INTERNATIONAL STANDARD

ISO 16000-23

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Indoor air —

Part 23:
Performance test for evaluating the reduction of formaldehyde concentrations by sorptive building materials

Air intérieur —
Partie 23: Essai de performance pour l'évaluation de la réduction des concentrations en formaldéhyde par des matériaux de construction sorptifs

Reference number
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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 16000-23 was prepared by Technical Committee ISO/TC 146, *Air quality*, Subcommittee SC 6, *Indoor air*.

ISO 16000 consists of the following parts, under the general title *Indoor air* :

— *Part 1: General aspects of sampling strategy*

— *Part 2: Sampling strategy for formaldehyde*

— *Part 3: Determination of formaldehyde and other carbonyl compounds — Active sampling method*

— *Part 4: Determination of formaldehyde — Diffusive sampling method*

— *Part 5: Sampling strategy for volatile organic compounds (VOCs)*

— *Part 6: Determination of volatile organic compounds in indoor and test chamber air by active sampling on Tenax TA® sorbent, thermal desorption and gas chromatography using MS/FID*

— *Part 7: Sampling strategy for determination of airborne asbestos fibre concentrations*

— *Part 8: Determination of local mean ages of air in buildings for characterizing ventilation conditions*

— *Part 9: Determination of the emission of volatile organic compounds from building products and furnishing — Emission test chamber method*

— *Part 10: Determination of the emission of volatile organic compounds from building products and furnishing — Emission test cell method*

— *Part 11: Determination of the emission of volatile organic compounds from building products and furnishing — Sampling, storage of samples and preparation of test specimens*

— *Part 12: Sampling strategy for polychlorinated biphenyls (PCBs), polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs) and polycyclic aromatic hydrocarbons (PAHs)*

— *Part 13: Determination of total (gas and particle-phase) polychlorinated dioxin-like biphenyls (PCBs) and polychlorinated dibenzo-p-dioxins/dibenzofurans (PCDDs/PCDFs) — Collection on sorbent-backed filters*

— *Part 14: Determination of total (gas and particle-phase) polychlorinated dioxin-like biphenyls (PCBs) and polychlorinated dibenzo-*p*-dioxins/dibenzofurans (PCDDs/PCDFs) — Extraction, clean-up and analysis by high-resolution gas chromatography and mass spectrometry*

— *Part 15: Sampling strategy for nitrogen dioxide (NO_2)*

— *Part 16: Detection and enumeration of moulds — Sampling by filtration*

— *Part 17: Detection and enumeration of moulds — Culture-based method*

— *Part 18: Detection and enumeration of moulds — Sampling by impaction*

— *Part 23: Performance test for evaluating the reduction of formaldehyde concentrations by sorptive building materials*

— *Part 24: Performance test for evaluating the reduction of volatile organic compounds (except formaldehyde) concentrations by sorptive building materials*

— *Part 25: Determination of the emission of semi-volatile organic compounds by building products — Micro-chamber method*

The following parts are under preparation:

— *Part 19: Sampling strategy for moulds*

— *Part 26: Measurement strategy for carbon dioxide (CO_2)*

— *Part 28: Sensory evaluation of emissions from building materials and products*

The following parts are planned:

— *Part 20: Detection and enumeration of moulds — Sampling from house dust*

— *Part 21: Detection and enumeration of moulds — Sampling from materials*

— *Part 22: Detection and enumeration of moulds — Molecular methods*

— *Part 27: Standard method for the quantitative analysis of asbestos fibres in settled dust*

— *Part 30: Sensory testing of indoor air*

Furthermore

— ISO 12219-1, *Indoor air — Road vehicles — Part 1: Whole vehicle test chamber — Specification and method for the determination of volatile organic compounds in car interiors* [planned document]

— ISO 16017-1, *Indoor, ambient and workplace air — Sampling and analysis of volatile organic compounds by sorbent tube/thermal desorption/capillary gas chromatography — Part 1: Pumped sampling*

— ISO 16017-2, *Indoor, ambient and workplace air — Sampling and analysis of volatile organic compounds by sorbent tube/thermal desorption/capillary gas chromatography — Part 2: Diffusive sampling*

focus on volatile organic compound (VOC) measurements.

Introduction

Sorptive building materials have been marketed in the form of sheet and board products for removing airborne pollutants via physical sorption or chemical reaction.

Harmonized test methods for evaluating sorptive effects are important for comparative assessment of the performance of sorptive building materials that are used for reducing levels of indoor air contaminants.

This part of ISO 16000 specifies procedures for evaluating the performance of sorptive building materials for reducing indoor air formaldehyde concentrations over time.

The performance of sorptive building materials is evaluated by sorption flux and saturation mass per area and is affected by a number of factors. Specific test conditions are therefore defined in this part of ISO 16000.

