INTERNATIONAL STANDARD

**ISO 16000-28**

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# Indoor air —

## Part 28: Determination of odour emissions from building products using test chambers

*Air intérieur —*

*Partie 28: Détermination des émissions d'odeurs des produits de construction au moyen de chambres d'essai*

Reference number
ISO 16000-28:2012(E)

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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# Foreword

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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 16000-28 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 in indoor air and test chamber air — 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 or 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 (NO2)*

— *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 19: Sampling strategy for moulds*

— *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 compound (except formaldehyde) concentrations by sorptive building materials*

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

— *Part 26: Sampling strategy for carbon dioxide (CO2)*

— *Part 28: Determination of odour emissions from building products using test chambers*

The following parts are under preparation:

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

— *Part 27: Determination of settled fibrous dust on surfaces by SEM (scanning electron microscopy) (direct method)*

— *Part 29: Test methods for VOC detectors*

— *Part 30: Sensory testing of indoor air*

— *Part 31: Measurement of flame retardants and plasticizers based on organophosphorus compounds — Phosphoric acid ester*

— *Part 32: Investigation of constructions on pollutants and other injurious factors — Inspections*

# Introduction

Odour evaluation is a complementary method to the chemical testing of emissions from building products.

The determination of odour acceptability, intensity and hedonic tone, and intensity of emissions from building products using test chambers has objectives such as:

— to provide manufacturers, builders, and end users with data useful for the evaluation of the odour impact of building products on the indoor air quality;

— to promote the development of improved products.

The method can also be used for building furnishings.

ISO 16017[31] [32] and ISO 12219[26]–[30] focus on volatile organic compound (VOC) measurements.

# Indoor air —

# Part 28: Determination of odour emissions from building products using test chambers

## 1 Scope

This part of ISO 16000 specifies a laboratory test method using test chambers defined in ISO 16000-9 and evaluation procedures for the determination of odours emitted from newly produced building products under defined climate conditions. The method can also, in principle, be applied to aged products. This part of ISO 16000 is applicable to various test chambers used for the determination of emissions from building products.

NOTE This part of ISO 16000 can also be used for other products or materials.

Sampling, transport and storage of materials under test, as well as preparation of test specimens are described in ISO 16000-11.

## 2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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 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*

EN 13725, *Air quality — Determination of odour concentration by dynamic olfactometry*

## 3 Terms, definitions, symbols, units and abbreviated terms

### 3.1 Terms and definitions

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

**3.1.1**
**odour**
pleasant or unpleasant smell caused by chemical compounds emitting to indoor air from a building product or material

**3.1.2**
**acceptability**
assessment of an odour emission to indoor air which can be ascertained according to a scale ranging from “clearly acceptable” to “clearly unacceptable” set by value on a defined evaluation scale

**3.1.3**
**perceived intensity**
parameter to assess odour intensity based on a comparable scale

NOTE See 5492:2008, 2.8, 2.9 and 4.30.

**3.1.4**
**hedonic tone**
odour effect, which can be ascertained according to a scale ranging from “extremely pleasant” to “extremely unpleasant”

**3.1.5**
**panel selection**
procedure to determine which persons are qualified to serve as panel members

**3.1.6**
**sensory fatigue**
form of sensory adaptation in which a decrease in sensitivity occurs

**3.1.7**
**sensory adaptation**
temporary modification of the sensitivity of a sense organ due to continued and/or repeated stimulation, which is reversible

[ISO 5492:2008, definition 2.6]

**3.1.8**
**anosmia**
lack of sensitivity to some olfactory stimulus due to physiological defects, which is not reversible

NOTE Adapted from ISO 5492:2008, 2.32.

**3.1.9**
**sensory odour panel**
group of trained or untrained assessors performing the sensory assessment of the odour emission from building products or materials

NOTE See ISO 5492:2008, definition 1.9.

**3.1.10**
**panel leader**
person whose primary duties are to manage panel activities and recruit, train and monitor the assessors

**3.1.11**
**panel member**
person who is accepted to assess the odours

**3.1.12**
**untrained panel**
panel consisting of members who assess the odour emission without any training on odorous references

**3.1.13**
**trained panel**
panel consisting of members who are trained to judge the intensity of odour emission

**3.1.14**
**air exchange rate**
ratio of the volume of clean air brought into the test chamber hourly and the free test chamber volume measured in identical units

**3.1.15**
**outlet air flow rate**
air volume per time at the chamber outlet

NOTE The outlet air flow rate is expressed as volume per second.

**3.1.16**
**air velocity**
air speed over the surface of the test specimen

**3.1.17**
**area specific air flow rate**
ratio between the supply air flow rate and the area of the test specimen

**3.1.18**
**building product**
building material or component produced for incorporation in a permanent manner in construction works

NOTE A building product can be solid, liquid or combined (see ISO 16000-11).

EXAMPLE 1 Examples of solid building products include flooring, wall covering, ceiling materials.

EXAMPLE 2 Examples of liquid building products include paints, varnishes, oils, waxes, levelling compounds, plasters, mortars, concrete, adhesives, sealants, caulks, putties and surface coatings.

EXAMPLE 3 Examples of combined building products include glued applications, such as floor and wall coverings, which are fixed on the building site on to surfaces using adhesives.

**3.1.19**
**diffuser**
funnel-shaped device for assessing the odour from the test chamber or from an odour sample container

**3.1.20**
**mask**
auxiliary odour-assessment device for cases where the exhaust air volumes required by the diffuser cannot be reached

**3.1.21**
**test chamber**
enclosure with controlled operational parameters for the determination of volatile organic compounds and odours emitted from test specimens prepared from building products

**3.1.22**
**test room**
room where the odour test takes place

**3.1.23**
**clean air**
odourless air

See 3.1.29.

**3.1.24**
**product loading factor**
ratio of exposed surface area of the test specimen and the free test chamber volume

**3.1.25**
**sample container**
device for containing or carrying used for transporting the odour sample from the test chamber to the test room and for introducing the sample to the panel members

EXAMPLE A container may be a carton, can, tube, bag or packaging.

**3.1.26**
**sample**
part or piece of a building product as placed on the market

**3.1.27**
**test specimen**
part of the sample specially prepared for emission testing in a test chamber in order to simulate the odour emission behaviour of the material or product being tested

**3.1.28**
**odour sample**
air sample collected from the test chamber outlet in containers and being tested for its odour

NOTE An example of a container is a flexible bag.

**3.1.29**
**odourlessness**
odour assessed by the panel as being below the required value

## 3.2 Symbols and units

For the purposes of this document, the following symbols apply.

| Symbol | Meaning | Unit |
|---|---|---|
| $L$ | product loading factor | square metres per cubic metre |
| $n$ | air exchange rate | changes per hour |
| $q_{V,A}$ | area specific air flow rate ($n/L$) | cubic metres per square metre and hour |
| $A$ | surface area | square metre |
| $\Pi$ | perceived intensity | odour intensity unit pi |
| $q_{V,\mathrm{C}}$ | volumetric supply air flow rate | cubic metres per hour |

## 3.3 Abbreviated terms

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

FEP tetrafluoroethylene hexafluoropropylene copolymer

PVF polyvinyl fluoride

PET polyethyleneterephthalate

PU perceptual unit

RH relative humidity

QA quality assurance

QAPP quality assurance project plan

QC quality control

VOC volatile organic compound

# 4 Principle

The odour emission from building products is measured using a sensory odour panel. The odour determination may be carried out simultaneously with chemical emission measurements in accordance with ISO 16000-9. The odour characteristics addressed in this part of ISO 16000 are the acceptability and the perceived intensity. Depending on the measurement task, the acceptability, perceived intensity or both characteristics shall be determined.

Depending on the measurement task, the determination of hedonic tone may be used as a complementary method of these assessments.

# 5 Test facilities

## 5.1 General

A facility designed and operated to determine odours emitted from building products consists of a test chamber containing the test specimen. The test chamber is placed in an odourless well-ventilated testing room. The working environment for panel members containing the test chamber shall be pleasant and odourless. Any odour emissions from equipment, furnishings and materials (paints, wall and floor coverings and furniture, etc.) installed in the test room shall be avoided.

The test room in which the sensory assessment is performed shall comply with the general requirements described in 6.8.1.

The test chamber shall contain a clean air generation and humidification system, an air mixing system, and monitoring and control systems to ensure that the test is carried out to specified conditions in accordance with ISO 16000-9.

The chamber outlet shall be adapted to the direct assessment of the odour with a diffuser or mask or to the sampling of chamber air in containers.

If the odour assessment is carried out directly from the outlet of the chamber, the chamber material shall be non-transparent or the chamber shall be covered in order to avoid the panel members being influenced by visual recognition of the material in test.

General specifications and requirements, which apply to all types of test chambers, are included in this part of ISO 16000.

## 5.2 Apparatus

The equipment necessary for carrying out an odour emission test is the following.

**5.2.1 Clean air supply**, for example pressurized purified air or synthetic air in gas cylinders or odourless air from test room.

