
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*



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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 of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

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

This second edition cancels and replaces the first edition (ISO 16000-28:2012), which has been technically revised. The main changes compared to the previous edition are as follows:

- besides acceptability and perceived intensity, the hedonic tone is described as odour characteristic;
- a more detailed description of the comparative scale, including information on set-up, check-up and calibration devices;
- recommendation on panel sizes for the different testing procedures (acceptability, perceived intensity and hedonic tone);
- procedure in case of failing the confidence interval.

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

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

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

The determination of odour acceptability, intensity and hedonic tone of emissions from building products and materials 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 and materials on the indoor air quality;
- to promote the development of improved products.

The method can also be used for furnishings and consumer products. For this purpose, a suitable exposure scenario (according to the reference room defined in EN 16516) needs to be defined.

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Indoor air —

Part 28:

Determination of odour emissions from building products using test chambers

1 Scope

This document specifies a laboratory test method using test chambers defined in ISO 16000-9 and further specified in EN 16516 and evaluation procedures for the determination of odours emitted from building products and materials.

Sampling, transport and storage of materials under test, as well as preparation of test specimens are described in ISO 16000-11 and further specified in EN 16516.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

EN 16516, *Construction products: Assessment of release of dangerous substances — Determination of emissions into indoor air*

3 Terms and definitions

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

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

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

3.1

acceptability

assessment of an odour emission into 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

3.2

anosmia

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

3.3

building product

product for incorporation in a permanent manner in construction works

Note 1 to entry: A building product can be solid, liquid or combined (see ISO 16000-11).

3.4

hedonic tone

odour (3.5) quality, which can be ascertained on a scale ranging from “extremely pleasant” to “extremely unpleasant”

3.5

odour

sensory attribute perceptible by the olfactory organ on sniffing certain volatile substances

3.6

odour sample

air sample collected from the test chamber outlet in containers and being tested for its *odour* (3.5)

3.7

background odours

odours (3.5) released by equipment or location that might disturb the test procedure

3.8

panel leader

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

3.9

panel member

person who is accepted to assess odours according to a defined method

Note 1 to entry: Depending on the method panel members may need to be trained.

3.10

perceived intensity

parameter to assess the strength of an odour based on a comparative scale

Note 1 to entry: See ISO 5492:2008, 2.8, 2.9 and 4.30.

3.11

recovery room

room where the panel members can recover and acclimatize before and between *odour* (3.5) assessments

3.12

sample container

device for collection and transport of the *odour* (3.5) sample from the test chamber to the test room and for presentation of the sample to the *panel members* (3.9)

3.13

sensory adaption

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

[SOURCE: see ISO 5492:2008, 2.6]

3.14

sensory odour panel

group of trained or untrained *panel members* (3.9) performing the sensory assessment of the *odour* (3.5) emission from *building products* (3.3) or materials

[SOURCE: see ISO 5492:2008, 1.9]

3.15

test room

room where the *odour* (3.5) assessment takes place

3.16**test specimen**

part of a sample specially prepared for emission testing in a test chamber in order to simulate the *odour* (3.5) emission behaviour of the material or product being tested

4 Symbols and abbreviated terms

For the purposes of this document, the following symbols apply (see ISO 16000-9).

Symbol	Meaning	Unit
L	product loading factor	square metres per cubic metre
n	air change rate	changes per h
$q_{V,A}$	area specific air flow rate (n/L)	cubic metres per square metre and h
A	surface area	square metre
Π	perceived intensity	pi
$q_{V,c}$	volumetric supply air flow rate	cubic metres per h

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

PVF	polyvinyl fluoride
PET	polyethyleneterephthalate
rH	relative humidity
VOC	volatile organic compound
PAD	photoacoustic detector
PID	photo ionization detector
FID	flame ionization detector

5 Principle

The odour emission from building products and materials is measured using a sensory odour panel. The odour determination may be performed in parallel to chemical emission measurements in accordance with ISO 16000-9 and further specified in EN 16516. The odour characteristics addressed in this part of ISO 16000 are the acceptability, the perceived intensity and the hedonic tone. Depending on the measurement task, these odour characteristics or a combination of those can be determined.

