# DRAFT SAINT LUCIA NATIONAL STANDARD

## DNS/ISO 16000-30:2014

## Indoor air – Part 30: Sensory testing of indoor air (ISO 16000-30: 2014, IDT

## Stage 40 — ENQUIRY DRAFT

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# DRAFT SAINT LUCIA NATIONAL STANDARD

# DNS/ ISO 16000-30: 2014

## Indoor air – Part 1: General aspects of sampling strategy (ISO 16000-30: 2014, IDT)

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## National Foreword

This newly adopted standard is an identical adoption of *ISO 16000-30:2014* Indoor air – Part 1: General aspects of sampling strategy. This edition of *ISO 16000-30: 2014* was adopted by the National Standards Council as an identical adoption on DD MMM YYYY.

This standard specifies sensory testing and the evaluation of indoor odours using human panels. Testing can be performed in laboratories or on site. It is appropriate for office, administration and residential buildings, assembly halls, as well as other habitable rooms where the health and comfort of occupants is of interest.

Throughout the text of this standard where reference is made to “International Standard” it shall be taken to mean “National Standard” having been adopted as a Saint Lucia National Standard without deviation

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# Contents

Page

**Foreword** ..... **iv**
**Introduction** ..... **vi**
**1 Scope** ..... **1**
**2 Normative references** ..... **1**
**3 Terms, definitions, symbols, units, and abbreviations** ..... **1**
3.1 Terms and definitions ..... 1
3.2 Symbols, units, and abbreviations ..... 3
**4 Objectives of odour evaluations and boundary conditions** ..... **3**
4.1 General ..... 3
4.2 Clarification of the reasons for complaints from room occupants ..... 4
4.3 Determination of odour intensity occurring under special conditions ..... 4
4.4 Identification of sources ..... 4
4.5 Checking the success of remedial activities ..... 4
**5 Principle** ..... **5**
**6 Basic principle of the evaluation of indoor air** ..... **5**
6.1 Evaluation method selection ..... 5
6.2 Combination of evaluation methods ..... 5
6.3 Ways of testing ..... 6
6.4 Selection of the way of testing ..... 6
**7 Sensory test methods** ..... **7**
7.1 Determination of acceptability ..... 7
7.2 Determination of intensity ..... 9
7.3 Determination of the hedonic tone ..... 11
7.4 Odour quality ..... 12
**8 Measurement planning and requirements** ..... **13**
8.1 Selection of panel members ..... 13
8.2 Selection of measuring points ..... 13
8.3 Testing situation ..... 14
8.4 Testing date ..... 15
8.5 Odour-neutral recovery room for the panel ..... 15
8.6 Sampling ..... 15
8.7 Preparation of the testing log ..... 16
**9 Conducting the experiment** ..... **16**
9.1 Preparation ..... 16
9.2 On-site odour testing ..... 16
9.3 Sampling and evaluation in the laboratory ..... 17
**10 Assessment** ..... **18**
10.1 Accuracy of the sensory assessments ..... 18
10.2 Interpretation of the results ..... 19
**11 Documentation** ..... **19**
**Annex A** (normative) **Training procedure for intensity assessments using a comparative scale** ..... **20**
**Annex B** (informative) **Training procedure — Verification of olfactory function** ..... **24**
**Annex C** (informative) **Description of one possibility of a sampling and presenting device for air samples out of emission chambers** ..... **26**
**Annex D** (informative) **Example for the set-up of a comparative scale** ..... **29**
**Bibliography** ..... **30**

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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 meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is 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)*

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

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

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

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

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

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

— *Part 19: Sampling strategy for moulds*

— *Part 20: Detection and enumeration of moulds — Determination of total spore count*

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

— *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 ($CO_2$)*

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

— *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 buildings for pollutants and other injurious factors — Inspections*

The following parts are under preparation:

— *Part 33: Determination of phthalates with gas chromatography/mass spectrometry (GC/MS)*

— *Part 34: Strategies for the measurement of airborne particles (PM 2,5 fraction)*

— *Part 35: Measurement of polybrominated diphenylether, hexabromocyclododecane and hexabromobenzene*

— *Part 36: Test method for the reduction rate of airborne bacteria by air purifiers using a test chamber*

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# Introduction

Buildings are constructed airtight for reasons of energy saving and efficiency. The natural ventilation by infiltration and windows in airtight buildings does not ensure a sufficient air exchange for the well-being of the occupants and to remove moisture. Indoor odours are more frequently becoming a cause for user complaints. The sources of odours are mainly found inside, but odours also can be brought in from outside the building. These include construction products, materials for interior design, and furnishing including their emission and decomposition products, technical equipment, structural damage, animals, and the occupants themselves. In closed rooms, persistent odours, the existence of which occupants cannot control, are mostly considered objectionable. Exposure to such odours can lead to a decline in both the well-being and productivity of the occupants.

This part of ISO 16000 describes the procedure for the determination of indoor odours with trained or untrained panels. It describes assessment methods and planning, preparation, and execution of the olfactory tests. It also includes criteria and requirements for selection of panel members.

The methods can be applied to sensory evaluation with regard to acceptability, intensity, and hedonics. Olfactory tests of indoor air can either be conducted on site or in a laboratory. In the latter case, air is collected from the site and transported to the laboratory in sampling containers. It is necessary to record the physical conditions in the room during the testing or the sampling of the air, as they can influence the perception of the odours.

Odour testing can be required for hygiene evaluations of indoor air. The evaluation of the reasonability of an odour is an essential part of such an examination.

For the overall assessment of the indoor air, it is recommended that chemical tests be carried out in addition to the sensory tests. This is due to the fact that sensory tests do not provide information about possible health hazards. Chemical analyses are not discussed in this part of ISO 16000.

This part of ISO 16000 is based on VDI 4302-1[12] and VDI 4302-2.[13]

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# Indoor air —

# Part 30:
# Sensory testing of indoor air

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## 1 Scope

This part of ISO 16000 specifies sensory testing and the evaluation of indoor odours using human panels. Sensory testing can be performed on site or in laboratories; in the latter case, by means of air in sampling containers which were collected from the site.

The olfactory testing is appropriate for office and administration buildings, assembly halls, residential buildings, and other habitable rooms in which the comfort and health of the occupants is of interest. The test criteria in this part of ISO 16000 are not applicable to factory buildings and workshops or other rooms in which odours unavoidably stem from the production processes (kitchens, bakeries etc.). If an odour evaluation of such rooms is undertaken without the odour-producing processes, it is necessary to take into account that there is a possibility that the processes have influenced and changed the odour of the room through the adsorption of odorous compounds.

Sensory odour tests of indoor air can meet a variety of objectives. These include finding the cause(s) of unpleasant or objectionable odours, determining the reasonability of odours and the usability of affected rooms, and inspecting the results of renovation work. When seeking the cause of odours, it is wise to conduct additional laboratory tests on samples of the component materials according to ISO 16000-28. In the process of locating odour sources by means of olfactory tests, it is necessary to take into account the fact that the odour compounds can accumulate on other surfaces, which exacerbates the problem.

NOTE A risk assessment is intended to be carried out to clarify that no harmful compounds are present in the room. In some countries, an ethics committee can require this.

## 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 5496, *Sensory analysis — Methodology — Initiation and training of assessors in the detection and recognition of odours*

ISO 16000-8, *Indoor air — Part 8: Determination of local mean ages of air in buildings for characterizing ventilation conditions*

ISO 16000-28, *Indoor air — Part 28: Determination of odour emissions from building products using test chambers*

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

## 3 Terms, definitions, symbols, units, and abbreviations

### 3.1 Terms and definitions

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

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**3.1.1**
**odour**
pleasant or unpleasant smell caused by chemical compounds emitting to indoor air

[SOURCE: ISO 16000-28:2012, 3.1.1, modified]

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

[SOURCE: ISO 16000-28:2012, 3.1.2]

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

[SOURCE: ISO 16000-28:2012, 3.1.3]

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

[SOURCE: ISO 16000-28:2012, 3.1.4]

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

[SOURCE: ISO 16000-28:2012, 3.1.5]

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

[SOURCE: ISO 16000-28:2012, 3.1.6; ISO 5492:2008, 2.7]

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

Note 1 to entry: Sensory adaption is reversible.