This part of ISO 16000 can be applied to most sorptive building materials used indoors and for formaldehyde as an indoor air contaminant.

This part of ISO 16000 is based on the test chamber method as specified in ISO 16000-9.

Indoor air —

Part 23: Performance test for evaluating the reduction of formaldehyde concentrations by sorptive building materials

1 Scope

This part of ISO 16000 specifies a general laboratory test method for evaluating the reduction of formaldehyde concentrations by sorptive building materials. This method applies to boards, wallpapers, carpets, paint products, and other building materials. The sorption of formaldehyde can be brought about by adsorption, absorption and chemisorption. The performance of the material with respect to its ability to reduce the concentration of formaldehyde in indoor air is evaluated by measuring sorption flux and saturation mass per area. The former directly indicates material performance with respect to formaldehyde concentration reduction at a point in time; the latter relates to the ability of a product to maintain that performance.

The method specified in this part of ISO 16000 employs formaldehyde-spiked supply air to determine the performance of building materials in reducing formaldehyde concentrations. The characteristics of formaldehyde sorption depend greatly on humidity. Formaldehyde is less stable in air than other volatile organic compounds (VOCs), so it has to be tested on its own.

This part of ISO 16000 is based on the test chamber method specified in ISO 16000-9. Sampling, transport and storage of materials to be tested and preparation of test specimens are specified in ISO 16000-11. Air sampling and analytical methods for the determination of formaldehyde are specified in ISO 16000-3, which is part of the complete procedure.

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 554, *Standard atmospheres for conditioning and/or testing — Specifications*

ISO 6353-3, *Reagents for chemical analysis — Part 3: Specifications — Second series*

ISO 16000-3, *Indoor air — Part 3: Determination of formaldehyde and other carbonyl compounds — Active sampling method*

ISO 16000-6, *Indoor air — Part 6: Determination of volatile organic compounds in indoor and test chamber air by active sampling on Tenax TA® sorbent, thermal desorption and gas chromatography using MS/FID*

ISO 16000-9:2006, *Indoor air — Part 9: Determination of the emission of volatile organic compounds from building products and furnishing — Emission test chamber method*

ISO 16000-11, *Indoor air — Part 11: Determination of the emission of volatile organic compounds from building products and furnishing — Sampling, storage of samples and preparation of test specimens*

3 Terms and definitions

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

3.1
breakthrough time
t_b
⟨indoor air⟩ time at which the formaldehyde concentration in the air eluting from the sample tube reaches 0,5 % of the concentration in the supplied air

NOTE Adapted from ISO 16000-24:2009, 3.1.

3.2
degradation coefficient
⟨indoor air⟩ ratio of the mass of formaldehyde removed by the initial performance divided by the mass of the same compound lost by deterioration

NOTE Adapted from ISO 16000-24:2009, 3.2.

3.3
elapsed time
t_e
⟨indoor air⟩ time from start of test to the start of air sampling

NOTE Elapsed time is expressed in days.

[ISO 16000-24:2009, 3.3.]

3.4
equivalent ventilation rate per area
$F_{V,\,eq}$
⟨indoor air⟩ increased clean air ventilation rate giving the same reduction in formaldehyde concentration as the building material

NOTE Adapted from ISO 16000-24:2009, 3.4.

3.5
guideline concentration
⟨indoor air⟩ guideline indoor air concentration for formaldehyde as specified by the the WHO

NOTE Adapted from ISO 16000-24:2009, 3.5.

3.6
half-lifetime
⟨indoor air⟩ time elapsed from the start of the test until the formaldehyde concentration decreases to one-half of the initial concentration

NOTE Adapted from ISO 16000-24:2009, 3.6.

3.7
lifetime
t_{lt}
⟨indoor air⟩ time period over which the product continues to reduce formaldehyde concentrations

NOTE 1 The lifetime is given in days or years.

NOTE 2 The lifetime is estimated from the sorption flux and sorption capacity measured by the sample tube test.

NOTE 3 Adapted from ISO 16000-24:2009, 3.7.

3.8
mass transfer coefficient
k_a
⟨indoor air⟩ coefficient arising from the concentration difference between the test specimen and ambient air over its surface

NOTE Mass transfer coefficient is expressed in meters per hour.

[ISO 16000-24:2009, 3.8]

3.9
recovery
⟨indoor air⟩ measured mass of formaldehyde in the air leaving the test chamber with no sample present conditioned over a given time period divided by the mass of formaldehyde added to the test chamber in the same time period

NOTE 1 The recovery is expressed as a percentage and provides information about the performance of the entire method.

NOTE 2 Adapted from ISO 16000-24:2009, 3.9.

