INTERNATIONAL STANDARD

ISO 16000-23

Second edition
2018-12

Indoor air —

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

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

Reference number
ISO 16000-23:2018(E)

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Published in Switzerland

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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 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.

This second edition cancels and replaces the first edition (ISO 16000-23:2009), which has been technically revised. The main changes compared to the previous edition are as follows.

— The target chemical compounds subject to this document have been changed from formaldehyde only to formaldehyde and other carbonyl compounds.

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

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 quantitative performance assessment of sorptive building materials that are used for reducing levels of indoor air contaminants.

This document specifies procedures for evaluating the performance of sorptive building materials in reducing indoor air formaldehyde and other carbonyl compounds concentrations over time.

The performance of sorptive building materials is evaluated by measuring the area-specific reduction rate and the saturation mass per area. The former directly indicates material performance with respect to formaldehyde and other carbonyl compounds concentration reduction at a point in time; the latter relates to the ability of a product to maintain such a performance. This is affected by a number of factors and the performance test in conjunction with the standardized sampling, storage of samples and preparation of test specimens has objectives to provide manufacturers, builders, and end users with comparative performance data of sorptive building materials useful for the evaluation of the impact on the indoor air quality, and to promote the development of improved products. Specific test conditions are therefore defined in this document.

This document can be applied to most sorptive building materials used indoors and to formaldehyde and other carbonyl compounds used as an indoor air contaminant. This method does not apply to materials capable of decomposing target compound(s) by catalytic reaction in the presence of ultraviolet and visible rays.

This document 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 and other carbonyl compounds concentrations by sorptive building materials

1 Scope

This document specifies a general laboratory test method for evaluating the reduction of formaldehyde and other carbonyl compounds (aldehydes and ketones) concentrations by sorptive building materials. This method applies to boards, wallpapers, carpets, paint products, and other building materials. The sorption of those target compounds, i.e. formaldehyde and other carbonyl compounds, can be brought about by adsorption, absorption and chemisorption.

The method specified in this document employs formaldehyde and other carbonyl compound spiked supply air to determine the performance of building materials in reducing formaldehyde and other carbonyl compounds concentrations.

This document 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 and other carbonyl compounds are specified in ISO 16000-3, which is part of the complete procedure.

This document applies to the determination of formaldehyde and other carbonyl compounds, such as formaldehyde, acetaldehyde, acetone, benzaldehyde, butyraldehyde, valeraldehyde, 2,5-dimethylbenzaldehyde, capronaldehyde, isovaleraldehyde, propionaldehyde, o-tolualdehyde, m-tolualdehyde, p-tolualdehyde.

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.

ISO 16000-3, *Indoor air — Part 3: Determination of formaldehyde and other carbonyl compounds in indoor air and test chamber air — 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 or MS-FID*

ISO 16000-9, *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.

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
area-specific reduction rate
q_{ads}
mass of *target compound(s)* (3.14) sorbed per time unit per area at the specified *elapsed time* (3.4) from the test start

3.2
breakthrough time
t_b
time at which the *target compound* (3.14) concentration in the air eluting from the sample tube reaches 0,5 % of the concentration in the supplied air

3.3
degradation coefficient
ratio of the mass of *target compound(s)* (3.14) removed by the initial performance divided by the mass of the same compound(s) lost by deterioration

3.4
elapsed time
time from the start of test to the start of air sampling

Note 1 to entry: Elapsed time is expressed in hours or days.

3.5
equivalent ventilation rate per area
$q_{V,\,eq}$
increased clean air ventilation rate giving the same reduction in *target compound* (3.14) concentration as the building material

3.6
guideline concentration
corresponding threshold indoor air concentration for *target compound(s)* (3.14) as specified by the WHO or an appropriate national standards body

3.7
half-lifetime
time elapsed from the start of the test until the *target compound* (3.14) concentration reduction performance decreases to one half of the initial concentration reduction performance

3.8
lifetime
t_{lt}
time period over which the product continues to reduce *target compound* (3.14) concentrations

Note 1 to entry: The lifetime is given in days or years.