[SOURCE: ISO 16000-28:2012, 3.1.7]

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

[SOURCE: ISO 16000-28:2012, 3.1.8]

**3.1.9**
**sensory odour panel**
group of trained or untrained assessors performing the sensory assessment of the odour emission

[SOURCE: ISO 16000-28:2012, 3.1.9]

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

[SOURCE: ISO 16000-28:2012, 3.1.10]

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**.1.11**
**panel member**
person who is accepted to assess the odours

[SOURCE: ISO 16000-28:2012, 3.1.11]

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

[SOURCE: ISO 16000-28:2012, 3.1.12]

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

[SOURCE: ISO 16000-28:2012, 3.1.13]

**3.1.14**
**odour quality**
comparative description of an odour with olfactory experience

EXAMPLE "There is a smell" or, "It smells burnt, rotten", etc.

**3.1.15**
**comparative scale**
reference substance/air-mixtures with increasing concentration of the reference substance

Note 1 to entry: The mixtures are assigned to a defined scale by olfactory assessment.

Note 2 to entry: The mixtures are labelled according to the olfactory assessment by the sensory odour panel member to enable a comparative odour assessment of the sample air.

## 3.2 Symbols, units, and abbreviations

| Symbol | Name | Unit |
|---|---|---|
| $\Pi$ | perceived intensity | odour intensity unit pi |
| $n$ | total number of members of the sensory odour panel | – |
| $n_d$ | number of dissatisfied people | – |
| $PD$ | percentage of dissatisfied people | % |

# 4 Objectives of odour evaluations and boundary conditions

## 4.1 General

Before indoor air measurements are carried out, the objective of such measurements shall be clearly defined and a list of possible objectives is given in the following:

— elucidating the reasons for complaints, optionally with special regard to guide values for indoor air;

— determination of the odour intensity occurring under special conditions;

— identification of odour sources;

— inspection of the success of restoration measures.

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Depending on the objective, different environmental conditions shall be maintained or recorded before and during measurements. These environmental conditions principally relate to the ventilation condition, the room temperature, and the relative humidity.

## 4.2 Clarification of the reasons for complaints from room occupants

In many cases, indoor air analyses are initiated by various types of complaints expressed by the room occupants. Complaints of this type can range, e.g. from the perception of unknown and frequently unpleasant odours, to headaches, nausea; or irritation of the nose, throat, or eyes.

For odour evaluations in naturally ventilated rooms, an intensive ventilation for 15 min is performed. Afterwards, doors and windows are kept closed for about 8 h (optimally overnight) prior to measurement, without additional sealing measures such as taping over window and door gaps. Measurements are then performed (see ISO 16000-6) with the room still closed off. To obtain information on the effectiveness of hourly intensive ventilation, the room is ventilated intensively after measuring by opening doors and windows for 5 min. Doors and windows are reclosed, and after a waiting time of 1 h, further measurement is performed.

When rooms which are ventilated by mechanical ventilation or air conditioning (VAC) systems are investigated, the system shall be operated according to the building codes or other normative guidelines; and the required ventilation shall be in operation at least for 3 h before the sampling is started. The functioning of the ventilation system should be recorded or measured (see ISO 16000-8). For rooms operated according to specified ventilation instructions (for example, schools and kindergartens where windows have to be opened after specified time periods), one complete and typical operating cycle has to be carried out prior to measurement. If room occupants make complaints during unusual conditions, for clarification, measurements should also be performed under these conditions. The functioning of the ventilation system shall be recorded or measured (see ISO 16000-8). The investigated spaces should preferably be operated according to the building codes or design guidelines, and, especially in complaint cases, any deviation shall be the reported. To obtain representative indoor air measurements, it is essential to perform the measurement under the climate conditions under which the room being investigated is usually used.

## 4.3 Determination of odour intensity occurring under special conditions

In some cases, it can also be of interest to obtain information on the odour intensity under special conditions. Such special conditions can occur, firstly, if a room is used under unfavourable climatic conditions, for example, at temperatures or relative humidity outside the comfort region without the room occupants being able to alter this.

NOTE The conditions for thermal comfort of temperate climate are described in ISO 7730. In the case of extreme climatic conditions, ISO 7243 or ISO 7933 are available.

Secondly, the emission of odours from sources which emit temporarily, for example, when a solvent is used, can also be an unusual situation of this type.

## 4.4 Identification of sources

If unusual odour intensities occur, it is of interest to identify the source. The potential sources, such as building materials, interior furnishings, office materials, or cleaning agents often have typical emissions reflected in the indoor air. Therefore, it is important to know the emission characteristics of materials and products.

## 4.5 Checking the success of remedial activities

Measurements are made before and after completion of remedial activities. The indoor air conditions shall be selected here to ensure comparability with the initial measurements. Attention shall be paid as to whether new substances have been introduced into the interior as a result of the remediation measures chosen.

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## 5 Principle

The principle of this part of ISO 16000 is to measure the odour in buildings using a sensory panel. Different test methods or combinations of test methods are described which differ in the questions presented to the sensory odour panel. The main odour test methods are the acceptability and the perceived intensity. It depends on the measurement task whether the acceptability, perceived intensity, or both characteristics can be determined.

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

## 6 Basic principle of the evaluation of indoor air

### 6.1 Evaluation method selection

The purpose of odour evaluation of indoor air determines the selection among the methods described in Clause 7. A sensory olfactory examination should be carried out either on the basis of acceptability or intensity.

It is recommended to conduct an evaluation of the acceptability, if

— it is to be determined, whether an odour meets the “requirements” in terms of a building code,

— the influence of the odour on comfort is to be determined,

— the quality of the air is to be determined,

— a prediction of the percentage of dissatisfied users is to be made,

— an examination for the certification of the building is to be carried out, and

— an examination is required due to complaints.

It is recommended to conduct an evaluation of the intensity, if

— it is to be determined, whether an odour is “reasonable” in terms of the building code (in combination with hedonics),

— the strength of the odour is to be determined,

— the quality of the air is to be determined, and

— an examination for the certification of the building is to be carried out.

The intensity evaluation should be carried out preferably by the intensity method with a comparative scale (perceived intensity). If the intensity is determined according to the categorising method, then a calibration of the panel’s sense of smell should be carried out to establish a uniform odour reference.

The evaluation of the hedonics indicates whether the odour is considered pleasant or unpleasant. It is wise to combine this assessment with an intensity evaluation (see 6.2).

### 6.2 Combination of evaluation methods

Evaluation methods with trained and untrained panel members are not combinable due to knowledge obtained from psychology of perception. A small group of trained panel members is possible for acceptance determination (use of the same group as for intensity evaluation) if, in addition to the intensity evaluation, the acceptance of the air to be evaluated shall also be evaluated in order to obtain further information. The acceptance determination and the determination of perceived intensity have to be carried out independent from each other.

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The acceptance method can be combined with an intensity assessment according to the category method if untrained panel members are used. In this case, it has to be considered that this intensity assessment is dependent on the context and subject to high uncertainties in case of comparisons between different examinations.

The intensity determination with trained panellists should be supplemented by a hedonic evaluation if the reasonableness shall be determined. Further combinations are possible.

The use of different test methods is affected by separate test cycles, i.e. for example the intensity evaluation is not started until the acceptance evaluation has been carried out by all panellists.

NOTE Indoor air can be modified by frequent entering of the room and the air change caused thereby. Where appropriate, a room air sampling and an odour measurement in a laboratory can be considered.

## 6.3 Ways of testing

Odour testing can be performed by means of two ways of testing, which includes

— direct odour testing on site, and

— air sampling and odour tests in a laboratory.

The odour examination is carried out in terms of an individual evaluation of the room by a single panel member who carries out the evaluation immediately after reaching the measurement position by inhaling the room air.

During sampling of indoor air, samples are taken at the measurement positions by means of a suitable appliance. The samples are stored in sampling containers. Subsequently, the sampling containers are transported to the odour laboratory where the odour measurement itself in terms of evaluation by the panel members is carried out later. In order to clarify the possibility of adaptation, the odour measurement can be repeated after an appropriate stay (e.g. after 5 min to 10 min) in the room to be examined. An examination of the adaptation can be necessary to discover possible masking effects.