3.10
saturation mass per area
ρ_{Aa}
theoretical maximum mass of formaldehyde that could be removed per area of the sorptive material

NOTE 1 Saturation mass per area is expressed in micrograms per area. It corresponds to the total mass per area of sorption at the half-lifetime, or is extrapolated from the sorption capacity derived from the test referenced in Annex A.

NOTE 2 Adapted from ISO 16000-24:2009, 3.10.

3.11
sorption capacity
w_s
total mass of formaldehyde sorbed at breakthrough time per mass of sorbent

NOTE 1 Sorption capacity is expressed in micrograms per gram and is measured using the test specified in Annex A.

NOTE 2 Adapted from ISO 16000-24:2009, 3.11.

3.12
sorption flux
F_m
mass of formaldehyde sorbed per time per area at the specified elapsed time from the test start

NOTE Adapted from ISO 16000-24:2009, 3.12.

3.13
supply air concentration
ρ_s
mass concentration of formaldehyde in the air for supply to the test chamber

NOTE Adapted from ISO 16000-24:2009, 3.13.

3.14
test chamber concentration
⟨indoor air⟩ concentration of formaldehyde measured at the outlet of a test chamber, derived by dividing the mass of the formaldehyde sampled at the outlet of the chamber by the volume of sampled air

NOTE Adapted from ISO 16000-24:2009, 3.14.

3.15
total mass per area of sorption
ρ_A
integral over time of sorptive flux from the start of the test to the specified elapsed time measured with the test chamber

NOTE Total mass per area of sorption is expressed in micrograms per area.

[ISO 16000-24:2009, 3.15]

3.16
vapour sampling period
〈indoor air〉 period of time during which air is sampled from the outlet of the test chamber using sampling tubes or other devices

[ISO 16000-24:2009, 3.16]

4 Symbols

Symbol	Meaning	Unit
ρ_A	mass of sorptive material per area (surface density)	grams per square metre
$\rho_{A\mathrm{a}}$	saturation mass per area	micrograms per square metre
$\rho_{A\mathrm{c}}$	total mass per area of sorption measured by chamber test	micrograms per square metre
$\rho_{\mathrm{in},\,t}$	concentration of formaldehyde at test chamber inlet at elapsed time t	micrograms per cubic metre
$\rho_{\mathrm{out},\,t}$	test chamber concentration at elapsed time t	micrograms per cubic metre
ρ_{s}	supply air concentration in sample tube	micrograms per cubic metre
A	surface area of test specimen	square metres
F_m	sorption flux per time per area	micrograms per square metre per hour
$F_{V,\,\mathrm{a}}$	air flow rate per area	cubic metres per square metre per hour
$F_{V,\,\mathrm{eq}}$	equivalent ventilation rate	cubic metres per square metre per hour
k_{a}	mass transfer coefficient determined using water vapour	metres per hour
L	product loading factor	square metres per cubic metre
m	actual mass of test specimen in sample tube	grams
n	air change rate	changes per hour
q_{c}	air flow rate of test chamber	cubic metres per hour
q_{s}	air flow rate of sample tube	litres per minute
t_{b}	breakthrough time	minutes
t_{e}	elapsed time	hours or days
t_{lt}	lifetime of the pollutant-removing performance	hours or days or years
V	air volume of test chamber	cubic metres
w_{s}	sorption capacity measured by sample tube	micrograms per gram

5 Principle

The performance of a building material, the test material, with respect to its ability to reduce the concentration of formaldehyde is evaluated by monitoring the reduction of the vapour concentration inside a test chamber containing a test specimen of that material. The test includes an assessment of both the initial performance of the material and how long that performance is maintained.

In this test method, formaldehyde-spiked air is supplied to a test chamber containing the material under test. The spiked air should be prepared approximately at the WHO guideline level for formaldehyde in indoor air. Reference to national standards is possible if this is clearly highlighted in the test report and certificate.

Performance is determined by monitoring the difference in concentration of formaldehyde vapour at the inlet and outlet of the test chamber. Testing should be continued for the half-lifetime, i.e. until the concentration of formaldehyde drops to half that at the start of the test under constant ventilation conditions. With this test, sorption flux, F_m, and total mass per area of sorption, $\rho_{A\mathrm{c}}$, at the half-lifetime are determined. The measured $\rho_{A\mathrm{c}}$ at the half-lifetime is defined as the saturation mass per area, $\rho_{A\mathrm{a}}$.

If a test material continues to reduce formaldehyde concentrations for longer than 28 days, alternative methods specified in Annex A for determining $\rho_{A\mathrm{a}}$ may be applied.

The performance of sorptive building materials is mainly determined by the formaldehyde concentration, the mass transfer coefficient of formaldehyde to the surface, and the sorption characteristics of the building materials themselves (adsorption isotherm, diffusion resistance, and so on). Therefore, the performance test method shall specify both the concentration of formaldehyde and the mass transfer coefficient associated with the sorptive building material.