**5.2.2 Test chamber system**.

**5.2.3 Humidification system**.

**5.2.4 Air humidity, temperature and air velocity monitoring systems**.

**5.2.5 Air flow meters**.

**5.2.6 Cleaning agent**, for cleaning the test chamber walls and the diffuser or mask.

**5.2.7 Equipment for measuring the mixture of air**.

**5.2.8 Equipment for odour sampling and assessment**.

## 5.3 Test chamber and equipment materials

The materials used in the chamber equipment shall be odourless, inert and non-sorbent (see 6.8.1).

The test chamber and the parts of the sampling system coming into contact with the emitted odours are normally made of surface treated (polished) stainless steel or glass. However, in all cases the requirements in 8.1 and 6.8.1 shall be fulfilled.

Other materials may be used for mixing devices, for instance fans, for sealing materials and odour sample containers. These shall be low emitting and low adsorbing and shall not contribute to the test chamber background odour.

## 5.4 Air supply and mixing facilities

The test chamber shall have facilities (e.g. electronic mass flow controller) capable of continuously controlling the air exchange rate at a fixed value with an accuracy of ±5 %.

The test chamber shall be designed to ensure proper mixing of the test chamber air.

NOTE Fans, multiport inlet and outlet diffusers, perforated floors and baffle plates are used to obtain adequate mixing.

## 5.5 Airtightness

The test chamber shall be airtight in order to avoid uncontrolled air exchange with external air.

The test chamber shall be operated slightly above atmospheric pressure to avoid any influence from the laboratory atmosphere.

The test chamber is considered sufficiently airtight if at least one of the following requirements is fulfilled:

— the air leakage is less than 0,5 % of the chamber volume per minute at an overpressure of 1 000 Pa;

— the air leakage is less than 5 % of the supply airflow rate.

## 5.6 Odour sampling and assessment devices

### 5.6.1 Odour assessment interface

The odour assessment interface shall ensure that

— the air flow is sufficient to guarantee that the panel members only inhale sample air during the assessment, and

— significant adsorption on the surfaces is avoided and the interface has no emissions of its own to interfere with the sample air.

### 5.6.2 Standard diffuser method

The odour evaluation interface consists of a diffuser, which is connected to the outlet of the test chamber. The diffuser and the inner surfaces of the connection ducting shall be composed of surface-treated (polished) stainless steel or glass. The air exhaust from the diffuser shall be between 0,6 l/s to 1 l/s. The air flow at the outlet of the diffuser shall be constant for the duration of each experiment. The design of the measurement diffuser ensures that no ambient air is sucked in and mixed with the sample air. An opening angle (both sides) of up to 12° ensures a homogeneous outflow of sample air.

NOTE In the case of a seated sniffing activity from a specific diffuser, a minimum air flow rate of 20 l/min (0,33 l/s) can be met (see EN 13725).

When using a minimum air flow rate of 20 l/min, the odour concentration for this type of diffuser shall be validated against the standard diffuser method.

### 5.6.3 Other methods

Alternatives for the standard diffuser such as odour masks (for an example, see Annex C) may be used if the method is proven to meet the requirements of 5.6.1. An odour mask may be used in cases where the area specific air flow rate (see 6.5) in small test chambers does not meet the requirements of the air flow rate from the diffuser (see 5.6.2), for example with bulky building products. The minimum volume of a mask shall be 1,5 l in order that three deep breaths of 0,5 l from the chamber air can continuously flow through the mask. The mask shall be made of odourless material, such as stainless steel or glass. The results of the method shall be validated against the standard diffuser method.

### 5.6.4 Sample containers

**5.6.4.1** Sampling in a container shall be carried out when the following requirements (see Annex D) cannot be fulfilled:

— the air flow rate at the outlet of the emission test chamber is not high enough to ensure that no air mixing with ambient air occurs during the sensory assessment;

— the environment of the emission test chamber does not comply with the requirements of 6.8.1 concerning the background odour requirements of the sensory test room.

The sample container shall not induce any alteration of the odour being sampled. The container shall, therefore, be airtight, odourless, non-permeable and non-adsorptive.

**5.6.4.2** So far, the following materials are considered appropriate for making sample containers:

— tetrafluoroethylene hexafluoropropylene copolymer (FEP);

— polyvinyl fluoride [PVF, Tedlar®[1)]];

— polyethyleneterephthalate [PET, Nalophan NA®[2)]].

Odour assessment from the sample container shall be carried out with a diffuser or mask meeting the requirements in 5.6.1 and 6.8.1.

Samples shall be analysed as soon as possible after sampling. After a storage time of more than 6 h, it shall be proven that there is no chemical change in the container.

Performance of the container may be validated as described in Annex D.

After sampling, the sample containers shall be kept in a temperature identical to that required of the test chamber.

All processes that can cause deterioration of the sampled odorants are progressive with time, such as adsorption, diffusion and chemical reactions. Experiments indicate that losses after 24 h to 30 h of storage can be significant for some substances. Samples shall not be exposed to direct sunlight or strong daylight to minimize (photo) chemical reactions (see EN 13725).

## 6 Test conditions

### 6.1 General

Test conditions are described in ISO 16000-9 and shall be met.

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1) Tedlar® is manufactured by Dupont. It is an example of a suitable product available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of this product. Equivalent products may be used if they can be shown to lead to the same results.

2) Nalophan NA® is manufactured by Kalle Nalo. It is an example of a suitable product available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of this product. Equivalent products may be used if they can be shown to lead to the same results.

All control measures to verify the test conditions shall be traceable to a reference standard according to the quality assurance (QA) and quality control (QC) schemes (see Annex A).

## 6.2 Temperature and relative humidity in the test chamber

The tests shall be performed at standard conditions at a temperature of 23 °C and a relative humidity (RH) of 50 % (as given in ISO 554). The tolerances are ±2 °C and ±5 % RH.

For products with applications under other climatic conditions, alternative temperature and air humidity conditions may be used, preferably as specified in ISO 554.

Temperature and relative humidity in the test chamber shall be monitored and recorded continuously to accuracy of temperature ±1,0 °C and ±3 % RH.

Temperature may be controlled by either placing the test chamber within a location controlled to the required temperature (see EN 13725) or by maintaining the temperature within the test chamber. In the latter case, the test chamber walls shall be insulated effectively to avoid condensation of moisture on the interior walls of the test chamber.

Relative humidity may be controlled using various systems of either external humidity control of the clean air supply or internal humidity control of the air in the test chamber. In the latter case, precautions shall be taken to avoid condensation or the spraying of water in the test chamber.

## 6.3 Supply air quality and background concentration in the test chamber

Supply air shall be odourless at levels better than the test chamber background requirements (see 6.8.1).

The test chamber background odour shall be low enough not to interfere with the odour determinations (see 6.8.1).

The water used for humidification shall be odourless.

## 6.4 Air velocity in the test chamber

The air velocity near the surface of the test specimen shall be in the range of 0,1 m/s to 0,3 m/s.

The air velocity in the test chamber shall be measured in at least one position, over the centre of the test specimen, and at a distance of 10 mm from the exposed surface of the test specimen. Other measurement points shall also be chosen, at representative positions, depending on the size of the test specimen.

NOTE 1 Adequate equipment for air velocity measurements are hot wire or film anemometers calibrated in the range of 0,1 m/s to 0,5 m/s.

NOTE 2 The air velocity can be important for evaporative controlled emissions, e.g. from some liquid products. This depends on the substrate.

## 6.5 Area-specific air flow rate and air exchange rate in the test chamber

The odour concentration from the building products in a space depends on the area-specific air flow rate which is selected as a parameter in designing the emission test conditions. The area-specific air flow rate shall be adjusted in the tests depending on the expected material use inside buildings. For this purpose, a model room is defined with a floor area of 7 $m^2$, a room height of 2,5 m and an air exchange rate of 0,5 $h^{-1}$ (Annex H). Loading factors were calculated which describe the surface area of the building material being tested in relation to the air volume of the standard room.

The area specific airflow rate between the airflow rate, surface area, air exchange rate and loading factor is calculated using Formula (1):

$$q_{V,A} = \frac{n}{L} = \frac{q_{V,\mathrm{c}}}{A} \quad (1)$$

where

$q_{V,A}$ is the area specific air flow rate, in cubic metres per hour and square metres;

$q_{V,\mathrm{c}}$ is the volumetric supply air flow rate, in cubic metres per hour;

$A$ is the surface area, in square metres;

$n$ is the air exchange rate, per hour;

$L$ is the loading factor, in square metres per cubic metre.

Examples of loading factors and area-specific air flow rates are given in Annex H.

The air exchange rate in the test chamber shall be regularly checked with a minimum frequency of every 12 months, either by using a calibrated gas meter or the tracer gas procedure. The air exchange rate shall not vary by more than ±3 % of the set value.

Air flow rate shall be monitored and recorded continuously to an accuracy of ±3 %.

**IMPORTANT If the test is carried out on the outlet with a gas volume meter/flow meter, which is not permanently installed, one should be aware that the back pressure introduced by the instrument can lower the air flow rate through the test chamber.**

NOTE With the required air exchange rate of 0,5 $h^{-1}$, the use of the standard diffuser method requires the use of sufficiently large chambers such as 1 $m^3$ or larger or the use of a sample container.

Regarding the minimum size of a mask, the outlet flow into the mask shall fulfil the requirement in 5.6.3.