## 6.4 Selection of the way of testing

Direct, on-site odour testing involves less technological complexity than sampling. If difficulties arise in the evaluation, the test can simply be repeated. On-site odour testing means an evaluation under a context.

In the case of sampling, there is a risk of alterations to the sample through transport and storage, especially in the case of high temperatures during transport due to exposure to direct sunlight, or through insufficient preparation of the sampling containers or storage over longer periods (see Reference [6] for specifications).

Air sampling and laboratory testing are preferable, if

— there is a risk of an influence regarding on-site evaluations through disruptive ambient conditions (e.g. noise, garish light),

— the odour of the air could be influenced by the panel members themselves (e.g. small room volume),

— visual recognition of possible sources is not desired,

— no space is available on site for the regeneration of panel's sense of smell,

— getting the panel to the place of inspection is logistically complex, and

— the use of the comparative scale can influence the odour of the air in the room (e.g. air flow from the installation site of the comparative scale to the room in question).

In preliminary testing, a small panel can be selected for orientational testing of the odour situation on-site. For testing very small rooms, the number of panel members shall also be limited, as the panel

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members themselves influence the odour of the room air. The minimum required panel size is four. In such cases, it is necessary to determine whether statistically confirmable results can be achieved with a panel of the selected size.

## 7 Sensory test methods

The applicable methods for odour evaluation are determined by the purpose and scope of the odour examination. Depending on the issue being investigated, different sensory test methods can be applied to determine indoor odours.

The odour assessing described in this part of ISO 16000 involves four different methods:

a) rating of acceptability by an untrained panel;

b) rating of intensity with a comparative scale by a trained panel;

c) rating of intensity with a category scale by a trained panel or an untrained panel;

d) rating of hedonic tone by a trained panel or an untrained panel.

### 7.1 Determination of acceptability

The acceptability of the odour is assessed by an untrained panel with at least of 15 members.

Acceptability is an evaluation parameter for the expected percentage of dissatisfied occupants, and is thus, a measure for the quality of indoor air. The predicted percentage dissatisfied ( $PD$ ) is determined by means of a yes-no question. The following question is asked:

“Imagine you are exposed to this odour in your everyday life. Would you consider this odour acceptable?”

The $PD$-value is calculated using Formula (1):

$$PD = \frac{n_{\mathrm{d}}}{n} \times 100\% \tag{1}$$

where

$n_{\mathrm{d}}$ is the number of dissatisfied people (number of people who answered “no”);

$n$ is the total number of people.

In addition to the direct determination of the $PD$-value, it is possible to allow for a differentiated view of the degree of dissatisfaction. The acceptability can be judged on a continuous scale from “clearly acceptable” to “clearly unacceptable” (Figure 1).

In this case, the following question is asked:

“Imagine you are exposed to this odour in your everyday life. How would you rate this odour on the following scale?”

NOTE 1 During odour assessment of indoor air, the consideration of the given room use can be useful in the context of this question.

The panel members evaluate the acceptability of the odour by indicating a position along the line between the end-points –1 (“clearly unacceptable”) to +1 (“clearly acceptable”) (Figure 1). The acceptability score is determined by imposing a scale in steps of 0,05 on the line and reading the value next to the assessment marking.

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The *PD* -value is calculated dividing the number of ratings in the negative part of the acceptability scale (<0) by the total number of ratings.

NOTE 2 According to Reference [16], there is an empirical correlation between acceptance and the *PD* -value. If this correlation is consulted for the evaluation of the *PD* -value, the applicability has to be proven in each individual case.

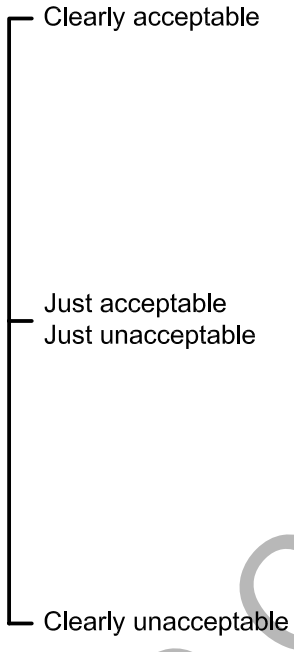


**Figure 1 — Acceptability scale**

The procedure for determining acceptability is as follows:

a) The first member of the panel sniffs the air to be evaluated. Depending on the chosen method, the sample air is rated on the acceptability scale or assessed as acceptable or unacceptable.

b) If the panel member is unsure, repeated sniffing of the sampled air and correction of the first assessment is possible.

c) After the completed assessment, the result is saved. Optimally, this should take place electronically before the panel member leaves the test room or the room to be assessed.

d) The duration of the entire assessment should not exceed 90 s. If the panel member cannot complete the assessment within 90 s, the assessment shall be repeated after a break of at least 5 min in an odour-neutral room.

e) The second member of the panel sniffs the sample air, and so on.

The average of the panel is determined from the individual results, as is the 90 % confidence interval of the mean. This procedure is only applicable if the continuous scale is used. The accuracy of the mean acceptability value is considered satisfactory if the half width of the 90 % confidence interval of the mean does not exceed 0,2 (see Clause 10). To achieve this level of accuracy, the acceptability assessment is conducted with a larger panel (at least 15 persons; see ISO 16000-28, recommended 25 persons and above). In order to achieve the required accuracy, the odour measurement can be carried on with additional panel members within two days, if the boundary conditions of the examination have not changed significantly and if no intermittent odour source is concerned. Otherwise, the results cannot be extrapolated, and the acceptability test shall be repeated.

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## 7.2 Determination of intensity

There are two methods for odour intensity determination:

— the use of a comparative scale and evaluations carried out by a small panel of trained panel members (at least 8 persons, recommended 12 persons to 15 persons, see 7.2.1);

— the use of category scales and evaluations carried out by an untrained panel of at least 15 persons (recommended 20 persons to 25 persons) or a trained panel of at least 8 panel members (recommended 12 persons to 15 persons, see 7.2.2).

### 7.2.1 Intensity evaluations using a comparative scale

The perceived intensity of an odour is ascertained through a sensory comparison between the sample and a series of concentrations of a calibrated reference substance (e.g. acetone). The use of the comparative scale allows for a standardization of the intensity evaluation and reduces the variance in the measured values by unifying the evaluation criteria. The unit of perceived intensity, $\Pi$ , is pi. Acetone is chosen as the reference material for the comparative scale. The reference scale should cover the whole intensity perception range of the indoor odour samples and should be made up of at least 5 levels. It is recommended that six different, fixed levels between 0 and 15 pi are used. The concentrations of the levels shall remain constant over the total measurement period. Up to 10 pi, a maximal discrepancy of ±0,5 pi is acceptable. From 11 pi on, a maximal discrepancy of ±1 pi is acceptable.

The scale is defined by the following points:

— 0 pi equates to an acetone concentration of 20 mg/m$^3$;

NOTE 1 At a concentration of 20 mg/m$^3$ acetone, only a few persons are able to perceive the odour of acetone.

— 15 pi corresponds to an acetone concentration of 320 mg/m$^3$ (if necessary, the scale can be extended upward);

— The concentrations for 1 pi to $n$ pi can be derived by means of a linear graduation of the acetone concentrations, i.e. an increase of 20 mg/m$^3$ corresponds to an increase of 1 pi.

NOTE 2 X · pi = 20 mg/m$^3$ acetone + X · 20 mg/m$^3$ acetone

NOTE 3 All concentrations refer to a temperature of 23 °C and atmospheric pressure.

If a reference odorant other than acetone is chosen, the odorant concentration at 0 pi should correspond to the odour threshold of the reference odorant. The concentrations of the suprathreshold intensity steps up to 15 pi and beyond are to be set such that they match the perceived intensities of the corresponding acetone pi levels exactly. With reference odorants other than acetone, it cannot be assumed that there is a linear relationship between the magnitude of chemical stimulus (odorant concentration) and the associated magnitude of the odour intensity (see Reference [10]).