6 Test facilities**6.1 General**

A facility designed and operated to determine odours emitted from building products and materials consists of an emission test chamber containing the test specimen. The emission 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 performed to indicated conditions in accordance with ISO 16000-9 and further specified in EN 16516.

The standard procedure for odour assessment is carried out by using sample containers (see 6.3.3). Alternatively, direct assessment from the outlet of the emission test chamber is possible if sufficient air flow is assured (see 6.3.1). In this case the outlet shall be fitted with a funnel.

NOTE Due to the requirements of 6.3.1 sufficient air flow is only possible if the following requirements are met: test chambers with more than 4,3 m³ volume at 0,5 h⁻¹ air change rate.

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.

The test room in which the sensory assessment is performed shall conform with the general requirements described in 7.2. The panel members shall not be influenced by the working environment (light, acoustics, background odours).

6.2 Test room and recovery room

The test room and the recovery room shall be odour neutral, sufficiently large and unobtrusively designed. Contamination of the room air by any source, e.g. by coatings, wall and floor coverings, furniture, shall be prevented. In preparation for sensory testing, the air in the test room and the recovery room shall be assessed for acceptability or perceived intensity (7.2.1), and the requirements set out in 7.2.2–7.2.4 shall be complied with.

6.3 Odour sampling and assessment devices

6.3.1 General

The odour sampling and assessment devices shall ensure that

- the air flow is sufficient to guarantee that the panel members inhale only 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.

6.3.2 Funnel

The odour evaluation interface consists of a funnel, which is connected to the outlet of the sample presentation system or to the outlet of the emission test chamber. The funnel and the inner surfaces of the connection ducting shall be composed of glass or surface-treated (polished) stainless steel. The air flow at the outlet from the funnel to the panel member shall be between 0,6 l/s to 1 l/s and shall be constant for the duration of each test session. The design of the measurement funnel 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 (see Figure 1). To prevent contamination of the test room air, the excess air flow shall be extracted above the funnel.

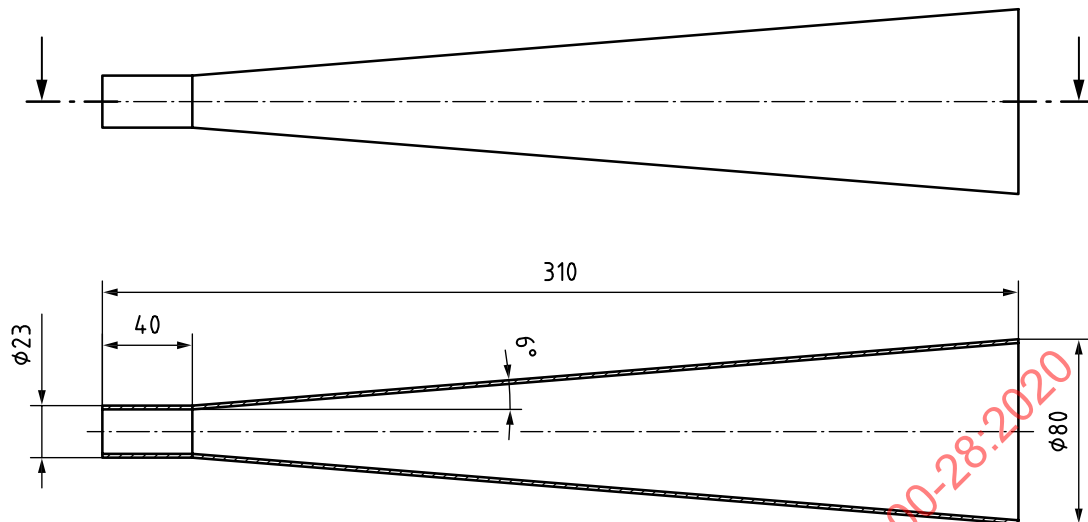


Figure 1 — Schematic of a standard funnel

6.3.3 Sample containers

The following materials are suitable to be used as a sample container:

- polyethylene terephthalate (PET, Nalophane®¹);
- polyvinyl fluoride (PVF, Tedlar®²).

All batches of container material shall be evaluated for unusual emissions/background odours before first use. PVF/Tedlar® containers need to be conditioned before first use, see 8.4 and Annex C.

Sample containers made of PET shall not be reused.

Other container materials may be used if the performance is tested according to Annex C.