## 6.6 Test chamber airtightness

The test chamber airtightness shall be checked regularly, by pressure drop measurements, by comparison of simultaneous measurement of air flow rates at the inlet and the outlet ports or by measuring using tracer gas dilution.

## 6.7 Efficiency of the internal test chamber air mixing

Tests to determine the efficiency of the air mixing shall be conducted with test specimens or the inert substrate of the test specimens located in the test chamber.

NOTE One approach for determining whether or not the test chamber air is adequately mixed is to blend a tracer gas with the inlet air at constant concentration and flow, and measure the concentration in the chamber outlet over time. The chamber concentration vs. time plot is then compared to the theoretical curve for a completely mixed chamber. A procedure can be to adjust the theoretical curve by least squares fit to the measured data using the chamber volume as a variable. The actual chamber volume can then be compared to the “apparent” chamber volume, based on the curve fit (see the Bibliography). It is intended that the Internal chamber air be properly mixed and be compliant with or within 10 % of the theoretical perfectly mixed model.

## 6.8 Test chamber and test room background odour

### 6.8.1 General

The odour background of the test chamber shall be low in order to avoid influences on the odour evaluation. The test chamber background odour shall be evaluated by the panel. The odour of the air in the test room shall be evaluated prior to the tests. The evaluation results shall meet the requirements in Tables 1 and 2[13][14].

**Table 1 — Requirements for background odour acceptability**

| Odour | Acceptability |
|---|---|
| Test chamber background odour including the sniffing equipment and sample container | ≥0,8 |
| Test room background odour | ≥0,6 |
| The test room background odour should be low enough not to cause sensory adaptation.<br>The test room background odour should be low enough for proper rating of the reference acetone-air mixtures. | |

**Table 2 — Requirements for perceived background odour intensity**

| Odour | Perceived intensity<br>pi |
|---|---|
| Test chamber background odour including the sniffing equipment and sample container | ≤3 |
| Test room background odour | ≤4 |
| The test room background odour should be low enough not to cause sensory adaptation.<br>The test room background odour should be low enough for proper rating of the reference acetone-air mixtures. | |

### 6.8.2 Exhaust air rate from the diffuser or other equipment

An air flow rate from the diffuser to the panel member shall be 0,6 l/s to 1 l/s (see 5.6.2).

NOTE In the case of a specific outlet configuration assuming that no air mixing occurs with ambient air, a lower flow rate of 20 l/min (0,3 l/s) can be used (see EN 13725). See also Note in 5.6.2.

### 6.8.3 Environmental control of test room

Temperature fluctuations during the measuring process shall be less than ±3 °C. The maximum temperature in the room shall be 25 °C. The relative humidity of the test room shall be (50 ± 5) % (as specified in ISO 554). Exposing the panel members to direct sunlight shall be avoided. The room shall be free of any sources with regard to noise and light, which can negatively affect the measurement in all progress.

For products with applications under other climatic conditions, alternative temperature and air humidity conditions may be used, preferably as specified in ISO 554.

### 6.8.4 Ventilation of the test room

The test room shall be ventilated to maintain an odourless environment and to provide fresh air to the panel members. A minimum ventilation rate with clean fresh air according to ventilation guidelines is necessary (e.g. 20 l/s per person or an air exchange rate of 5 $h^{-1}$ in accordance with EN 13779[4]) if people are not the main source in the room.

## 7 Test specimens

Studies of the emission of odours from building products in test chambers require proper handling of the product prior to testing.

ISO 16000-11 specifies examples of sampling of the product under test, storage of the sample before testing and the preparation of test specimens.

# 8 Odour testing from emission chamber

## 8.1 Test chamber preparation

Clean the test chamber and the test chamber equipment in order to fulfil the requirements of 6.8.1. Carry out cleaning by washing the inner surfaces of the test chamber and the equipment with an alkaline detergent followed by two separate rinses with freshly distilled water. Then dry and purge the test chamber and the equipment to test conditions. The test chamber may also be cleaned by thermal desorption. Clean the sample container by flushing with 80 °C warm air (see Annex D).

A blank test shall be performed previous to any test in order to confirm the efficiency of the cleaning step. Perform the blank test exactly as the standard procedure except that no specimen is introduced into the chamber. The odourlessness shall comply with the requirement in 6.8.1 before continuing the odour assessment of the test specimen.

## 8.2 Test specimen location in the test chamber

The test specimen shall be positioned in the centre of the test chamber to ensure that the air flow is evenly distributed over the emitting surface of the test specimen(s). The test specimens shall be conditioned for three days in the test chamber before the sensory evaluation.

## 8.3 Time of odour measurements

The measurements shall be carried out at predefined sampling times and mainly at the same time as the analytical emission test takes place.

Emission and odour test duration is determined by the purpose of the test. The test specimen shall be kept in the test chamber during the whole testing period.

It is not always possible to perform the odour measurement at the same time as analytical sampling. In this case, the odour measurement shall be carried out within 30 h (in accordance with EN 13725).

If it is not possible to keep the test specimen in the test chamber for the entire testing period, it shall be aged in similar conditions as required of the test chamber. No contamination from other sources during this external ageing time shall occur. The test specimen shall then be re-introduced into the test chamber at least 72 h prior to the required air sampling time. Each removal of the test specimen shall be documented in the test protocol.

# 9 Odour panels

## 9.1 Panel leader

The panel leader shall be in charge of the panels.

Before starting a session, the panel leader has the responsibility to check that the code of behaviour (9.3) is applied by all the panel members. A member shall be excluded in case of bad practice compromising the quality of the measurement.

The panel leader shall ensure that the code of conduct is fully understood by each panel member.

The panel leader has the responsibility of the whole process regarding the preparation of samples to be presented and the measurement session. He/she shall check, prior to the beginning of the session, that the conditioning of the test room fulfils the requirements of 6.8.1. He/she shall also check that the samples are suitable for the purpose of the test.

The panel leader shall explain to the panel members the aim of the test and present the expected time schedule. The panel leader shall manage the assessment and registration of data in such a way that no influence between panel members can be assumed.

The panel leader shall never take part to the rating of the sample odour.

The panel leader shall calculate and report the arithmetic mean of the odour assessments.

## 9.2 Panel selection

The panel members shall not be anosmic. No specific group shall be overrepresented. Subjects can be removed from the panel if there are:

— interpersonal differences in evaluations of the same sample;

— limitations in the sense of smell (i.e. not sensitive enough).

NOTE 1 Limitations in the sense of smell can be tested with a stick (see Annexes E and F).

NOTE 2 In selection of the panel, consider that women generally have a sharper olfactory sense than men and people have greater experience of odours with increasing age. However, after 60 years of age, the sense of smell decreases.

## 9.3 Code of behaviour of the panel members

To qualify as a panel member, the panel leader shall observe and approve the following code of conduct:

— the panel member shall be motivated to carry out his/her job conscientiously;

— the panel member shall be available for a complete measurement session;

— from 30 min before and during measurement, panel members shall not be allowed to smoke, eat, drink (except water) or use chewing gum or sweets;

— panel members shall take great care not to cause any interference with their own perception or that of others in the odour rooms by lack of personal hygiene or the use of perfumes, deodorants, body lotions or cosmetics;

— panel members suffering from a cold or any other ailment affecting their perception of smell (e.g. allergic fits or sinusitis) shall be excluded from participating in measurements;

— panel members shall be present in the odour testing room or in a room with comparable conditions 5 min before the measurements start in order to get adapted to the actual environment of the measuring room;

— panel members shall not communicate with each other about the results of their rating before the measurements are completed.

## 9.4 Panel size and accuracy of the evaluation

### 9.4.1 General

The panel size shall be large enough to meet the requirements of the accuracy of the odour evaluation. The accuracy of the evaluation shall be determined by the standard deviation of the given assessments and the panel size (see Annex B).

### 9.4.2 Acceptability

The minimum panel size is 15 untrained members. The evaluation expressed by the 90 % confidence interval shall be within ±0,2 for evaluations in the range of −1 to 1. If the first round of the evaluation does not meet the required accuracy, the test result shall be confirmed with an additional 15 members within 30 h of the first assessment.

### 9.4.3 Perceived odour intensity

The minimum panel size is eight trained members. The accuracy of the evaluation expressed by the 90 % confidence interval shall be within ±2 pi.

If the first round of the evaluation does not meet the required accuracy, a second round of testing with additional members shall be carried out within 30 h of the first assessment (in accordance with EN 13725) in order to reach the defined accuracy of the evaluation.

If hedonic tone is required, the minimum panel size is eight untrained members. The accuracy of the evaluation expressed by the 90 % confidence interval shall be within ±1.

# 10 Odour assessment

## 10.1 General

The odour assessment described in this part of ISO 16000 involves two optional methods:

a) rating of the acceptability by an untrained panel;

b) rating of perceived intensity by a trained panel.

This part of ISO 16000 also gives, if required, a complementary method of rating the hedonic tone using an untrained panel.

## 10.2 Acceptability using an untrained panel

### 10.2.1 General

The acceptability of the odour caused by the emission from building products is assessed by an untrained panel, the size of which is defined in 9.4; the acceptability is calculated by 10.2.3.

### 10.2.2 Assessment procedure

**10.2.2.1** The untrained panel assesses the acceptability of the air released from the test chamber via a diffuser or mask or from a sample container.