#### 7.2.1.1 Assessment procedure

The panel member stays in the odour-neutral room of the laboratory or in the building to be investigated for at least 10 min before the assessment procedure begins. This time can be used by the panel leader to explain the aims of the sensory testing.

**Step one: Preparation**

The first panel member smells each of the concentrations of the comparative scale in ascending order. Afterwards, the panel member sniffs neutral air and leaves the testing room. Then, the second panel member repeats this procedure, and so on. If no neutral air can be provided, the panel member returns to the odour-neutral room and breathes the neutral air there. If the panel member notices adaptation effects, it is possible to smell neutral air at any time.

**Step two: Calibration**

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For the calibration, the panel members rate the intensity of two acetone concentrations within the comparative scale. The panel leader knows the corresponding pi-values of the samples, but the panel members do not.

a) The first panel member smells the first unknown acetone sample. After this inhalation, the panel member shall decide which pi-value of the comparative scale matches the intensity of the unknown sample. Then, the corresponding reference concentration or the one below it is smelled. If it is then necessary to smell other concentrations, the lower concentration should always be smelled first to minimize adaptation effects.

b) If the chosen pi-value does not correspond to the sample, the panel member is allowed to change the choice. The procedure is described under a).

c) If the smelled pi-value corresponds to the expected one, it is kept as measurement value, if possible, electronically, before the panel member returns to the odour-neutral room.

d) The scaling task should not exceed 90 s per panel member. If a panel member is unable to achieve a measurement value within the 90 s, the panel member can conduct the measurement again after a "nose relaxing" period of 5 min.

e) The second panel member smells the first unknown acetone sample, and so on.

f) When all panel members have completed the assessment of the first unknown acetone sample, the panel members receive feedback on their results. If an assessment deviates more than ±2 pi from the actual value, that panel member can repeat the test following the procedure described under a). If there is no success in identifying the concentration to within ±2 pi in the allowed time limit, the respective panel member will be excluded from the sensory odour testing.

g) The procedure as described above is followed for the second acetone concentration.

**Step three: Sensory odour testing**

Step three is the same procedure as step two. The only difference is that the panel member assesses unknown samples and do not receive any feedback at the end of the evaluation procedure.

The arithmetic mean of the panel is determined from the individual results, as is the 90 % confidence interval of the mean. The accuracy of the mean intensity with comparative scale value is considered satisfactory if the half width of the 90 % confidence interval of the mean does not exceed 2 pi (see Clause 10). If the desired level of accuracy is not reached in the first round of tests, it is possible to continue the test with additional panel members within a time period of two days, if a change in the sample air is not expected in this time period. Otherwise, the results cannot be exploited, and the sensory test shall be repeated.

For assessments of indoor air, the comparative scale has to be set up in an odourless, well-ventilated location (test room), preferably close to the room to be examined. The comparative scale should be placed under a fume hood. If this is not possible, then the panel members should test the air of the room holding the comparative scale upon entry. Acetone concentration measurements are to be conducted in this room during the sensory odour testing. If the acetone concentration exceeds 40 mg/m$^3$, a different procedure should be employed for the sensory testing, e.g. by means or air samples in sampling containers (see 7.2.2).

#### 7.2.1.2 Panel training and calibration

A panel is trained on the comparative scale of perceived odour intensity as a function of the reference concentrations. The panel members are 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 consists of five training days. An overview of the training program is displayed in Annex A.

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Calibration: After the training, the panel members measure at least two different unknown acetone samples. The panel members are 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 criteria for the perceived intensity of the acetone measurements. Thus, the performance and intraindividual variance of each panel member are verified. The scaling is conducted in the same way for unknown acetone samples as for unknown material odour samples.

### 7.2.2 Intensity evaluations using a category scale

Intensity evaluations with a category scale are not performed for the assessment of materials according to ISO 16000-28. The category scale is made up of seven levels (see Table 1) from "no odour" (0) to "extremely strong" (6). The panel members match their odour impression to one of the terms on the scale in Table 1. The level 1 "very weak" is to be chosen when the intensity is just above the odour threshold. This means that the panel member shall be sure in perceiving an odour, even if the odour is not clearly recognizable or definable.

The category scale used in this part of ISO 16000 is an ordinal scale with classes set up in a particular order:

no odour < very weak < weak < distinct < strong < very strong < extremely strong

**Table 1 — Category scale for odour intensity**

| Odour | Intensity level |
|---|---|
| extremely strong | 6 |
| very strong | 5 |
| strong | 4 |
| distinct | 3 |
| weak | 2 |
| very weak | 1 |
| no odour | 0 |

The panel is informed during the orientation that odours that go beyond "extremely strong" are to be evaluated with Level 6. Only whole numbers are allowed as responses.

The mean value of the evaluation of the group, the standard deviation and the 90 % confidence interval of the mean are then calculated. The accuracy of the intensity assessment is considered sufficient, if the half width of the 90 % confidence interval of the mean does not exceed 1 (see Clause 10).

To achieve the desired accuracy, the sensory odour testing can be continued with additional panel members within two days, if a change in the sample air is not to be expected in this time period. Otherwise, the results cannot be used, and the odour testing shall be repeated.

## 7.3 Determination of the hedonic tone

The hedonic tone describes whether an odour is perceived as pleasant or unpleasant. This impression depends on the odorant or odorant mixture, the odorant concentration – the perceived odour intensity – and on the panel member's personal background experience with odours.

To determine the hedonic odour tone, the indoor odour is assessed on a 9-level scale ranging from "very pleasant" (+4) to "extremely unpleasant" (–4) (Figure 2).

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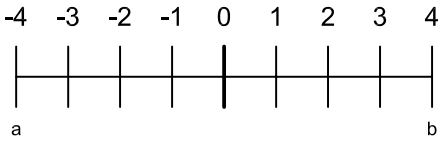


**Key**

a extremely unpleasant

b very pleasant

**Figure 2 — Scale for determining the hedonic tone**

The arithmetic mean and the standard deviation of the responses are calculated, as is the 90 % confidence interval of the mean. The accuracy of the evaluation of the hedonic tone is considered sufficient, if the half width of the 90 % confidence interval of the mean does not exceed 1 (see Clause 10).

To achieve the required standard deviation, a large untrained panel (at least 15 members, recommended 20 persons or more) shall be used. If the testing is conducted in combination with an intensity assessment, a smaller, trained panel can be employed (the same panel as for the intensity assessment, see 7.2) to assess the hedonic tone in addition to the intensity.

If the required level of accuracy is not reached, the sensory odour testing can be continued with additional panel members within two days, if a change in the sample air is not to be expected in this time period. Otherwise, the results cannot be used, and the odour testing shall be repeated.

The procedure for assessing the hedonic tone is as follows:

a) The first panel member smells the unknown air sample and rates it on the hedonic scale.

b) If the panel member is unsure, repeated sniffing of the sample air and correction the first assessment is possible.

c) After the completed assessment, the result is saved. Optimally, this should take place electronically before the panel member returns to the odour-neutral room.

d) The assessment should not exceed 90 s per panel member. If a panel member is unable to achieve a measurement value within the 90 s, the panel member can conduct the measurement again after a "nose relaxing" period of 5 min. When assessing indoor air, the assessment can take longer.

e) The second panel member smells the unknown air sample, and so on.

## 7.4 Odour quality

In general, descriptive (verbal) classifications are used for the characterization of odours. Words for sensory, especially taste and olfactory perception are applied.

From the realm of sensory perception of the trigeminal nerve come descriptors such as itchy, tingly, warm, burning, pungent, sharp, cool, and metallic. Several other descriptors exist for the denotation of different odours, for example the established primary odours according to Reference [14]: ethereal, camphorous, musky, floral, minty, pungent, and putrid. Instead of using common words to define the odour quality, ISO 5496 describes the use of vocabulary based on chemical descriptors (see also Reference [15]). It includes the training procedure of the panel and the evaluation of individual performance.

On an "odour wheel", some of the following descriptors could be used: herbal, fruity, flowery, medical, chemical, fishy, repulsive (see also Reference [20]). Odour wheels are used, for example, in the characterization of drinking water quality, whereby certain odours are assigned to chemicals (see also Reference [22]).