Note 2 to entry: The lifetime is estimated from the *area-specific reduction rate* (3.1) and sorption capacity measured by the sample tube test.

3.9
mass transfer coefficient
k_a
coefficient arising from the concentration difference between the test specimen and ambient air over its surface

Note 1 to entry: Mass transfer coefficient is expressed in metres per hour (m/h).

3.10
recovery
measured mass of *target compound(s)* (3.14) in the air leaving the test chamber with no sample present conditioned over a given time period divided by the mass of target compound(s) added to the test chamber in the same time period

Note 1 to entry: The recovery is expressed as a percentage and provides information about the performance of the entire method.

3.11
saturation mass per area
ρ_{Aa}
theoretical maximum mass of *target compound(s)* (3.14) that could be removed per area of the sorptive material

Note 1 to entry: Saturation mass per area is expressed in micrograms per area. It corresponds to the total mass per area of sorption at the *half-lifetime* (3.7), or is extrapolated from the *sorption capacity* (3.12) derived from the test referenced in Annex A.

3.12
sorption capacity
w_S
total mass of *target compound(s)* (3.14) sorbed at *breakthrough time* (3.2) per mass of sorbent

Note 1 to entry: Sorption capacity is expressed in micrograms per gram and is measured using the test specified in Annex A.

3.13
supply air concentration
ρ_S
mass concentration of *target compound(s)* (3.14) in the air for supply to the test chamber

3.14
target compound
formaldehyde or other carbonyl compound in indoor air

3.15
test chamber concentration
concentration of *target compound(s)* (3.14) measured at the outlet of a test chamber, derived by dividing the mass of the target compound(s) sampled at the outlet of the chamber by the volume of sampled air

3.16
total mass per area of sorption
ρ_A
integral over time of *area-specific reduction rate* (3.1) from the start of the test to the specified *elapsed time* (3.4) measured with the test chamber

Note 1 to entry: Total mass per area of sorption is expressed in micrograms per area.

3.17
air sampling period
period of time during which air is sampled from the outlet of the test chamber using sampling tubes or other devices

4 Symbols

Symbol	Meaning	Unit
A	surface area of test specimen	square metres
q_{ads}	Area-specific reduction rate	micrograms per square metre per hour
$q_{V,a}$	air flow rate per area	cubic metres per square metre per hour
$q_{V,eq}$	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, days or years
V	air volume of test chamber	cubic metres
w_s	sorption capacity measured by sample tube	micrograms per gram
ρ_A	mass of sorptive material per area (surface density)	grams per square metre
ρ_{Aa}	saturation mass per area	micrograms per square metre
ρ_{Ac}	total mass per area of sorption measured by chamber test	micrograms per square metre
$\rho_{in,t}$	concentration of target compound(s) at test chamber inlet at elapsed time t	micrograms per cubic metre
$\rho_{out,t}$	test chamber concentration at elapsed time t	micrograms per cubic metre
ρ_s	supply air concentration in sample tube	micrograms per cubic metre

5 Principle

The performance of a building material in reducing the concentration of target compound(s), i.e. formaldehyde and other carbonyl compounds, from the indoor air is evaluated by monitoring the reduction of the concentration of these substances in the air of a test chamber containing a specimen of the test material. The test assesses both the initial performance of the material and how long that performance is maintained.

In this test method, target compound spiked air is supplied into the test chamber. The spiked air should be prepared at approximately the guideline concentration level for the target compound(s) in indoor air. Reference to the WHO or an appropriate national standards body can be made if this is clearly highlighted in the test report.

Performance is determined by monitoring the difference in the concentration of target compound(s) at the inlet and outlet of the test chamber. Testing should be carried out for the half-lifetime, i.e. until the concentration reduction performance of target compound(s) drops to one half of the performance recorded at the start of the test under constant ventilation conditions. With this test, the area-specific reduction rate, ρ_{ads}, and total mass per area of sorption, ρ_{Ac}, at the half-lifetime are determined. The value measured for ρ_{Ac} at the half-lifetime is defined as the saturation mass per area, ρ_{Aa}.