6.3.4 Sample presentation system

A sample presentation system is a device designed for providing odour samples from the sample containers to the interface (funnel) for odour testing. The size of the sample presentation system is based on the size of the sample containers. The system shall be designed to minimise influence on the odour samples and test room conditions. Any parts in direct contact with the odour sample shall be made from glass, polished stainless steel or polytetrafluoroethylene (PTFE).

NOTE For an example of a suitable sample presentation system see Annex C.

6.4 Comparative scale

6.4.1 General

A comparative scale offers at least six different reference stimuli by means of presentation funnels. The reference odorant is acetone (quality grade $\geq 99,8\%$). The comparative scale is made up of three basic parts: clean air ducts, acetone source and dosing device. Only materials of very low odour emission and

1) Nalophan® is the trade name of a product of Kalle Nalo GmbH. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.

2) Tedlar® is the trade name of a product. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.

absorption, such as glass, polished stainless steel or polytetrafluoroethylene (PTFE) shall be employed for the parts that come in contact with sample air to avoid influencing the stimuli. The background odour of the comparative scale, (i.e. the comparative scale is operated with supply air), must not exceed the requirements in [Table 1](#) (see [7.2.1](#)).

The flow rate and the concentration of the reference odorant shall be constant both over time as well as locally within the funnel outlet and independent of the ambient conditions. The flow rate at the outlet of the funnel shall be between 0,6 l/s and 1,0 l/s and shall be constant for the duration of each test session. The funnels shall meet the requirements of [6.3.2](#). The relative humidity and the temperature of the mixture of air and reference odorant shall be kept constant and shall meet the requirements for the test chamber 23 °C and 50 % RH (± 3 K and ± 10 % rH). A schematic of a possible comparative scale is given in [Figure 2](#).

6.4.2 Set up of the comparative scale

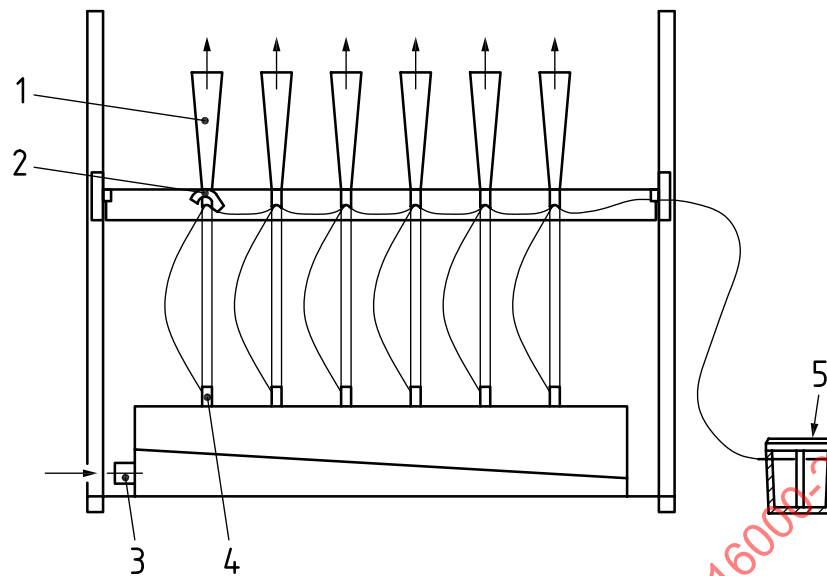
The comparative scale is connected to a supply of odour-neutral air. To cover the whole intensity perception range of indoor odour samples the comparative scale shall be made of at least the six fixed levels 0 pi, 3 pi, 6 pi, 9 pi, 12 pi, 15 pi. The test setup shall also provide neutral air to the panel members. The presented concentrations shall be kept constant over the total measurement period. Between 0 and 10 pi, a maximum deviation of ± 10 mg/m³ ($\pm 0,5$ pi) is acceptable. From 10 pi on, a maximum deviation of ± 20 mg/m³ (± 1 pi) is acceptable.

The scale levels of the comparative scale are defined by the following frame conditions:

- 0 pi is assigned to an acetone concentration of 20 mg/m³;
- the concentrations for 1 pi to 20 pi can be derived by means of a linear graduation of the acetone concentrations, i.e. an increase of 20 mg/m³ corresponds to an increase of 1 pi;
- 15 pi correspond to an acetone concentration of 320 mg/m³. If necessary, the scale can be extended upward. Linearity is shown up to 380 mg/m³ by [\[37\]](#), [\[38\]](#). National occupational exposure limits shall be considered.