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Typical words for generally known odour qualities in indoor air are: shally, mouldy, like damp wall, woody, solvent-like, etc. The description of the odour quality can provide a hint to the source of the odour.

# 8 Measurement planning and requirements

## 8.1 Selection of 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 the job conscientiously;

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

— two hours before and during the odour measurement, the panel members are not allowed to smoke; there shall not be any odour pollution by the panel members, e.g. by contamination of clothing and hair;

— from 30 min before and during measurement panel members shall not be allowed to 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 of a cold or any other ailment affecting their perception of smell (e.g. allergic fits, sinusitis) shall be excluded from participating in measurements;

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

The goals of the examination are to be ascertained and suitable methods chosen. The panel members are to be selected according to the following criteria:

— Age: Panel members are to be at least 18 years old;

— Health: Those who suffer from diseases or allergies which affect the sense of smell (e.g. sinusitis, anosmia) are not suited; an examination by an ear, nose, and throat doctor is recommended.

The panel members shall have a verification of their sense of smell according to Annex B before they take part in the testing. Panel members determining intensity by means of the reference method are also to be trained in the use of the comparative scale. The training programme is described in Annex A. The odour perception of intensity panel members using the categorising method should be calibrated with a butanol reference before the tests. This is mandatory, if the intensity represents the only evaluation parameter.

## 8.2 Selection of measuring points

Depending on the objective, different environmental conditions shall be maintained or recorded before and during measurements. These environmental conditions principally relate to the ventilation condition, the room temperature, and the relative humidity.

The examination should generally be conducted in the centre of the room or area. The tests are performed in a standing position. Sampling is to be carried out at a height of 1,50 m. Examinations can also be conducted directly at the work station of a room user, but in this case, the height of the measuring point can be adapted for a seated person (1,10 m). In larger rooms, it can be of interest to carry out the odour testing in several places (large offices, shopping centres, etc.). In this case, it should be determined in advance which odour evaluations are expected in which areas to avoid superfluous assessments. The same is true for odour tests in several rooms of a single building. Tests should only be conducted in rooms which can be expected to provide different results.

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For the ascertainment of odour sources, it can be useful to do a test near a possible source in addition to the test in the middle of the room.

Before evaluations are conducted, the measuring points shall be clearly defined and labelled. The panel leader of the assessments shall ensure that the panel members know the exact positions of the measuring points.

## 8.3 Testing situation

### 8.3.1 Room use

The use of a room determines what odour intensity and air quality will be considered acceptable. Rooms that are used over long periods of time, such as bedrooms and living rooms, offices and school rooms require a higher level of air quality than rooms that are only used occasionally and/or for short periods of time.

### 8.3.2 Age of the room

When examining and evaluating odours, it is necessary to consider the age of the building, furniture and installations, the condition of the building, and the time of the last changes made to the building and the rooms. In a period of approximately four to six weeks after the construction or renovation of a building or part of a building, odours found in the examination area can be customary, product-related, and short-term emissions from construction materials; and it is important to account for their decay rates in the evaluation. The time required for the odours to disperse depends on the material and how it is integrated in the room. The odour should abate rapidly after the material has been placed in the room.

Sensory testing in indoor rooms should take place at least six weeks after construction, renovation, or changes to the furniture and fixtures. Exceptions here are examinations of the decay rates of odorous substances.

### 8.3.3 Temperature and relative humidity

Emissions of odorous substances from materials are influenced by the temperature and relative humidity of room air, as is the perception of odours. The influences of temperature and humidity on the evaluation of odours have been shown in tests. The acceptability value sinks with a rise in the enthalpy of the air, independent of whether the increase is due to changes in temperature or relative humidity. The intensity, determined using the category scale, also sinks with rising enthalpy compared to dry, cold air. For intensity assessment with a comparability scale, the intensity of odour decreases with increasing relative humidity. In contradiction to the assessment by means of the category scale, there is no direct dependence on the specific enthalpy. No information is available on the influence of relative humidity and temperature on the evaluation of hedonics.

The testing should take place under the normal conditions of the room when it is in use. The temperature and relative humidity of room air are to be measured and recorded in the log.

The maximum temperature in the laboratory shall be 25 °C. Temperature fluctuations during the evaluation process shall be less than ±3 °C. The relative humidity of the test room shall be (50 ± 5) % (as specified in ISO 554).

### 8.3.4 Outside weather conditions

The outside wind speed and temperature and air pressure differences between inside and outside of the building can have a decisive influence on the exchange of air, and, thus, on the results of odour tests. Climatic parameters can cause pressure differences in the building itself, which can lead to odours only being emitted intermittently.

The climatic parameters of the ambient condition shall be noted. If a significant influence is to be expected from outside conditions due to leaks and/or extreme weather conditions then the exchange of air at the time of testing shall be determined.

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### 8.3.5 Known or expected release of odours

Special steps shall be taken if the release of the odorous materials is intentional (ex. room scenting) or if the odours arise from activities (such as cleaning). In these cases, it is necessary to differentiate between the normal odour intensity related to the activity and abnormally high odour intensities.

## 8.4 Testing date

The panel members should be informed of the testing date in a timely manner. The testing schedule is to be determined before the testing date, and the panel members are to be notified.

## 8.5 Odour-neutral recovery room for the panel

Before the sensory olfactory tests, the panel members are to stay in an environment with good air quality and without conspicuous odours. It is important to ensure that the panel members feel comfortable.

A suitable room without conspicuous odours should be established in advance. If no such room is available, then it is necessary to make sure that the recovery area for the panel has a different odour from that of the room to be evaluated. In this case, the panel should neutralize their sense of smell with outdoor air shortly before making their evaluations, as long as the outside air does not exhibit extreme odours. The recovery room should be odour-neutral, sufficiently big, and pleasantly decorated. Contamination of the room air by, e.g. paintings, floor and wall coverings, furniture, samples are to be avoided. In the frame of the preparation of the odour assessment, the air in the recovery room has to be assessed regarding acceptance (Table 2) or intensity (Table 3). The recovery room should be well ventilated. The air exchange rate of 20 l/s per person is recommended.

NOTE The recovery room is limited by local conditions. The recommended air exchange rate might not be met. In this case, it has to be guaranteed that the panel member always smells a neutral air sample.

The background odour of the odour assessment equipment of the sample container and the recovery room has to be low in order to avoid influences on the assessment. If the background odour does not meet the requirements defined in Table 2 or 3, the odour assessment cannot take place.

The air in the panel members resting area shall also be evaluated by means of sensory tests. The evaluation of the resting area is to be recorded in the log.

**Table2 — Requirements for background odour acceptability**

| Odour | Acceptability |
|---|---|
| background odour including the sniffing equipment and sample container | ≥ 0,5 |
| recovery room background odour | ≥ 0,3 |

**Table 3 — Requirements for perceived background odour intensity**

| Odour | Perceived intensity in pi |
|---|---|
| background odour including the sniffing equipment and sample container | ≤ 3 |
| recovery room background odour | ≤ 4 |

## 8.6 Sampling

If the olfactory tests are not conducted on-site and the air is collected in sampling containers and transported to a laboratory to be tested, it is important that

— the containers demonstrate no odour emissions,

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— no extraneous air is in the containers,

— no impurities from the collecting device reach the inside of the container, and

— the admissible storage periods between collection and testing are not exceeded.

If the testing is conducted in a laboratory with sampled air taken from the site, then the schedule is to be planned from the preparation of the samples to the tests in the laboratory. Sampling and testing should be coordinated, so that the time spent in transport and storage does not exceed 24 h. By means of chemical analyses during sampling and directly before the odour testing in the laboratory, it is possible to guarantee that no changes occurred in the sampled air during storage.

### 8.7 Preparation of the testing log

A testing log is to be prepared prior to sensory testing. Directly before the experiments, the conditions in the room shall be measured and logged by the panel leader, especially those conditions which could have significant influence on the odour. These include

— ventilation (frequency, duration, time of the last airing),

— occupancy of the room (number of people, also pets, if applicable),

— room use,

— furnishings,

— operating state of the air conditioning installation, if present,

— heating,

— measurements of temperature and humidity,

— climatic conditions, and

— others.

