ISO 16000 series can be found on the ISO website.

Introduction

Airborne particulate matter (colloquially known as “fine dust”) plays a role not only outdoors, but is also significant in terms of hygiene, especially indoors. People in industrialized countries spend most of the day indoors. Either particles are transported into indoor air from outdoor environments or the particles directly result from indoor sources, such as smoking, residential wood burning and cooking.

$PM_{2,5}$ concentration and composition in indoor environments strongly depend on parameters such as the room size, relative humidity, air exchange rate, airflow conditions and sink effects on surfaces (e.g. walls, ceilings, floor coverings, furnishings). In addition, particles already sedimented are temporarily resuspended to the air through various activities and can be inhaled. All this can result in highly variable levels of indoor $PM_{2,5}$ pollution that are not easily ascertained or assessed in terms of their impacts on health.

This document describes the general strategies for the measurement of indoor $PM_{2,5}$ concentration.

This document was prepared in response to the need for improved comparability of methods for particle measurement.

Indoor air —

Part 37:
Measurement of $PM_{2,5}$ mass concentration

1 Scope

This document specifies the measurement methods and strategies for determining the $PM_{2,5}$ mass concentrations of suspended particulate matter (PM) in indoor air. It can also be used for determining PM_{10} mass concentration.

The reference method principle consists of collecting $PM_{2,5}$ on a filter after separation of the particles by an impaction head and weighing them by means of a balance.

Measurement procedure and main requirements are similar to the conditions specified in EN 12341.

This document also specifies procedures for operating appropriate supplementary high time resolution instruments, which can be used to highlight peak emission, room investigation and as part of the quality control of the reference method.

Quality assurance, determination of the measurement uncertainty and minimal reporting information are also part of this document.

The lower range of application of this document is 2 µg/m^3 of $PM_{2,5}$ (i.e. the limit of detection of the standard measurement method expressed as its uncertainty).

This document does not cover the determination of bioaerosols or the chemical characterization of particles. For the measurement and assessment of dust composition, see the relevant technical rules in the International Standards in the ISO 16000 series.

This document does not cover passenger compartments of vehicles and public transport systems.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

EN 12341, *Ambient air — Standard gravimetric measurement method for the determination of the* PM_{10} *or* $PM_{2,5}$ *mass concentration of suspensed particulate matter*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

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

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

3.1
aerodynamic diameter
diameter of a sphere of density 1 g cm^{-3} and the same setting velocity in still air as the particle of interest under prevailing conditions of temperature, pressure and relative humidity

Note 1 to entry: The aerodynamic diameter is calculated using the formula:

$$D_a = D_p \sqrt{\frac{1}{\chi}} \sqrt{\frac{\rho_p}{\rho_0}}$$

where

- D_a is the aerodynamic diameter;
- D_p is the particle diameter;
- ρ_p is the density of the particle;
- ρ_0 is the standard density;
- χ is the form factor.

Note 2 to entry: The form factor describes by how much the resisting force of an irregular shaped particle is greater than that of a sphere with the same volume[10].

Note 3 to entry: The aerodynamic diameter determines the sedimentation and the separation properties of particles in impactors. It is also of particular importance for penetrative behaviour and the retention of particles in the human body.

Note 4 to entry: Various definitions are used for the particle diameter, depending on the measurement method. These different diameters are only indirectly comparable since different particle properties are being measured, e.g. geometric diameter, diameter according to dielectric mobility, diameter according to light scattering properties.

[SOURCE: ISO 7708:1995, 2.2, modified — "particle" has been removed from the term, the definition has been reworded, and the original Note 1 to entry has been replaced by Notes 1 to 4 to entry.]

3.3
mass concentration
c
ratio of the mass *m* of the measured component and the gas volume *V*, as shown by:

$$c = \frac{m}{V}$$

[SOURCE: EN 15259:2007, 3.26]

3.4
particle
small discrete mass or solid or liquid matter

[SOURCE: ISO 29464:2017, 3.2.111]

3.5
PM_x
particulate matter suspended in air which is small enough to pass through a size-selective inlet with a 50 % efficiency cut-off at x µm aerodynamic diameter

[SOURCE: EN 12341:2014, 3.1.14]

3.6
cut-off diameter
aerodynamic diameter at which the impactor stage has a separation efficiency of 50 %

[SOURCE: ISO 23210:2009, 3.1.2, modified — The definition has been changed from "where the separation efficiency of the impactor stage is 50 %".]

3.7
calibration
operation which, under specified conditions, in a first step, establishes a relation between the quantity values with measurement uncertainties provided by measurement standards and corresponding indications with associated measurement uncertainties and, in a second step, uses this information to establish a relation for obtaining a measurement result from an indication

[SOURCE: JCGM 200:2012, 2.39, modified — The notes have been removed.]

3.8
uncertainty
<of measurement>parameter, associated with the result of a measurement, that characterizes the dispersion of the values that could reasonably be attributed to the measurand

[SOURCE: JCGM 100:2008, 2.2.3, modified — The notes have been removed.]

3.13
parallel measurement
measurement from a measuring system that takes samples from the same air over the same time period

3.14
reference method
RM
measurement method(ology) which, by convention, gives the accepted reference value of the measurement

4 Abbreviated terms

For the purposes of this document, the following abbreviated terms apply.