The panel members shall be carefully instructed in using the evaluation form in Annex I so that it is filled in correctly. The assessment is carried out in the following two phases, where the test room air quality is first assessed and then continued to assess the building product odour from the test chamber.

a) Firstly, the panel members shall assess the air quality of the test room using the form in Annex I[15]. The panel members mark their assessment on a continuous biphasic 20 point visual scale ranging from “clearly acceptable” to “clearly unacceptable” by recording their assessment on the evaluation form in Annex I.

b) If the test room air quality is acceptable (see 5.1 and 6.8.1), the assessment process is continued by assessing the acceptability of the building product emissions from the test chamber. In other cases, actions shall be taken to improve the test room air quality.

Before assessing the building product odour, the panel members shall wait in the test room for at least 2 min before the first evaluation of the test chamber air. Then, the panel members place their noses inside the diffuser and make the assessment.

**10.2.2.2** As a basis for assessing of the acceptability of the emissions, the panel members shall answer the following question.

— “Assuming that you, daily, for several hours, are exposed to the air from the test chamber, how acceptable is the air quality?”

The panel members mark their assessment on the continuous biphasic visual scale ranging from “clearly acceptable” to “clearly unacceptable” by recording their assessment on the evaluation form in Annex I.

The members of the panel shall not discuss their evaluations with each other during the sensory assessments.

NOTE 1 The number of the panel members simultaneously present in the test room depends on the ventilation rate (see 6.8.4).

NOTE 2 The acceptability is not determined simultaneously with the assessment of the intensity.

#### 10.2.3 Calculation of the odour acceptability

For calculation, both parts of scales are divided into equal segments. Each segment is numbered so that “clearly acceptable” is given the numerical value +1. Correspondingly, “clearly unacceptable” is given the value of -1. The resolution of the scale is 0,05.

The arithmetic mean of the assessments represents the acceptability of the building product odour emission.

### 10.3 Perceived odour intensity

#### 10.3.1 Method

##### 10.3.1.1 General

The perceived intensity, $\Pi$, is determined by comparing the intensity of the sample with different specified intensities of the reference substance (e.g. acetone, quality grade: 99,8 %). The smelling capability varies from human to human. The use of comparative sources reduces the inter-individual variance of the test result since all panel members evaluate the odour intensity based on the same reference scale.

##### 10.3.1.2 Perceived intensity unit and comparative scale

The unit of $\Pi$ is pi. The comparative scale consists of reference substance-air mixtures. The comparative scale of intensity is defined by the following points:

— 0 pi = odour threshold concentration of the acetone-air mixtures (e.g. 20 mg acetone/$m^3$ air) at which 50 % of the panel can perceive the odour acetone (acetone quality grade: 99,8 %).

— Concentrations for 1 pi to $n$ pi follow a linear gradation of the acetone concentrations.

The acetone-air-mixture concentration shall be stable over time. Maximum change is 0,5 pi. Six different mixes of acetone concentrations in the range of between 20 mg/$m^3$ (= 0 pi) and 320 mg/$m^3$ (= 15 pi) help the panel members gain their orientation in determining the perceived intensity of an unknown sample. If the odour of the sample is higher than 15 pi, the range shall be extended.

Higher concentrations may be used, if needed.

It is possible to use other reference substances [e.g. *n*-butanol (spectroscopic grade)]. In this case, validation shall be carried out using the acetone scale.

#### 10.3.2 Panel training and performance tests

##### 10.3.2.1 Panel training

A panel shall be trained on the comparative scale of perceived odour intensity as a function of the reference concentrations. The panel members shall be familiarized with the type of target unknown material odours. This is necessary for the panel to be able to make accurate reproducible measurements with a small standard deviation.

The training occurs over five days. An overview of the training programme is given in Annex G.

##### 10.3.2.2 Performance test

After the training and during the real measurements, the panel members shall measure at least two different unknown acetone samples. The panel members shall be informed about the results of this test, so that they can see whether their determinations are too high or too low. The panel member shall always fulfil the required selection criterion for the perceived intensity of the acetone measurements. Thus, the performance and intra-individual variance of every single panel member can be verified. The scaling is conducted in the same way for unknown acetone samples as for unknown material odour samples.

A member shall be removed from the panel if there are:

— too large interpersonal differences to the rest of the panel in performance,

— limitations in the sense of smell.

The history and follow-up of each panel member shall be documented.

#### 10.3.3 Assessment procedure

At the beginning of every measurement session, the panel members shall smell once at every reference concentration provided for the comparative scale.

Firstly, the panel members shall smell the unknown sample once. After this inhalation, they shall decide in which range of the comparative scale they would match the intensity of the unknown sample. In doing this, they should smell at the corresponding reference concentrations in increasing order. To minimize adaptation effects, the panel members shall smell at clean air (see 6.3) before smelling at the sample again and before smelling at a lower reference concentration or whenever the panel members need to flush their noses. The scaling task should not exceed 90 s per panel member. After a panel member has finished the scaling task, a single measurement value is written in a form (if possible, an electronic form). If it is not possible to achieve a measurement value within the 90 s, the panel member may conduct the measurement again after a "nose relaxation" period of 5 min.

The mean value of the evaluation of the group, the standard deviation is calculated at the end. At the beginning of every measurement session, the panel members shall smell once at every reference concentration provided for the comparative number scale. Afterwards, the panel members shall measure at least two different unknown acetone samples. The panel members shall be informed about the results of this test, so that they can see whether their determinations are too high or too low.

The arithmetic mean of the eight assessments represents the intensity of the building product odour emission.

### 10.4 Complementary method — Hedonic tone using an untrained panel

The emotional effect of an odour can be described with the hedonic tone. The hedonic tone describes whether the odour is perceived as pleasant or unpleasant. The determination of hedonic tone of an odour sample may be taken as an indication of its nuisance effect.

As a basis for voting for the hedonic tone of the emissions, the panel members shall answer the following question.

— "Assuming that you, daily for several hours, are exposed to the air from the test chamber, how pleasant is the air quality?"

The assessment shall be carried out with whole-numbers from the nine-point scale from -4 meaning unpleasant to +4 meaning pleasant (see Annex J).

The hedonic tone shall not be determined simultaneously with the assessment of the intensity.

## 11 Test report

The test report shall include at least the following information:

a) test laboratory:

   1) name and address of the laboratory;

   2) name of the responsible person;

3) description of the equipment and methods used (test chamber, clean air system, environmental control, sample collection, analytical instrumentation, standard generation and calibration);

b) sample description:

1) type of product (and brand name if appropriate);

2) sample selection process (e.g. random);

3) product history (date of production, date of arrival to the test laboratory);

c) test specimen preparation:

1) date and time of unpacking and test specimens preparation (hour, day, month and year);

2) method of preparation, including thickness and substrate, including for liquid products, the substrate, the amount per unit area and/or the thickness and other relevant information;

d) experimental conditions and procedures:

1) chamber conditions (temperature, relative humidity, air exchange rate, supply air flow rate);

2) test specimen area and loading ratio;

3) sensory panel;

e) results:

1) method 1 — Odour acceptability:

i) arithmetic mean of the acceptability assessments;

ii) uncertainty/accuracy (standard deviation, number of panel members, etc.);

iii) acceptability of the test chamber or sampling bag background odour;

2) method 2 — Perceived odour intensity:

i) arithmetic mean of the perceived intensity assessments;

ii) uncertainties/accuracy (standard deviation, number of panel members, etc.);

iii) intensity of the test chamber or sampling bag background odour;

3) Complementary method — Hedonic tone, if required:

i) arithmetic mean of the hedonic tone assessments;

ii) uncertainty/accuracy (standard deviation, number of panel members, etc.);

iii) hedonic tone of the test chamber or sampling bag background odour;

f) Quality assurance/quality control: quality of the environmental variables (temperature, relative humidity, air exchange rate, air velocity).

# Annex A
(normative)

# System for quality assurance/quality control

## A.1 General

Small chamber testing of organic emissions from indoor materials/products shall be conducted within the framework of a quality assurance project plan (QAPP). The QAPP shall contain a project description, data quality objectives/acceptance criteria, quality assurance/quality control (QA/QC) approaches/activities and QA/QC audits.

## A.2 Project description

A brief description shall include the materials which are being tested, how the testing is being conducted and who is responsible for various project activities. The project experimental design should contain the necessary information for this portion of the QAPP.

## A.3 Data quality objectives and acceptance criteria

The data quality objectives and acceptance criteria (of the QAPP) define the precision, accuracy and completeness desired for each parameter being measured.

## A.4 QA/QC approaches/activities

The types of QA/QC activities which can be specified in the QAPP include the establishment of a system of records/notebooks to ensure proper operation of equipment and recording of data, such as:

— sample log to record receipt, storage and disposition of materials;

— instrument maintenance logs to document maintenance and repairs of all equipment;

— materials testing logs, in which to record all pertinent information for each test, including sample details, sample ID number and GC run ID number;

— floppy disk or CD storage log to document location and content of electronically stored data;

— manuals governing operation of all equipment used by the project.

QC activities are carried out by project staff in a routine, consistent manner to provide necessary feedback in the operation of all measurement systems. Such activities can include routine maintenance QA/QC audits.