The date and time of the beginning and end of testing are to be logged. The sample is to be clearly marked, including the site of the building, the location in the building (room number), and the exact position of the testing or sampling.

For tests conducted in a laboratory, the conditions during testing are to be logged in addition to the conditions during sampling.

## 9 Conducting the experiment

### 9.1 Preparation

The room to be tested is to be prepared according to ISO 16000-1[6] and ISO 16000-5,[7] especially when chemical analysis of the indoor air is to be conducted concurrently to the sensory testing.

Directly before the experiments, the panel leader is to log the test conditions as described in 8.7. The panel leader is to measure the temperature and relative humidity of the indoor air and the temperature of the outdoor air.

### 9.2 On-site odour testing

The panel members enter the room individually and assess the odour immediately upon arriving at the measuring point, before an adaptation can take place. The results are recorded directly afterwards in a questionnaire, if possible in electronic form, or is conveyed to the panel leader in such a way that the other panel members do not see/hear. Then, the panel member leaves the measuring point. After a short

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pause, the next panel member enters. The testing at the measuring point is completed when the last panel member has left the room. The exact procedure is described in Clause 7.

When using different testing methods, they shall be conducted in separate cycles.

To clarify the possibility of adaptation of the nose, the evaluation can be repeated after a sufficient time (5 min) in an appropriate recovery area.

To keep the panel members from influencing one another, they are not allowed to communicate during the testing. Nonverbal communication is also to be avoided.

If the panel member is unsure about the evaluation, it is possible to return to the measuring point and repeat the examination after a sufficient period of regeneration in the recovery area.

### 9.3 Sampling and evaluation in the laboratory

The panel leader collects the samples in odourless sampling containers, as described in Annex C. The amount of sampled air is to be calculated so that enough air is available for the whole panel. The conditions, measuring points, and sampling procedure are to be logged by the panel leader (see 8.7). The collection device is to be constructed of suitable materials and with a routing of air flow that will not significantly affect the odour of the sample (no ventilator or pump in the airflow). If the equipment is installed in the airflow, it has to be proven odourless and not affecting the odour evaluations. It is important to ensure that no extraneous air gets into the containers (they should be evacuated or filled several times) and that the containers themselves are odourless (if necessary heated or washed). After the air has been sampled, the containers are to be vacuum-sealed and clearly labelled. The labelling of the sampling containers is to be noted in the log.

Sampling and odour assessment have to be adjusted on each other in order to minimize time for transport and storage so that it does not exceed 24 h. The storage time has to be documented. By means of a chemical analysis of the room air during sampling and chemical analysis of the air from the sampling container shortly before odour assessment at the laboratory, it can be guaranteed that there is no change of the sample air during storage.

A sensoric comparison of the room air on site and the air from the sampling container should be performed because a chemical analysis does not cover all odour-relevant substances.

In the laboratory, the evaluation of sampled air is carried out by a panel. The testing is performed in an odourless testing room. The panel members enter the testing room individually, one after another, to perform the evaluation. The temperature and humidity in the testing room are to be set, such that the conditions are normal and comfortable (e.g. 23 °C, 50 % relative humidity). If required, the conditions can be set as they were during sampling.

The air is presented to the panel members in a constant flow that is calculated so that the evaluation is not influenced by secondary air. It is preferable to present the air to the panel through a funnel. The angle of aperture shall allow for a constant flow (maximum 12°). The volume flow rate should be high enough to avoid any dilution of sample air with the room air before the presentation to the nose. Very high flow rates are to be avoided, because there is a limited amount of sample air available.

A minimum volume flow rate of 0,35 l/s should be assumed for small diameter (about 4 cm to 5 cm, length about 5 cm) outlet of the sniffing port (according to EN 13725), and higher flow rates for outlets with bigger outlets like a funnel (8 cm diameter, lengths about 31 cm, maximum angle 12°). The volume flow rate should be at least 0,6 l/s and should be the same for all of the panel members. Very high flow rates are to be avoided, because there is a limited amount of sample air available.

The results are to be recorded in an evaluation sheet immediately. To keep the panel members from influencing one another, they are not allowed to communicate during the testing. Nonverbal communication is also to be avoided.

Between evaluations, the panel members are to stay in an odourless, well-ventilated, and air-conditioned room.

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# 10 Assessment

## 10.1 Accuracy of the sensory assessments

The accuracy achieved through the sensory olfactory tests conducted can be expressed by means of a confidence interval. Here, it is assumed that the observed criteria are distributed normally.

In Formula (2), the two-sided confidence interval for the true value of $\mu$ is the random interval around the estimated mean value, $\bar{x}$, with a statistical certainty of (1–α) and contains the actual mean value, $\mu$:

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

where

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

$n$ is the panel size;

α is the probability of error.

Formula (3) is used to determine concrete interval limits on the basis of panel assessments:

$$\left[ \bar{x} - \frac{s}{\sqrt{n}} \cdot t_{(1-\alpha/2);n-1}; \bar{x} + \frac{s}{\sqrt{n}} \cdot t_{(1-\alpha/2);n-1} \right] \tag{3}$$

The achievable confidence interval for sensory olfactory tests is determined by the panel size, the estimated standard deviation of the evaluations of the panel members, and α, the probability of error. An increase in the size of the panel allows for a narrower confidence interval.

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

If the half width of the estimated confidence interval is given, see Formula (4)

$$d = \frac{s}{\sqrt{n}} \cdot t_{(1-\alpha/2);n-1} \tag{4}$$

then, the sample size, i.e. the minimum necessary panel size, can be determined iteratively using Formula (5):

$$\lceil n_{i+1} \rceil \geq (\frac{s}{d} \cdot t_{(1-\alpha/2);n_i-1})^2 \text{ with i = 0, and } n_0 = \infty \tag{5}$$

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 can be combined.

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### 10.2 Interpretation of the results

As long as no standard values exist for acceptability, intensity, or hedonic tone; the overall evaluation of a room is conducted by means of a situational-integrative evaluation.

— in the case of direct odour assessments, the individual evaluations for acceptability, intensity, hedonic tone, or odour quality; the appraisal of the situation by the panel leader are used as a basis;

— the factors established by questioning room occupants (constant or intermittent odour, course of the intensity, etc.), the physical boundary parameters of the testing as well as the use of the room are to be considered.

The analysis of the results depends on the aim of the testing and the room use. A high level of air quality is desirable for rooms that are used for long periods.

## 11 Documentation

The test report shall include the following information:

— description of the room/object/location/dimensions to be examined (check ISO 16000-5);

— date and time of the test, and, if applicable, sampling;

— description of the applied method;

— description of procedures;

— specifications of the test laboratory, if the tests are not conducted on-site;

— information about the panel leader (name, company, address, qualifications);

— panel size;

— environmental conditions (room temperature, relative humidity, ventilation patterns, outside air conditions) during tests, and, if applicable, sampling;

— indication of further factors with a possible influence on the evaluation;

— results of the sensory odour tests (individual assessments);

— statistical quantification of the results (e.g. mean, standard deviation, confidence interval, measurement uncertainty);

— evaluation of the results according to the requirements;

— details of the recovery room for the panel members (room temperature, air humidity, ventilation behaviour, kind of ventilation, sensory assessment);

— in case of odour assessments with perceived intensity: details of the positioning of the comparative scale (room temperature, air humidity, ventilation behaviour, kind of ventilation, sensory assessment, acetone concentration in the room);

— in case of sampling and odour assessment in the laboratory: storage time of the samples;

— details with respect to the number of the repeated measurements of an odour assessment.

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# Annex A
(normative)

# Training procedure for intensity assessments using a comparative scale

## A.1 General

The evaluation of perceived intensity using a comparative scale according to 7.2.1 requires that the panel of test subjects 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 7.2.1) and serves as a regular monitor of the training of the panel. An abbreviated training course (consisting of days 4 and 5 in Table A.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 group becomes too big.

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 verification of olfactory function (Annex B).

An overview of the training programme is provided in Table A.1. The sensory olfactory tests last approximately two to three hours per day of training. The abbreviated 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 panel leader 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, there is the possibility to smell the acetone concentration again with the knowledge of the actual pi value.