If a test material continues to reduce target compound concentrations for longer than 28 days, the alternative methods specified in Annex A for determining ρ_{Aa} may be applied.

The performance of sorptive building materials is mainly determined by the target compound concentration, the mass transfer coefficient of target compound(s) 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 target compound(s) and the mass transfer coefficient associated with the sorptive building material.

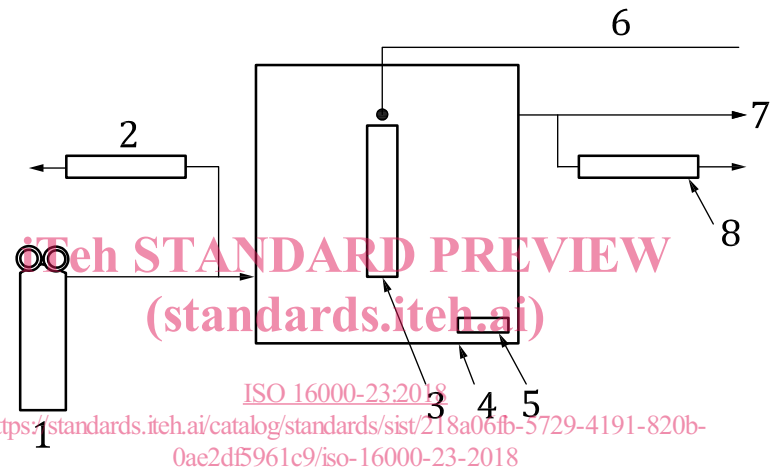
A re-emission test should be conducted following the test for evaluating the concentration reduction performance, as described in 11.3.1.

NOTE The long-term formaldehyde target compound reduction performance is represented by the saturation mass per area, ρ_{Aa}, and, if necessary, the lifetime of the pollutant-removing performance, t_{lt}, as the subsidiary index.

6 Apparatus and materials

The usual laboratory apparatus and, in particular, the following.

6.1 Test chamber, complying with the 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.



Key

1 supply air spiked with target compound(s) (6.3)
2 air sampling device (6.6)
3 test specimen
4 test chamber (6.1)
5 device to circulate air and control air velocity
6 temperature/humidity monitoring apparatus (6.4)
7 test chamber outlet
8 air sampling device (6.6)

Figure 1 — Outline of the test chamber system

6.2 Air purifier or **cylinder of clean air**, to ensure the supply air is as clean as possible before being spiked with target compound(s), i.e. it shall not contain any contaminants at levels greater than the chamber background requirements.

6.3 Supply air spiked with target compound(s), created by applying a standard gas (whose target compound concentration is known) to the test chamber. Alternatively, use a stable source to generate air spiked with target compound(s) that can be supplied to the test chamber. The stability of the spiked target compound concentration shall be monitored.

6.4 Temperature and humidity monitoring apparatus.

Temperature shall be maintained either by installing a test chamber in a place maintained at the required temperature, 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.

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

6.6 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 kept at the same air temperature as that of 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 target compound spiked air and any chemicals emitted from the test material are isolated from the laboratory environment.

6.7 High performance liquid chromatograph (HPLC), 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.

An example is given in Annex C.

7.2 Test conditions to determine concentration reduction performance

7.2.1 Temperature and relative humidity

The temperature in the test chamber should be set to 23 °C ± 1 °C, and the relative humidity should be 50 % ± 5 % during the test.

For building materials with applications under other climatic conditions, alternative temperatures and air humidity conditions may be used, preferably as specified in ISO 554. State the conditions in the test report.

Initial variations can be observed in the test chamber climate after opening the test chamber door and loading a test specimen. These variations should be recorded.

NOTE Temperature and relative humidity can affect area-specific reduction rate and re-desorption from the test material.

7.2.2 Supply air quality and background concentration

The background concentration of the supply air for the test chamber and the air prior to spiking with target compound(s) shall be low enough not to interfere with the test. The total volatile organic compound (VOC) background concentration shall be lower than 20 µg/m^3. The background