NOTE 2 All concentrations refer to a temperature of 23 °C and 50 % RH (± 3 K and ± 10 % rH and atmospheric pressure.

If a reference odour other than acetone is chosen it shall be proven that the odours' pi levels match the pi levels of acetone. As concentration for the 0 pi level the odour threshold of the reference odour is recommended. With reference odours other than acetone, it cannot be assumed that there is a linear relationship between the magnitude of chemical stimulus (odour concentration) and the associated magnitude of the odour intensity.



Key

- 1 funnel
- 2 dosing valve
- 3 air inlet
- 4 acetone injection
- 5 acetone source (in cool box with $10\text{ °C} \pm 2\text{ °C}$)

Figure 2 — Schematic of a possible comparative scale

6.4.3 Check-up of the comparative scale

The concentration at the funnel outlet of the comparative scale shall be checked every work day and whenever settings are adjusted. When using needle valves to adjust the acetone gas flow, additional checking of the acetone concentration during or between the assessments is recommended.

The concentration at the funnel shall be measured in the middle of the funnel opening and 1 cm to 3 cm deep from the upper rim of the funnel. For this purpose, an adaptor fixing the position of the end of the sampling line is helpful.

6.4.4 Measurement of acetone concentration and calibration of the measurement device

The comparative scale provides acetone concentrations over a large range. Therefore, a suitable detector covering the entire range (e.g. 0 mg/m^3 to 320 mg/m^3 for 0 pi to 15 pi) is needed for the calibration of each individual concentration. PAD, PID and FID are possible devices for the quick determination of the acetone concentrations. The used detector/analyzer needs to be calibrated using acetone before use.

FID often feature an inbuilt oxygen compensation which can cause offsets with test gases supplied in pure nitrogen — synthetic air is often better suited for such instruments. PID are sensitive to water content; a calibration with humidified test gas is therefore required. Substantial deviations between different detectors calibrated with the same calibration gas were observed. Sufficient cross-checks with other analytical methods are recommended. PAD are sensitive towards the water content. The water content of the analyzed air has to be measured simultaneously and used for an automatic correction of the measured values.

7 Test requirements

7.1 General

Test conditions for the emission test chambers are described in ISO 16000-9 and further specified in EN 16516 and shall be met.

The supply air shall be clean enough to ensure that the background requirements for the emission test chambers can be met (see 7.2).

7.2 Emission test chamber and test room background odour

7.2.1 Background odour

The background odour of the air in the test room and of the emission test chamber including the sample presentation system and sample container shall be low in order to avoid influences on the odour assessment.

The background odour of the emission test chamber including the sample presentation system and sample container shall be evaluated by the sensory odour panel (see 10.2).

The background odour (acceptability and perceived intensity) of the air in the recovery room and the test room including all equipment under working conditions shall be evaluated according to ISO 16000-30 before starting odour assessments for the first time.

Both assessment results shall meet the requirements in Tables 1 or 2^{[13][14]}.

The odour evaluation in the test room should be repeated, if required (e.g. after construction works).

Table 1 — Requirements for background odour acceptability

Odour	Acceptability (dimensionless); see Figure 4
Emission test chamber background odour including the sample presentation system and sample container	≥0,8
Test room and recovery room background odour	≥0,6

Table 2 — Requirements for perceived background odour intensity

Odour	Perceived intensity (pi); see Clause 10
Emission test chamber background odour including the sample presentation system and sample container	≤3
Test room and recovery room background odour	≤4

7.2.2 Test room conditions

The conditions (temperature, humidity) of the test room shall be close to the conditions given by the emission test chambers 23 °C and 50 % RH with a deviation of maximum ±3 K and ±10 % rH.

Exposing the panel members to direct sunlight shall be avoided. The room shall be free of any disturbing sources such as noise and light that can negatively affect the measurement in all progress.

7.2.3 Ventilation of the test room

The test room shall be ventilated to maintain a neutral environment and to provide fresh air to the panel members.