JCGM Joint Committee for Guides in Metrology

PM particulate matter

QA quality assurance

QC quality control

5 Measurement strategy for determing $PM_{2,5}$ indoors

5.1 Location and number of sampling points

The measurement usually takes place in the centre of the room at approximately 1,5 m height (see ISO 16000-1 and ISO 16000-34).

As a minimum, one measurement per investigated room should be performed. If stable conditions cannot be guaranteed for all points in the same room, additional locations should be investigated.

The sampling volume extracted per hour shall not exceed 10 % of the hourly volume of room air exchanged. If this is unknown, the sampling volume extracted per hour shall not exceed 10 % of the room's volume.

The indoor area is usually a quieter space compared to outdoors. Additional isolation of the sampling system or relocating the pump outside the room should be considered to limit noise impact.

5.2 Measurement strategy for source attribution

The indoor sources of PM are diverse. ISO 16000-34 describes the necessary procedure for assigning and evaluating individual indoor sources. The number and place of the sampling points are also specified in this document, taking into account the type of room and expected activity.

In order to classify the relevance of specific sources, indoor measurements under different conditions (examples are given in Annex A) may be necessary. Furthermore, three different operational states are defined.

a) Resting state without activity: This state is characterized by the absence of users and user activities and by switching off all fixed equipment (e.g. ventilation system, gas heating, refrigerators, servers).

b) Resting state with equipment activity: This state is characterized the absence of users and user activities, but with operation of all fixed and/or constantly operated equipment.

c) Active user state: This state is characterized by usage activity of the relevant persons and by the operation of all fixed and/or constantly operated equipment.

5.3 Indoor air condition

Indoor air conditions (e.g. temperature, pressure, humidity) have a direct effect on indoor air measurements. These parameters shall be measured in the investigated room and specified in the report.

Outdoor conditions (e.g. rain, strong wind) can strongly affect the result. Thus, parallel outdoor measurements of $PM_{2,5}$ are always recommended.

The user's normal ventilation arrangements should be maintained. The usage and ventilation conditions can be documented through concurrent measurements of CO_2 concentration.

The impact of door and window openings can be very important. This aspect should be discussed with the client and the situation during the measurement should be documented in the report.

6 Principle of measurement

6.1 General considerations

For source regulatory purposes (i.e. for comparison with an assessment value, for auditing whether it is complied with), only the reference method described in Clauses 6 and 7 can be used.

6.2 Description of the standard measuring principle

The conditions for determining the $PM_{2,5}$ particle mass concentration shall conform to the conditions specified in EN 12341. A specific statement shall be given when deviation from EN 12341 is allowed or mandatory.

Indoor air is passed through a size-selective inlet at a known, constant flow rate. Due to their inertia, large particles are collected on a greased impactor plate. Small particles follow the gas stream and are collected on a backup filter. The sampling head is constructed in such a way that only the particle size fraction with diameters up to the specified cut-off value of 2,5 µm is deposited on the filter. The $PM_{2,5}$ fraction is thus collected on a filter for a known sampled volume. The collected mass of the PM material is then determined by weighing the filter at pre-specified, constant conditions before and after collection.

Key factors that can affect the result of the measurement are addressed by EN 12341 and include:

— the design and construction of the size-selective inlet;

— the sampling flow;

— particle deposition losses in tubing between the inlet and the filter;

— uncontrolled losses in the tubing and on filter due to drying and evaporation losses of semi-volatile PM at any time between collection and weighing;

— changes in the weight of the filters or PM due to, for example, adsorption of water vapour and semi-volatile compounds, or the spurious addition or loss of material, buoyancy or static electricity.

In order to minimize the effects of these factors, EN 12341 gives requirements for a series of parameters that determine the magnitudes of these effects.

7 Equipment and facilities

7.1 Sampling system components

The conditions related to the sampling system and procedure shall conform to the conditions specified in EN 12341.

The following deviations from the requirements in EN 12341 are allowed by this document.

— Indoor temperatures are expected to be quite stable. Therefore, using a conditioning sampler is not mandatory, if a room temperature between 15 °C and 25 °C is continuously observed and if the filter is returned to the weighing room within a maximum of 5 days after particle collection.

— The sampling period could be split (i.e. 2 × 12 h or 3 × 8 h), provided that all samplings are performed on same filter and completed within 3 days for a 24 h overall sampling time. This would allow a focus on a specific period of time where a source of pollution is expected (i.e. office hours only).

— In polluted areas where a 24 h sampling can result in an overload of the impaction head, sampling time can be reduced in a way that a quantity between 5 mg to 10 mg is eventually collected on the filter.

— It is allowed for the purposes of a supplementary method (see Clause 8) to take a minor side flow after the inlet and before the filter holder, as long as the flow is smaller than the allowed averaged error (<2 %) and does not disturb the main flow or gravimetrically collection.

In order to correctly estimate the best procedure for application (e.g. estimation of $PM_{2,5}$ concentration, estimation of the presence of punctual sources, presence of specific cycle), the use of real-time supplementary methods are recommended at any time as part of the QC of the reference method.

7.2 Weighing facilities and procedure

The conditions related to the weighing facilities and procedures shall conform to the conditions specified in EN 12341.

8 Supplementary high time resolution method

8.1 General

For source regulatory purposes, only the reference method described in Clauses 6 and 7 can be used.

Nevertheless, a high time resolution instrument is required for capturing high peak emission or for room investigation. Thus, supplementary methods could be used for exploratory purpose, following recommendations described in this clause.