## A.5 QA/QC audits

Finally, the QA/QC programme shall include periodic audits by QA personnel to evaluate compliance with QAPP protocols.

# Annex B
(informative)

# Statistical background

## B.1 General

For the maintenance of a desired level of accuracy for sensory olfactory tests with panels of test subjects, it is necessary that certain limits set for the employed olfactory measurands not be exceeded. This can be achieved with a predetermined confidence interval.

Perceptual units (PUs) having an unlimited or limited continuous scale (such as visual analogue scales) can be considered to have a roughly normal distribution, even though this is only true for unlimited scales. For normally distributed PUs, the mean value of each set of evaluations, μ, can only be approximated with the estimated mean value, $\bar{x}$ , as given by Formula (B.1).

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i \tag{B.1}$$

where

$n$ is the number of panel members;

$x_i$ is the assessment in the perceptual unit of panel member $i$.

The precision of the determination of the distance between the predetermined limit and the mean value is influenced by the parameters panel size, $n$, the probability of error, $\alpha$, and the estimated standard deviation, $s$, of the evaluations of the panel. A probability of error of $\alpha$ = 10 % is used for olfactory tests according to this part of ISO 16000.

The estimated standard deviation, $s$, is calculated using Formula (B.2):

$$s = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}\left(x_i - \bar{x}\right)^2} \tag{B.2}$$

The type of olfactory measurand used and the corresponding scale have an influence on the choice of the distribution model and thus on the calculation of the confidence interval. Many olfactory measurands are considered to have roughly a normal distribution. If the variance of the panel evaluations is unknown, the Student's $t$-distribution is to be used for statistical inferences instead of the normal distribution. The Student's $t$-distribution approaches the normal distribution for large number of evaluations. The $t$-distribution can thus be used for inferences with small or large panel sizes.

## B.2 Accuracy of the assessments

The accuracy achieved through the sensory olfactory tests conducted by the panel member can be expressed by means of a confidence interval. Here, it is assumed that the observed criteria are distributed normally. The two-sided confidence interval for the true value of μ is the random interval around the estimated mean value $\bar{x}$, which, with a statistical certainty of (1 - $\alpha$), contains the actual mean value μ:

$$P\left(\mu \in \left[\bar{x} \pm \frac{s}{\sqrt{n}} \cdot t_{(1-\alpha/2);n-1}\right]\right) = (1-\alpha) \tag{B.3}$$

where

$t_{(1-\alpha/2);n-1}$ presents the $(1-\alpha/2)$-percentile of the $t$-distribution;

$n$ is the number of panel members;

$\alpha$ is the probability of error;

$P$ is the probability.

This is used to determine concrete interval limits on the basis of panel assessments, as given by Formula (B.4):

$$\left[\bar{x} - \frac{s}{\sqrt{n}} \cdot t_{(1-\alpha/2);n-1}; \bar{x} + \frac{s}{\sqrt{n}} \cdot t_{(1-\alpha/2);n-1}\right] \tag{B.4}$$

The achievable confidence interval for sensory olfactory tests is determined by the panel size, the estimated standard deviation of the evaluations of the panellists and $\alpha$, the probability of error. An increase in the size of the panel gives a narrower confidence interval.

Confidence intervals can also be applied as a measure for the accuracy of the standard deviation.

If the half width of the estimated confidence interval:

$$d = \frac{s}{\sqrt{n}} \cdot t_{(1-\alpha/2);n-1} \tag{B.5}$$

is given, then the sample size, i.e. the minimum necessary panel size, can be determined iteratively [see Formula (B.6)]:

$$\lceil n_{i+1} \rceil \geq \left[\frac{s}{d} \cdot t_{(1-\alpha/2);n_i-1}\right]^2 \tag{B.6}$$

with $i$ = 0,... and $n_0$= ∞.

The iteration ends when either the sample size does not change for two consecutive iterations or a predetermined number of iterations has been reached.

If the level of accuracy achieved in the assessments is too low, the testing is to be repeated with a larger panel. The increase in the number of panel members can take place without repetition of the tests, if the additional panel members can perform the assessments under the same conditions within two days of the original tests. If this is the case, the results of the testing may be combined.

# Annex C
(informative)

# Examples of diffuser and mask used for odour evaluation

**Figure C.1 — Diffuser**

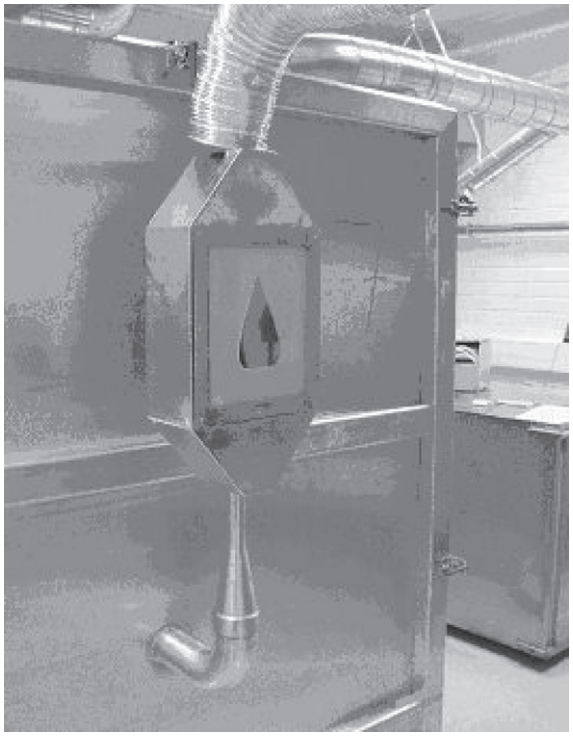


**Figure C.2 — Mask**

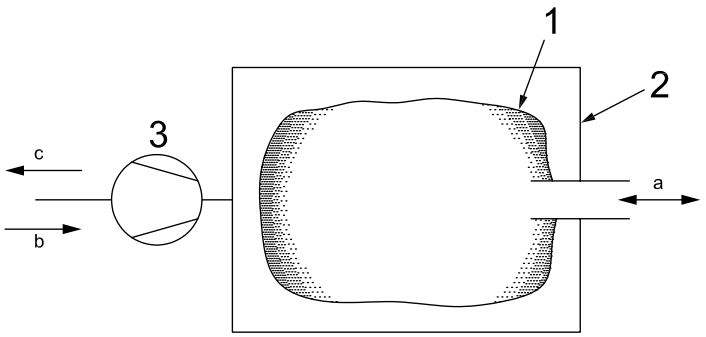
# Annex D
(informative)

# Description of a possible sampling and presentation device for air samples collected at the emission chamber outlet

## D.1 Sampling and presentation device using Tedlar®

The sampling system guarantees that the composition of the sampled air does not change over time. The sampled air is only allowed to pass through materials made of stainless steel, polytetrafluoroethene or glass during the sampling process and is then stored directly in a sample container. It is intended that the stainless steel tubes be as short as possible to avoid adsorption effects on the surface of the tube. The system needs no internal air pumps, which is also very important to guarantee the fewest possible changes in the composition of the sampled air. The air flow is driven by a fan, which changes the pressure in the environment of the sample container (see Figure D.1). The sample container is installed in the sampling system with only one opening for the sampling and presenting procedure. This system guarantees that the sampled air is not affected by any chemical components of the fans or casing. The volume of about 300 l of the sample container ensures that a group of up to 12 persons can investigate the perceived intensity of the sample (two containers for the acceptability or hedonic tone method). The casing is to be chosen in a way that the container fits in. One example of a casing is the use of an aluminium casing with the dimensions of 1 200 mm × 800 mm × 510 mm.

It is possible to control the air flow. The air flow is calculated with a pressure measurement and shown on a display. The air flow is adjustable. A button is installed on the casing for the panel member, so that the sample air flows only when a person presses the button. The panel members thus have more time for their evaluation. In between tests, the air flow rate is reduced to a minimum.




**Key**

1 sampling bag
2 casing
3 fan
a Air sample in or out.
b Deflating.
c Filling.

**Figure D.1 — Diagram illustrating the principle of the AirProbe[3)] [16] sampling system**

3) AirProbe, which is manufactured by the University of Berlin, is an example of a suitable product available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of this product. Equivalent products may be used if they can be shown to lead to the same results.

## D.2 Sample container

The sample container is made from Tedlar® [1]. The capacity of the container is around 300 l. The material is to be heated for 12 h with a temperature of 80 °C before use. After heating the container it is to be welded. After each use it is possible to clean the container by heating it with 80°C warm air for 3 h. The air washes the container during the heating time. The cleaned containers have to be stored airless and in a room without other contaminates. Before using them again, the containers are to be flushed with clean warm 80 °C air for 1 h again. For all mentioned container materials, it is advisable to apply this cleaning method after the use of the container: Tedlar® [1] Polyvinylfluorid (PVF, transparent), in a thickness of 0,05 µm or 0,025 µm.

It is possible to sample the air with the AirProbe or directly at the outlet of the emission chamber. It is to be guaranteed that the container is filled completely with the air out of the emission chamber; therefore, it is necessary to fill the container with the AirProbe three times before using it. The bag should be conditioned by filling it with the sample at least twice and evacuating it again or by flushing it with the sample air for an appropriate amount of time (depending on the capacity of the bag). A possible container form is shown in Figure D.2.