In addition to the directly extracted air above the funnels, a minimum air change rate of 5 h⁻¹ with clean fresh air is recommended.

7.2.4 Recovery room conditions

Orientating conditions: Relative humidity below 40 % leads to disturbance of the odour perception. Higher values than 70 % interferes the acceptability evaluation (see [Annex B](#)).

8 Odour testing from emission test chambers

8.1 General

The standard procedure for odour assessment is carried out by using sample containers (see [6.3.3](#)). Alternatively, direct assessment from the outlet of the emission test chamber is possible if sufficient air flow is assured (see [6.3.2](#)) and it is provided that the results are comparable or correlate with the result of the standard procedure under the conditions applied. The validity of the correlation with the standard procedure is limited to the field of application for which it has been established.

8.2 Emission test chamber preparation

The specifications given by ISO 16000-9 and further specified in EN 16516 shall be considered. A background odour test shall be performed previous to any loading of the emission test chambers in order to confirm the efficiency of the cleaning step. The background odour test shall be performed exactly as the standard procedure except that no test specimen is introduced into the emission test chamber. The background odour shall conform with the requirement in [7.2.1](#) before proceeding with the preparation of the odour assessment of the test specimen.

8.3 Time of odour measurements

The measurements shall be carried out at predefined sampling times.

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

8.4 Conditioning of sample containers

Sample containers shall be airtight and shall not cause background odours that interfere with the test result.

According to the chosen material (PVF or PET) of the sample containers, different pre-treatments are required (see [C.2](#)). Sample containers made of PVF shall be heated and purged with clean air before use (see [C.2.3](#)). The background odour of the sample container shall be ascertained for at least one sample of each batch of cleaned containers. For this purpose, the blank container is filled with supply air and assessed for its background odour after at least 2 h storage time. The background odour shall conform with the requirement in [7.2.1](#).

Due to cleaning processes or normal use, cracks or leaks may occur at the welds or in the material of sample containers. Care shall be taken before use that each individual sample container is sufficiently airtight.

8.5 Handling of sample containers

Odorous organic substances from the odour sample may adsorb to the inner surface of the container material causing inaccurate low results. When filling the odour sample container, care must be taken that the entire volume of the container is sufficiently rinsed with sample air to achieve a steady state between adsorption and desorption at the inner surface. For this purpose, the container shall be filled and emptied with the emissions test chamber exhaust air at least three times and emptied again before being finally filled with sample air and sealed. Depending on the air flow available, this procedure may take several hours. The container may also be connected to the exhaust and flushed overnight before being filled with sample air (provided the air flow from the chamber is sufficient to replace the

container volume at least three times). More than one container may be flushed and filled in parallel from one emission test chamber provided that the air flow is sufficient.

Rinsing or filling of sample containers shall not influence the air exchange rate of the emission test chamber significantly. When using active sampling the requirements of ISO 16000-9 regarding sampling air flow shall be followed.

The assessment of the odour samples shall be finished within 6 h after finalization of sampling.

NOTE For some reactive substances, losses can occur within 6 hours, so it is advisable to assess the samples as soon as possible, but within 6 hours at the latest.

After sampling, the sample containers shall be kept at conditions (temperature and relative humidity) close to the conditions in the respective emission test chambers (± 3 K; ± 10 % rH) and shall not be exposed to direct sunlight or strong daylight to minimize (photo) chemical reactions (see EN 13725).

9 Sensory odour panel and panel leader

9.1 Panel leader

9.1.1 General requirements for the panel leader

The panel leader shall be in charge of the sensory odour panel and shall guide and supervise them. The panel leader should not be anosmic (needs to identify distractive odours around panel members, etc.), but nonetheless shall never be part of the sensory odour panel.

The conditioning of the test and/or recovery room according to 7.2.1 to 7.2.4 shall be checked by the panel leader before and during assessment. If necessary, the panel leader shall adjust the climate conditions to meet the requirements. If it is not possible, the test shall be postponed.

The panel leader shall make sure that all panel members are aware of the code of conduct (see 9.3), that it is well-understood and strictly considered. The code of conduct shall be accepted by each panel member.

It is the responsibility of the panel leader to make sure that each panel member acclimatised for at least 5 min before starting the assessment.

The panel leader shall explain to the panel members the importance of the test and time schedule. Furthermore, the panel leader shall monitor the procedure of the panel members but shall avoid any communication which may influence the result.