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

| Training day | Topic | Tasks |
|---|---|---|
| Day 1 | Presentation of the training programme<br>Familiarization | 8x sample air with different acetone concentrations |
| Day 2 | Training<br>Familiarization with assessments of materials used in interiors | 4x sample air with different acetone concentrations<br>4x sample air from materials used in interiors |
| Day 3 | Training<br>Familiarization with the testing procedure | 2x sample air with different acetone concentrations (calibration)<br>6x sample air from materials used in interiors |
| Day 4 | Testing cycle to determine the results of the training | 2x sample air with different acetone concentrations (calibration)<br>4x sample air with different acetone concentrations<br>2x sample air from materials used in interiors |
| Day 5 | Testing cycle to determine the results of the training<br>Evaluation of the training programme | 2x sample air with different acetone concentrations (calibration)<br>4x sample air with different acetone concentrations<br>2x sample air from materials used in interiors |

On day 2 of training, the panel members are requested to test sample air from materials used in interiors 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, so 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 7.2.1. That means that first two samples of acetone concentrations are provided for calibration, for which the panel member is informed of the actual pi value, so that a correction of the assessment is possible. 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 4, the pi values are only given during the calibration (see 7.2.1). 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 materials used in interiors are provided.

## A.2 Evaluating of the training programme

The panel leader documents the assessments and achievement of each panel member over the entire course of the training program. It is essential that the panel members are 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, the person 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 in a diagram as presented in Figure A.1, which shows the deviation of the test from the preset pi value and the range of tolerance.

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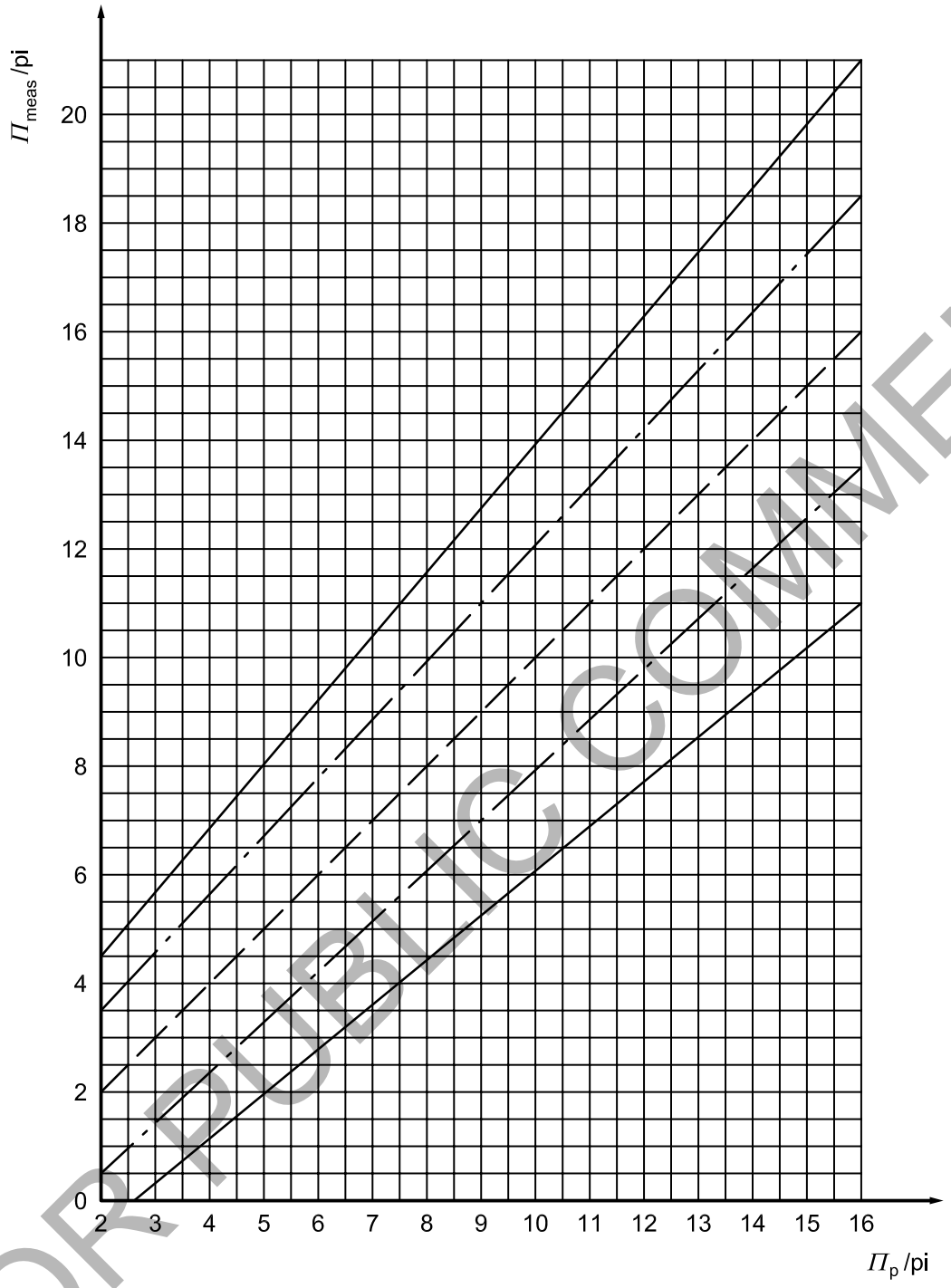


**Key**

$\Pi_{meas}$ measured perceived intensity, in pi
$\Pi_p$ preset perceived intensity, in pi
– – – preset pi value
– · – core area
–––– rim area

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

If the assessment is on the dashed line, then 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

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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 the continuous lines.

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# Annex B
(informative)

# Training procedure — Verification of olfactory function

## B.1 General

To test the eligibility of potential panel members, validated olfactory methods are employed to test the olfactory ability of the panel members. The ability to identify and differentiate between odours is established, as well as the odour threshold.

Before the first odour assessment, the normal olfactory function of a potential panel member is tested by means of either inhaler sticks or an olfactometer. Other methods that provide equivalent results are also admissible.

Potential panel members who do not pass the test due to e.g. an illness are allowed to repeat the test. Only persons with a normal sense of smell can be employed for sensory testing.

At the latest, the verification of olfactory function shall be performed every three years. If there are indications that the olfactory function of the panel member might have changed (e.g. in the case of pregnancies, diseases, or accidents), the verification shall be performed promptly.

**Method 1** tests the sense of smell by using inhaler sticks.[17][18][19] To this purpose, an identification test, a discrimination test, and a threshold test are conducted. The results of the identification and discrimination tests are generally seen as the expression of the central olfactory processing, while the threshold test reflect the peripheral olfactory function. The individual results are added to make the value, which represents the suitability of the panel member (see also Reference [23]).

Inhaler sticks are felt cylinders filled with odorous materials, which are released when the cap is removed.[11]

**Method 2** is determination of the odour threshold according to EN 13725[9] with an olfactometer. On three non-consecutive days, a total of at least 10 individual assessments of the odour threshold for the reference odorant n-Butanol are performed. The final 10 individual assessments for n-butanol are averaged, and the standard deviation is calculated. The average should be within the range: 62 µg/m$^3$ < average < 246 µg/m$^3$ and the standard deviation $s_r$ < 2,3 to fulfil the requirements.

## B.2 Training potential panel members

### B.2.1 Training for intensity testing with the category scale by means of olfactometry

This training programme is to be conducted at least twice a year; the recommended interval is every quarter of a year. The intensity training is divided into two areas, which includes

a) training through familiarization with intensity impressions, and

b) testing the ability to assess intensities according to specifications.

The basis of the intensity assessment is the following intensity scale (Table B.1).

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**Table B.1 — Intensity scale**

| Odour | Intensity level |
|---|---|
| extremely strong | 6 |
| very strong | 5 |
| strong | 4 |
| distinct | 3 |
| weak | 2 |
| very weak | 1 |
| no odour | 0 |

The following concentrations of n-butanol are employed to calibrate the panel members for the intensity values (Table B.2). When using an olfactometer with a gradation (e.g. a factor of 2), the preset concentrations should be produced on the olfactometer with an accuracy of ±20 %.