In EN 13725, the following other container materials are mentioned:

— Copolymer out of polytetrafluoroethene and hexafluorpropylen (FEP);

— Polyethylenteraphthalat [PET, Nalophan® [2]];

— Tedlar® [1] Polyvinylfluorid (PVF).

It is expected that all sample containers be tested for airtightness and odourlessness before use.

After the container is filled,  the odour test shall be carried out as soon as possible, at the latest after 30 h.

For the odourlessness test, fill the bag with neutral fresh air and test the odour of the bag after 4 h to 12 h. For the acceptability scale, the odour is expected to be acceptable, i.e. > 0,1 and for the intensity method, the mean average shall be ≤ 3 pi.

Dimensions in millimetres

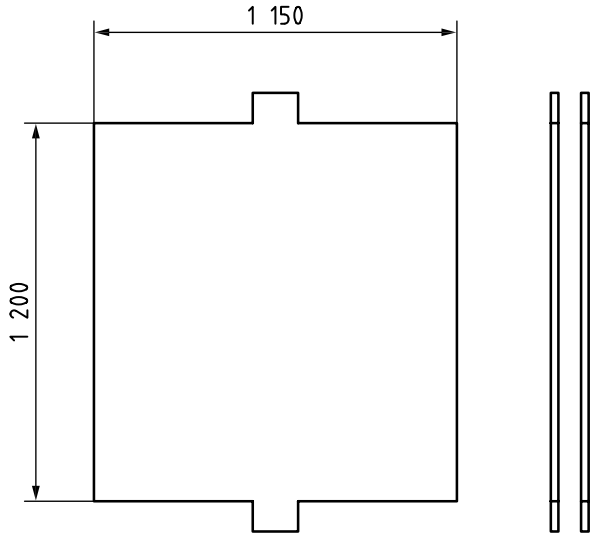



**Figure D.2 — Sectional drawing of the sample container**

**Figure D.3 — Photograph of the sample container used[16]**

## D.3 Validation procedure for new materials

Various tests, based on analytical methods and sensory measurements, are to be performed for the selection of the optimal container material.

a) The first analytical test guarantees that the materials themselves do not pollute the air during the storage time.

b) The permeation and adsorption behaviour of the container materials is to be tested using, for instance, ten different selected VOCs in three different experimental set-ups. The investigated VOCs are listed according to their boiling points in Table D.1. The VOCs are selected because they are typical emissions from building materials and have a wide range of boiling points.

The odour thresholds given in Table D.1 are taken from the VOC-Base[17].

**Table D.1 — VOCs for use in analytical tests**

| Class | Substance | Totals formula | Molar mass g/mol | Boiling point °C | Odour threshold ppb | Odour threshold µg/m³ |
|---|---|---|---|---|---|---|
| Ketones | Acetone | $C_3H_6O$ | 58,08 | 56,5 | 4 580 | 13 900 |
| Esters | *n*-Butyl acetate | $C_6H_{12}O_2$ | 116,16 | 126,1 | 6,6 | 47 |
| Aldehydes | Hexanal | $C_6H_{12}O$ | 100,16 | 131 | 13,8 | 57,5 |
| Alcohols | 1-Pentanol | $C_5H_{12}O$ | 88,15 | 137,9 | 5,1 | 20 |
| Aromatic hydrocarbons | o-Xylene | $C_8H_{10}$ | 106,17 | 144,5 | 490 | 2 140 |
| Terpenes | $\alpha$-Pinene | $C_{10}H_{16}$ | 136,24 | 155 | 692 | 3 890 |
| Glycol ethers | 2-Butoxy ethanol | $C_6H_{14}O_2$ | 118,18 | 171 | 0,97 | 5,10 |
| Alkanes | *n*-Decane | $C_{10}H_{22}$ | 142,29 | 174,1 | 741 | 4 370 |
| Alcohols | Benzyl alcohol | $C_7H_8O$ | 108,14 | 205,3 | 5 550 | 25 000 |
| Glycol esters | Butyl diglycol acetate | $C_{10}H_{20}O_4$ | 204,27 | 245 | 1,6 | 15 |

## D.4 Experimental set-up of the analytical investigations

### D.4.1 First analytical investigation

Test the emission from the material itself. The containers are to be filled with clean air (free of emissions). The air is stored over 24 h. Before closing the back and after 24 h, an analytical test is to take place and after 24 h,

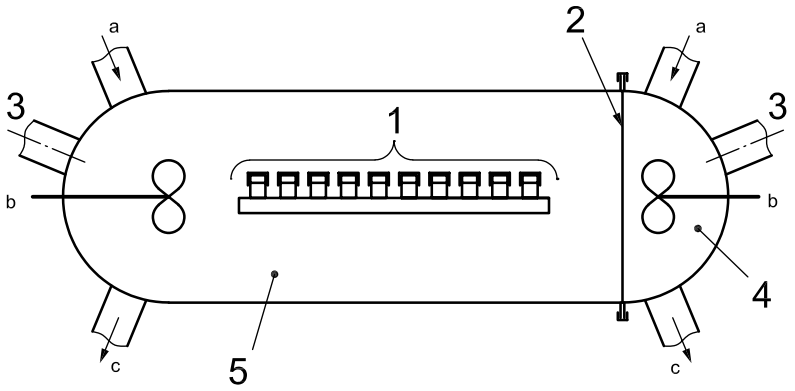
also a sensory test. If there is any odour emitted from the material, it is not suitable for use in odour testing. A cleaning procedure is to be tested.

### D.4.2 Second investigation

Ten VOCs (see Table D.1) are to be injected into the container. The decrease in the concentration of the VOCs is to be measured over a period of up to two days.

### D.4.3 Third investigation

The chamber experiment, focuses on the permeation of the VOCs through the container material. For this, a special test facility is to be designed (see Figure D.4). A chamber is divided into two parts by the container material. The sources with the VOCs are placed in the first part of the chamber (see Figure D.4). Applying a constant air flow rate leads to defined concentrations of the substances inside the first part of the chamber. The second part of the chamber contains only clean air at the beginning of the experiment. The concentrations of the substances are to be tested over a period of up to seven days on both sides of the chamber. The detected substances in the second part of the chamber are substances which have permeated the container material. With this method, it is possible to calculate permeation coefficients at atmospheric air pressure. The standard permeation coefficient for plastic material is normally investigated under vacuum conditions.



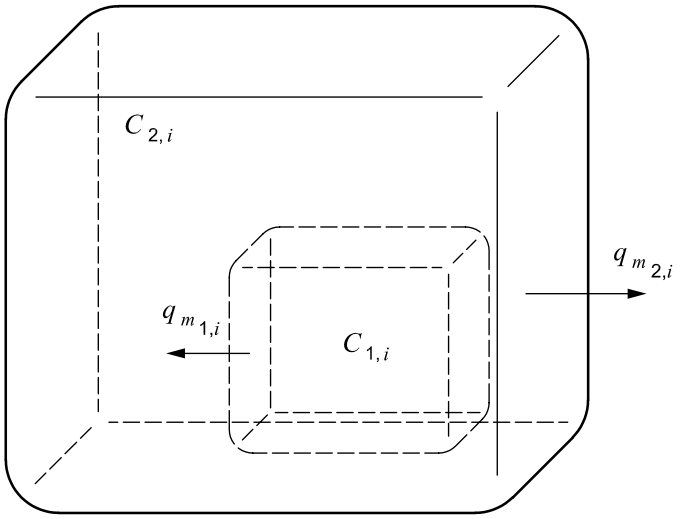

**Key**

1 10 VOCs/substances
2 material
3 sampling area
4 second part of chamber
5 first part of chamber
a Inlet of clean air.
b Mixing.
c Outlet of exhaust air.

**Figure D.4 — Chamber for testing permeation effects**

### D.4.4 Fourth investigation

A small container is to be constructed and filled with VOCs and air. The small closed container is to be placed in a bigger outer container filled with clean air (see Figure D.5). The decrease in the VOC concentration in the small container is to be measured on the first day and after seven days at the end of the investigations. The increase in the concentration of VOCs in the outer container is to be tested every day during the test period. This test shows the permeation effects of the materials in combination with leakage and adsorption effects.




**Key**

| | |
|---|---|
| $C_{1,i}$ | concentration 1 of compound $i$ |
| $q_{m_{1,i}}$ | mass flow 1 of compound $i$ |
| $C_{2,i}$ | concentration 2 of compound $i$ |
| $q_{m_{2,i}}$ | mass flow 2 of compound $i$ |

**Figure D.5 — Principle figure of “container in container” experiment**

The material can be used for odour tests if less than 20 % change in the starting concentration is reached over a test period of two days.