If a panel member does not fulfil the requirements given by the code of conduct or displays insufficient performance during the measurement procedure the panel leader shall consequently exclude the panel member at least from the current test run. Additionally, the panel leader shall consequently exclude panel members with distractive body odours (e. g. lack of hygiene, smoke odours, perfumes, etc.).

The panel leader shall make sure that the measurement values determined by the panel members are recorded without causing interference to other panel members.

9.1.2 Additional requirements for the panel leader for perceived intensity assessments

The panel leader shall make sure that the comparative scale provides reliably the desired acetone concentrations (see 6.4) and that the sampling of the odorous air out of the emission test chambers is conducted properly (see 8.4, 8.5).

The panel leader shall check if the panel members meets the criteria of the performance test (see 9.2.1).

The panel leader shall consider the development of each panel member to:

- identify changes in the panel members sense of smell;

- assure a reliable overview regarding the training and experience level of each panel member;
- schedule refresh trainings efficiently and without delay;
- identify the need to refresh the panel members training even though the scheduled refresh training is not yet due.

9.2 Panel selection

9.2.1 General requirements for panel selection

Candidate panel members shall not be anosmic. There are different olfactory function tests available (e.g. Sniffin Sticks [ISO 16000-30], EN 13725). The olfactory test results shall be documented.

Panel members shall be removed temporarily or permanently from the sensory odour panel if:

- a limitation in the sense of smell occurs (e. g. caused by an accident, a sinusitis, or other diseases);
- they violate the code of conduct.

9.2.2 Additional requirements for the panel selection for perceived intensity assessments

Candidate panel members shall not be anosmic.

There are different olfactory function tests available (e.g. Sniffin Sticks^{[17][18]}, or EN 13725). The olfactory test results shall be documented.

The test should be conducted before the full training starts. Moreover, candidates shall pass the full training (see [10.4.3](#)) to become a member of the trained sensory odour panel.

Panel members shall be removed temporarily or permanently from the sensory odour panel if:

- frequently the correct pi-level in the calibration process cannot be determined within the second try (see [10.4.4.3](#));
- they do not pass refresh trainings.

9.3 Code of conduct of the panel members

Each panel member shall fulfil the requirements of the code of conduct described below to be allowed to participate in a test run.

- the panel member shall be available for a longer period and carry out their job precisely;
- the panel member shall avoid activities which distract their concentration;
- at least 30 min (recommended: 60 min) before and during each test run, panel members shall not smoke, eat (includes sweets, chewing gums, etc.) or drink (drinking of flavourless water is allowed anytime);
- panel members shall take care not to cause any interference with their own perception or that of others in the test room and/or recovery room. They should avoid interference, e.g., eating spicy food or through lack of personal hygiene or the use of perfumes, odorous antiperspirants, body lotions, cosmetics, odorous detergents and softeners, etc.;
- panel members suffering from a cold or any other factors affecting their perception of smell (e.g. allergic fits or sinusitis) shall inform the panel leader;
- the panel leader shall be informed in case of significant differences in the perception of the reference odorant concentrations compared to previous test runs;

- panel members shall not communicate with each other about the perceived odour in general and the measurement results for the perceived intensity, hedonic tone or acceptability in particular;
- correct position of the nose at the funnel (see [10.2](#) and [Figure 3](#)).

9.4 Correct procedure for determination of the panel size

The panel size varies depending on the applied sensory test method and is described in detail in [Clause 10](#). It shall be large enough to meet the requirements of the accuracy of the odour evaluation (see [Clause 10](#)).

9.5 Panel training

A training of the sensory odour panel is required only for the determination of the perceived intensity with comparative scale (see [6.4](#), [10.4](#)). For the assessment of the acceptability and hedonic tone no training is intended.

10 Sensory test methods and procedure

10.1 General

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 for the assessment of odours.

10.2 Procedure

Before a test run starts it is essential for each panel member to acclimatise to the test environment. Therefore, they shall stay in the odour-neutral test room / recovery room (see [10.4.4](#)) for at least 5 min before the test run begins.