This method does not apply to materials capable of decomposing formaldehyde by catalytic reaction in the presence of ultraviolet and visible rays.

NOTE The long-term formaldehyde reduction performance is represented by the saturation mass per area, $\rho_{A\mathrm{a}}$, and, if necessary, the lifetime of the pollutant-removing performance, t_{lt}, as the subsidiary index.

6 Apparatus and materials

Usual laboratory equipment, and in particular the following.

6.1 Test chamber, complying with relevant specifications and requirements of ISO 16000-9 (see Figure 1). No air shall be allowed to circulate from the outlet back to the inlet.

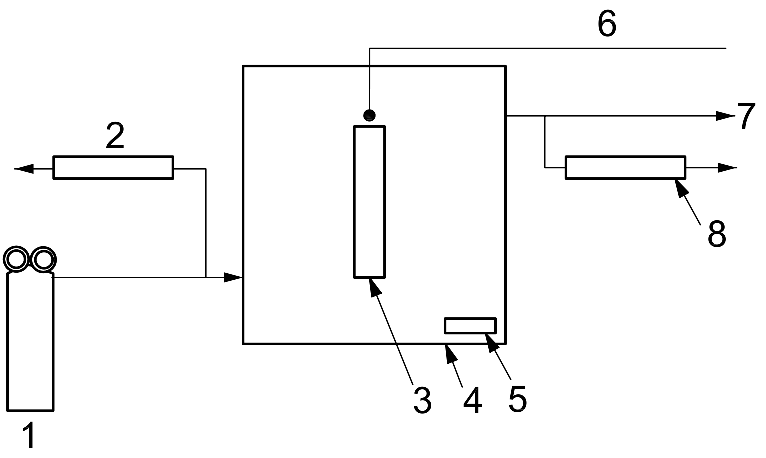
6.2 Sealing material for test specimens, such as **aluminum foil** or a **tape covered with aluminum foil** to cover the edges and the back of the test specimen, if only the surface normally directly exposed to the indoor environment under the intended conditions of use is the subject of the test.

6.3 Air purifier or **cylinder of clean air**. The purifier shall ensure the supply air is as clean as possible before being spiked with formaldehyde, i.e. shall not contain any contaminants at levels greater than the chamber background requirements. In order to prevent a rise in background concentration, an air purifier shall be provided or a cylinder of clean air shall be used.

6.4 Supply air spiked with formaldehyde. Apply a standard gas (with known formaldehyde concentration) to the test chamber. Alternatively, use a stable source like a formaldehyde solution as specified in ISO 6353-3), or paraformaldehyde, to generate air spiked with formaldehyde that can be supplied to the test chamber. The stability of the spiked formaldehyde concentration shall be monitored.

6.5 Temperature and humidity control. Temperature shall be maintained either by installing a test chamber in a place maintained at the required temperature, such as a constant-temperature climate chamber, or by maintaining the required temperature in the chamber. Relative humidity shall be maintained at the required humidity of the supply air. Temperature and humidity controls of the supply air are described in ISO 16000-9.

6.6 Air flow meter, installed at the inlet or the outlet of the test chamber to measure the air flow rate through the chamber.



Key

1 supply air spiked with formaldehyde
2 sampling device
3 test specimen
4 test chamber
5 device to circulate air and control of air velocity
6 temperature/humidity monitoring apparatus
7 test chamber outlet
8 sampling device

Figure 1 — Outline of the test chamber system

6.7 Air sampling devices. Use the inlet and outlet air of the test chamber for sampling. When a separate sampling port is used, sample directly from the inlet or outlet of the chamber.

If a duct or tube is used, it shall be as short as possible and maintained at the same air temperature as that in the test chamber. Such a duct or tube shall be made of a material with a very low sorption capacity, e.g. polytetrafluoroethylene.

The sum of sampling air flow rates shall be smaller than the air flow rate into the chamber. Sampling devices shall comply with the specifications of ISO 16000-3. When the air is sampled from the inlet, ensure the supply air flow rate remains constant.

A multiport sampling manifold may be used to provide flexibility for duplicate air sampling. A mixing chamber between the test chamber and the manifold or between the air inlet and the test chamber can be included to permit addition and mixing of internal standard gases with the test chamber air stream.

The exhaust from the test chamber should be ducted into a fume hood, ensuring that formaldehyde-spiked air and any chemicals emitted from the test material are isolated from the laboratory environment.

6.8 Analytical instrument. A high performance liquid chromatograph (HPLC) shall be used as specified in ISO 16000-3.

7 Test conditions

7.1 General

The test conditions shall comply with 7.2 and 7.3. This test shall be conducted under atmospheric pressure conditions.