# Annex E
(informative)

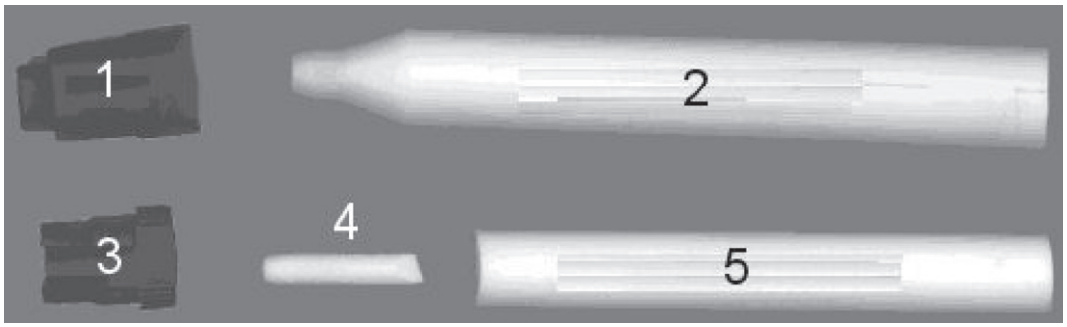
# Panel selection using the stick method

## E.1 General

A panel member is to be tested for normal olfactory functioning before the first odour test according to method 1 ("Sniffin' Sticks")[18] or method 2 (Olfactometer; see E.3). Panel members who did not pass the test are allowed to repeat it, for example following an illness. Only panel members with normal olfactory function should be used for odour measurements.

## E.2 Screening of olfactory function with "Sniffin' Sticks"

To test the olfactory function of the panel members, the "Sniffin' Sticks" test[4] can be used. The test relies on pen-like odour dispensing devices.




**Key**

1 cap
2 body of the pen
3 plug
4 felt tip
5 tampon

**Figure E.1 — Photograph of a "Sniffing' Stick"[19]**

## E.3 Testing olfactory function with olfactometry in accordance with EN 13725

Measurements at the olfactometer may be carried out in accordance with EN 13725. In order to select panel members with average odour sensitivity, it is intended that results be obtained from at least 10 dilution series with test gas *n*-butanol (of spectroscopic grade) in nitrogen (CAS No. 71-36-3). The data for each individual panel member is to be collected on three different, non-consecutive days. The panel member is expected to satisfy the following eligibility requirements (see EN 13725).

The measurement performance of each panel member is to be recorded and kept. To this end, at least three dilution series with this reference substance is to be measured with each panel member about every six months. The results of this reference measurement are used to supplement and evaluate the measurement performance of the panel member in question. Evaluation is carried out by calculating the above-mentioned

4) The Sniffin' Sticks test, which is manufactured by Burghart GmbH, Germany, is an example of a suitable product available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of this product. Equivalent products may be used if they can be shown to lead to the same results.

selection parameters from at least the 10, and at most the 20, most recent dilution series (see EN 13725). After this, the results are to be compared with the selection criteria. If the panel member fails to satisfy the conditions, he/she is excluded from all future measurements until he/she again satisfies the conditions.

## E.4 Supplementary tests

To test and train the powers of discrimination of panel members, it is advisable to apply additional test methods[1] [6]–[11].

a) The quality test checks whether or not the panel member is capable of correctly assigning given terms to the odour quality of certain common odorants[10].

b) For the odour intensity test, the panel member is expected to correctly rank, in ascending order of intensity, odour samples whose odorant concentration differs by a factor of 10 in each case (smelling bottles)[9] [11].

# Annex F
(informative)

# Panel selection using five standard odorants

## F.1 General

In order to select a panel member having normal olfactory function, panel members are to be screened using five standard dilution liquids. These standard odorants are called the “T&T olfactometer”.

## F.2 Five standard odorants

The five standard odorants are: β-phenyl ethyl alcohol, methyl cyclopentenolone, isovaleic acid, γ-undecalactone and skatole. Table F.1 shows the concentration (the dilution liquid is odour-free liquid paraffin) and odour quality of these five standard odorants.

**Table F.1 — Mass fraction and odour quality of the five standard odorants**

| Name of odorant | Mass fraction<br>% | Qualities of the odour |
|---|---|---|
| β-Phenyl ethyl alcohol | 10 to 4,0 | Odour of rose; light, sweet odour |
| Methyl cyclopentenolone | 10 to 4,5 | Burnt odour, caramel odour |
| Isovaleic acid | 10 to 5,0 | Putrid odour, odour of long-worn socks,<br>odour of sweat, odour of fermented soybeans |
| γ-Undecalactone | 10 to 4,5 | Odour of canned peaches; heavy, sweet odour |
| Skatole | 10 to 5,0 | Odour of vegetable garbage, oral odour, repulsive odour |

## F.3 Test room

The test room in which the panel screening test is conducted shall fulfil the following conditions.

a) The room is to be free of any odour and noise, and is to be a comfortable place where the panel members are not subjected to any kind of psychological stress during the test.

b) No person is to be permitted to enter the test room except for the panel leader and the panel members.

c) The temperature and relative humidity is to be well controlled. The temperature in summer should be less than 25 °C, and the temperature in winter should be over 17 °C. The relative humidity should be between 40 % and 70 %.

## F.4 Panel members

Panel members are to be at least 18 years old and not be anosmatic. They observe the following matters:

a) panel members take great care not to use perfumes, deodorants or cosmetics on the day of the test;

b) panel members are to be present and should relax in a waiting room at least 10 min before the test;

c) panel members do not communicate with each other about the standard odorants.

## F.5 Procedure of test

a) The method is used as the procedure for the panel screening test.

b) Five odour-free papers (size: 14 cm × 7 mm) are prepared. The panel leader soaks the top 1 cm of two papers in a standard odorant liquid. The others three papers are soaked in the odour-free liquid paraffin using the same method. The five papers are presented to each panel member. After sniffing each paper, the panel member identifies the two papers which contain the odour.

c) Each panel member is to be tested for the five standard odorants using this same test method.

d) The panel member who answers all five standard odorants completely correctly is to be deemed to have passed the panel screening test (see Figure F.1).

**Figure F.1 — Screening of panel members using the five standard odorants**

# Annex G
(informative)

# Training procedure for the comparative scale

## G.1 Training procedure for intensity assessment using a comparative scale

The evaluation of perceived intensity using a comparative scale according to 10.3 requires that the panel members be trained. The goal of the training is to familiarize the panel members with the assessment method and the reference substance. A calibration is conducted before each test (see 10.3) and serves as a regular monitor of the training of the panel. An condensed training course (consisting of days 4 and 5 in Table G.1) should be carried out at least once a year and when a panel member has not performed any tests for more than three months. An additional complete version of the five-day training is to be conducted when:

— new members are introduced to the panel, and

— the calibration before the test exhibits large discrepancies and the standard deviation of the panel becomes too great.

The training programme encompasses a set of tests over five days. During the five days, the panel members are to familiarize themselves with the method. The success of the training is assessed by means of the samples provided to the panel members on the final two days. Only those panel members who pass the test are considered to be trained and can take part in sensory tests for perceived intensity.

A prerequisite for the training is the testing of the olfactory function of the panel members (see Annex E).

An overview of the training programme is provided in Table G.1. The sensory olfactory tests last approximately two to three hours per day of training. The condensed training course is made up of the final two days of the programme.

On the first day of training, the panel receives an explanation of the assessment procedure and the use of the comparative scale. Each panel member then assesses the odour intensity of eight different acetone concentrations. The person conducting the experiments chooses these concentrations, such that they are distributed over the entire range of concentrations (e.g. 2 pi to 15 pi). After the assessments, the panel members are informed of the actual intensity levels of the concentrations in pi. If the assessment of a panel member deviates significantly from the actual pi value, he/she is given the opportunity to smell the acetone concentration again with the knowledge of the actual pi value.

**Table G.1 — Example of a programme for training panels**

| Training day | Topic | Task |
|---|---|---|
| Day 1 | Presentation of the training programme<br>Familiarization | Eight times: sample air with different acetone concentrations |
| Day 2 | Training<br>Familiarization with assessment of building products | Four times: sample air with different acetone concentrations<br>Four times: sample air from building products |
| Day 3 | Training<br>Familiarization with the testing procedure | Two times: sample air with different acetone concentrations (calibration)<br>Six times: sample air from building products |
| Day 4 | Testing cycle to determine the results of the training programme | Two times: sample air with different acetone concentrations (calibration)<br>Four times: sample air with different acetone concentrations<br>Two times: sample air from building products |
| Day 5 | Testing cycle to determine the results of the training programme<br>Evaluation of the training programme | Two times: sample air with different acetone concentrations (calibration)<br>Four times: sample air with different acetone concentrations<br>Two times: sample air from building products |