**Table B.2 — Calibration table for the intensity assessment by means of n-butanol**

| Intensity level | n-Butanol µg/m³ |
|---|---|
| 1 | 154 |
| 2 | 340 |
| 3 | 830 |
| 4 | 1900 |
| 5 | 4500 |

Each intensity should be offered to each panel member at least once. During the subsequent testing, each intensity (Table B.2) is offered to each panel member at least twice. The order should be random. In each round, at least one null sample (intensity level 0) should be offered. The panel member shall match each concentration of n-butanol to the corresponding intensity level. To determine whether the panel member has completed the task successfully, a $Q$_value (quality value) is calculated using Formula (B.1):

$$Q_value = \sum_{k=1}^{k} \frac{\sum_{i=1}^{i} (x_{ik} - I_k)^2}{i} \quad \text{(B.1)}$$

where

$x$ are the individual results of the panel member;

$i$ is the number of rounds (one round includes the assessment of all concentrations according to Table B.2);

$k$ is the number of different concentrations according to Table B.1;

$l$ is the intensity level according to Table B.1.

As a basic principle, the smaller the $Q$_value, the closer the panel member was to correctly assessing the intensity. The maximum $Q$_value for successful assessment shall not exceed 6.

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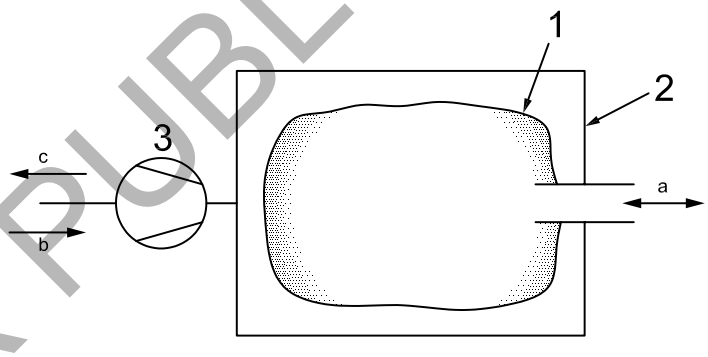
# Annex C
(informative)

# Description of one possibility of a sampling and presenting device for air samples out of emission chambers

## C.1 Sampling and providing device (for Tedlar®)

The sampling system guarantees that the composition of the sampled air will 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 sampling container. The stainless steel tubes are to 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 airflow is driven by a fan that changes the pressure in the environment of the sampling container, see Figure C.1. The sampling 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 sampling 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 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 1200 mm x 800 mm x 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 C.1 — Principle picture of the sampling system AirProbe[21]**

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## C.2 Sampling container

The sampling container is made out of 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[2)] 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 sampling container should be conditioned by filling it with 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 sampling container). A possible container form is shown in Figure C.2.

In EN 13725[9], the following other container materials are mentioned:

— Copolymer out of polytetrafluoroethene and hexafluoropropylene (FEP);

— Polyethyleneteraphthalate (PET, Nalophan® [3)]);

— Tedlar® [1)] Polyvinylfluorid (PVF).

All sampling containers have to be tested for air tightness and odourlessness before use. After filling the container, the odour test is to be done as soon as possible, at the latest after 24 h.

To test that the sampling container is odourless, it is necessary to fill the sampling container with neutral fresh air and test the odour of the sampling container after 4 h to 12 h. For the acceptability scale, the odour rating has to be acceptable ≥ 0,5 and for the intensity method, the mean average has to be ≤ 3 pi.

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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 part of ISO 16000and does not constitute an endorsement by ISO of this product. Equivalent products can be used if they can be shown to lead to the same results.

2) AirProbe is manufactured by TU Berlin. It is an example of a suitable product available commercially. This information is given for the convenience of users of this part of ISO 16000and does not constitute an endorsement by ISO of this product. Equivalent products can be used if they can be shown to lead to the same results.

3) ) 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 part of ISO 16000 and does not constitute an endorsement by ISO of this product. Equivalent products can be used if they can be shown to lead to the same results.

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All dimensions in mm

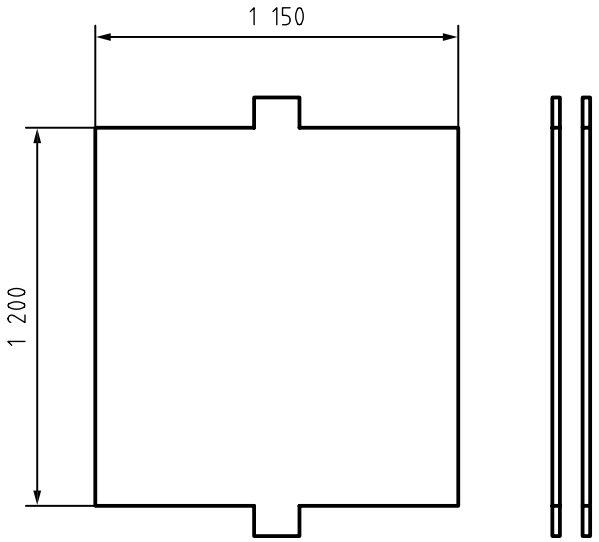


**Figure C.2 — Sectional drawing of the sampling container**

**Figure C.3 — Picture of the sampling container used[21]**

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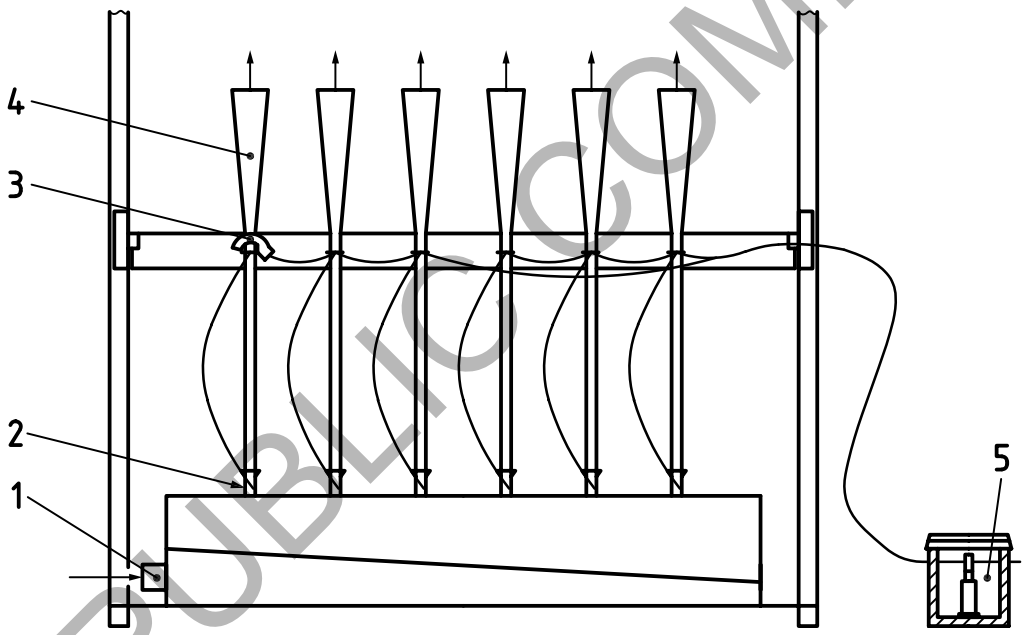
# Annex D
(informative)

# Example for the set-up of a comparative scale

The set-up of a comparative scale is highly significant. The volume flow and the concentration of the reference odorant should be constant and independent of the ambient conditions. The relative humidity and the temperature of the mixture of air and reference odorant should be kept constant. A schematic of a possible comparative scale is given in Figure D.1. This comparative scale offers six different stimuli by means of presentation funnels. The reference odorant is acetone. The comparative scale is made up of three basic parts: sample air ducts, acetone source, and dosing device. Only materials with very low odour emission and absorption, such as steel, glass, and Polytetrafluoroethylene (PTFE) are employed for the parts that come in contact with sample air, so as to avoid influencing the stimuli. The comparative scale is connected to a supply of odour-neutral air.




**Key**

1 air inlet
2 acetone injection
3 dosing valve
4 funnel
5 acetone source

**Figure D.1 — Schematic of a possible comparative scale**

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