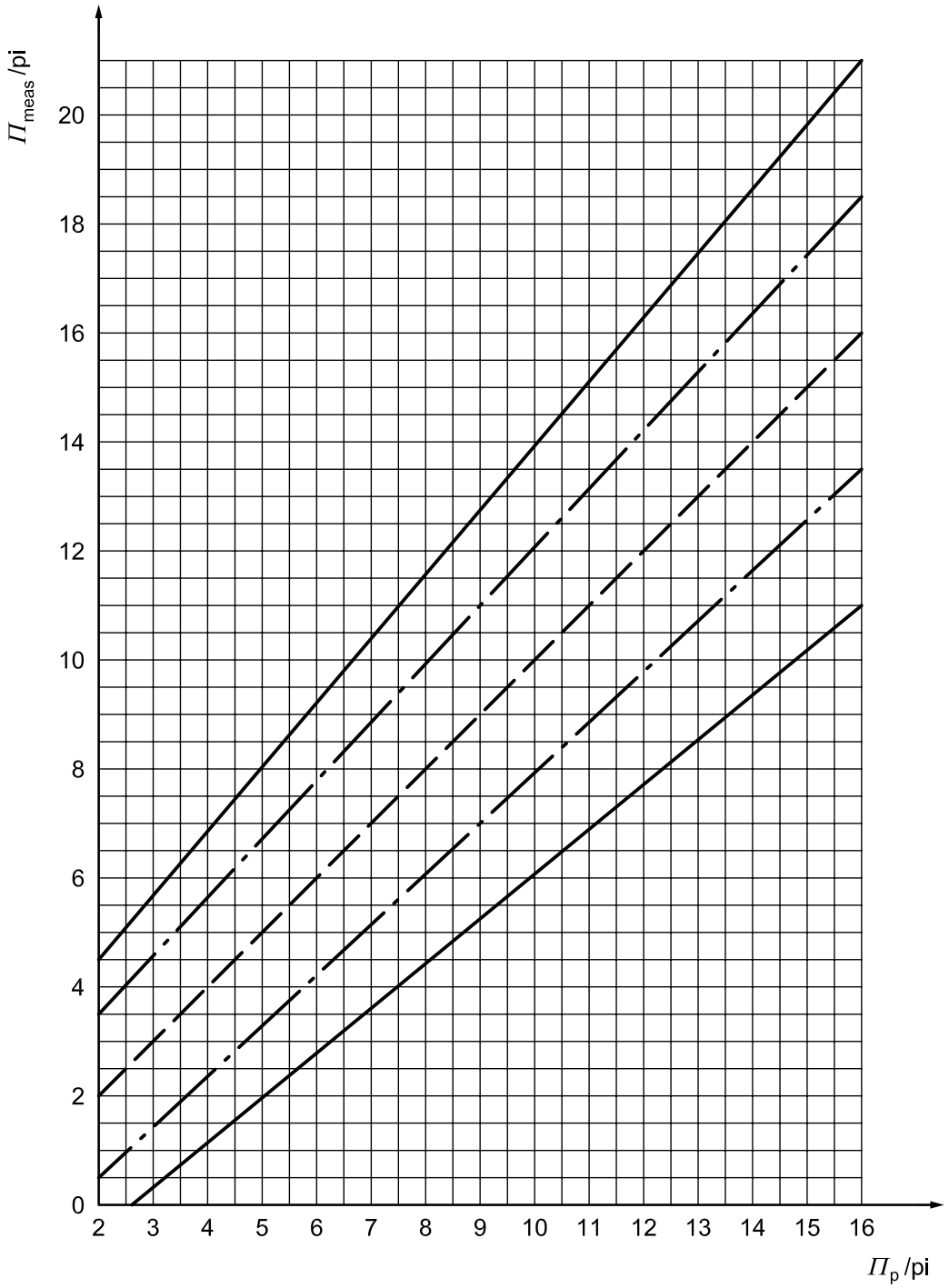
On day two of the training, the panel members are requested to test sample air from building products in addition to the sample air with different acetone concentrations. They are to be trained to rank the intensity of odour samples, which vary from the reference substance on the comparative scale. There is no assigned perceived intensity for these samples; therefore, the assessments of the individual panel members are compared with the mean value of the evaluation of the entire panel. The panel as a whole is evaluated by means of the standard deviation. The panel members are informed of the mean value of the panel on the first three days of training and can, if necessary, smell the unknown sample and the comparative scale again.

On the third day of training, the tests are performed as they are in the actual sensory odour tests according to 10.3. This means that the first two samples of acetone concentrations are provided for calibration, for which the panel member is informed of the actual pi value, so that he/she can correct his/her assessment. Afterwards, unknown samples are tested. On this day, the panel members are informed of the mean value of the panel as a whole.

As of day four, the pi values are only given during the calibration (see 10.3). The panel members are reminded that assessments made on the final two days are considered in the results of the training programme and the success of the panel members. On each of these days, four acetone concentrations and two odour samples from building products are provided.

## G.2 Evaluation of the training programme

The person in charge of the experiments documents the assessments and achievement of each panel member over the entire course of the training programme. It is essential that the panel members be informed about their individual achievements to keep up their motivation. If a panel member does not show any improvement in the first three days of training, he/she can be excluded from the panel before completing the testing cycle. In the evaluation of the training programme, the assessments of the acetone concentrations provided by each panel member on the last two days are plotted on a diagram as presented in Figure G.1, which shows the deviation of the test from the preset pi value and the range of tolerance.




**Key**

| | |
|---|---|
| $\Pi_{meas}$ | measured perceived intensity, in pi |
| $\Pi_p$ | preset perceived intensity, in pi |

**Figure G.1 — Tolerance zone for perceived intensities measured by panel members**

If the assessment is on the dashed line, the evaluation conforms to the preset pi value. The area between the dashed, dotted lines represents the core area. The area outside of the core area, but between the continuous lines, is the rim area. A panel member is considered to have passed the training programme if at least five of the eight acetone samples from the final two days are in the core area. Two or three can be in the rim area, and a maximum of one outside of the continuous lines.

# Annex H
(informative)

# Examples of area-specific air flow rates in a model room

**Table H.1 — Examples of area specific air flow rates in a model room**

| **Model room**[a]<br>Surface area, $A$ | **Loading factor**<br>$L$ [$m^2 \cdot m^{-3}$] | **Area specific air flow rate**<br>$q_{V,A}$<br>$m^3/(m^2 \cdot h)$ or $n/L$ |
|---|---|---|
| Air exchange rate, $n$ = 0,5 $h^{-1}$ [a] | | |
| Model room volume 17,4 $m^3$ | | |
| Floor/ceiling area = 7 $m^2$ [a] | 0,410 | 1,2 |
| Wall area = 24 $m^2$ [a] | 1,4 | 0,4 |
| Sealant area = 0,2 $m^2$ [a] | 0,012 | 44 |
| Window frames, area 0,2 $m^2$ [b] | 0,012 | 44 |
| Door area = 2 $m^2$ [b] | 0,11 | 4,4 |
| a Danish Standard/INF 90[5]<br>b Nordtest 1990[12] | | |

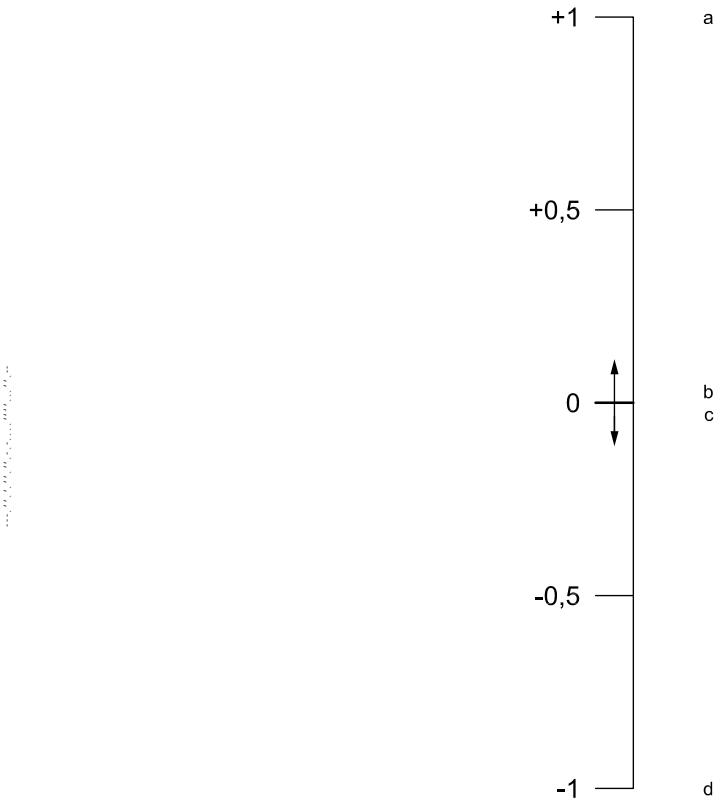
# Annex I
(normative)

# Acceptability scale for an untrained panel

The following is the question posed to each panel member to assess acceptability.

— “Imagine that you, daily for several hours, are exposed to the air from the test chamber. How acceptable is the air quality?”

— Please place a mark on the scale.




**Key**

a Clearly acceptable.
b Just acceptable.
c Just unacceptable.
d Clearly unacceptable.

**Figure I.1 — Acceptability scale for an untrained panel**

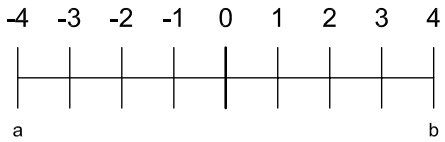
The arithmetic mean of the assessments represents the acceptability of the building product odour emission.

# Annex J
(normative)

## Hedonic scale for an untrained panel

As a basis of voting for the hedonic tone of the emissions, the panel members shall answer the following question.

— “Assuming that you, daily for several hours, are exposed to the air from the test chamber, how pleasant is the air quality?”




**Key**

a Unpleasant.

b Very pleasant.

**Figure J.1 — Hedonic scale**

The arithmetic mean of the eight assessments represents the hedonic tone of the building product odour emission.

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5) Under preparation.

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