The odour samples that shall be assessed are provided to the panel members via funnels. The procedure of sniffing at the samples is — independent of the method and test parameter — recommended as follows:

- sniff at the funnel once;
- step back and let the impression of the odour sink in;
- if necessary to be certain about the acceptability / perceived intensity / hedonic tone of an odour (sample or reference) the steps a) and b) may be repeated several times.

Sniffing at the funnel shall ensure that the nose is surrounded by sample air being provided to the funnel and no external air is inhaled.



Figure 3 — Figures depicting the correct (left) and incorrect (right) position of the nose at the funnel^[36]

To avoid interference, the evaluation of acceptability, perceived intensity and hedonic tone shall be carried out in separate test cycles.

10.3 Determination of acceptability

The acceptability of the odour is assessed by an untrained panel with a minimum panel size of 15 untrained members. In order to achieve the 90 % confidence interval a panel size of 25 members is recommended. The evaluation expressed by the 90 % confidence interval shall be within $\pm 0,2$ for evaluations in the range of -1 to 1 . If the assessment is not finalized with the required confidence interval within 6 hours after sampling, further sampling and assessment within 30 h is possible. In case the requirement for the confidence interval is not reached, it shall be documented in the test report.

NOTE If the acceptability of the sample air is to be assessed as supplementary information to the perceived intensity, it is possible to use the same group of trained panel members (trained on perceived intensity).

Acceptability can be expressed as an evaluation parameter for the expected percentage of occupants dissatisfied 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 \(1\)](#):

$$PD = \frac{n_d}{n} * 100 \% \quad (1)$$

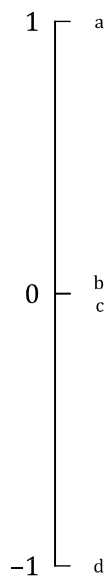
where

n_d is the number of dissatisfied panel members (number of panel members who answered “no”);

n is the total number of panel members.

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 4](#)). 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.

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.

**Key**

- a clearly acceptable
- b just acceptable
- c just unacceptable
- d clearly unacceptable

Figure 4 — 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 recorded. This should take place electronically before the panel member leaves the test room.
- 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.
- e) The second member of the panel sniffs the sample air, and so on.

10.4 Determination of the perceived intensity using a comparative scale

10.4.1 Comparative scale

The utilisation of the comparative scale (see 6.4) allows the standardized assessment of the perceived intensity and reduces the inter-individual variance. The perceived intensity (Π ; unit π) is determined by comparing the intensity of the sample with different intensities of the reference substance (acetone).

10.4.2 Panel

For the statistics (see Annex D) at least 10 evaluable measurement results are useful for each sample. Considering the results from the individual acetone-performance test of the panel members (see 10.4.4.3) it is always possible that one or more panel members have to be excluded due to insufficient calibration values. Thus, the utilisation of a larger panel of at least 12 to 15 panel members

is recommended. In case the requirement for the confidence interval (90 %; $\pm 2,0$ pi) is not reached, it shall be documented in the test report.

10.4.3 Panel training

A panel is trained to use the comparative scale as a means of assigning a reference concentration to a perceived odour intensity. The panel members are also familiarized with the assessment of unknown material odour in order to compare the unknown odour with the standardized odour provided by the comparative scales. This is necessary for the panel to be able to make accurate reproducible measurements with an acceptable standard deviation.

The procedure for the training of the panel is described in [Annex A](#).

10.4.4 Procedure

10.4.4.1 General information

During the whole test run an adaptation to the provided odour samples and particularly to the reference odour of the comparative scale shall be avoided. Therefore, the process of sniffing at the funnels shall generally be kept as short as possible and the first impression of the perceived odour should be decisive for the panel members' assessment. The general process of sniffing is described in [10.2](#).

The measurement of one odour sample or reference concentration shall not take longer than 90 s. Otherwise the panel member shall abort the process and re-acclimatise for at least 5 min before reassessing the provided odour.

For each test run the procedure consists of the following three steps:

10.4.4.2 Step one: Acclimatisation

Before the test run the panel members have to acclimatise to the test environment (see [10.2](#)).

To adjust to the test conditions, each panel member should be given the opportunity to sniff at reference concentrations of the comparative scale in ascending order.

Afterwards, the panel member sniffs supply air and returns to the recovery room.

If a panel member notices adaptation effects in such a way that he is no longer able to find a clear assessment of the provided air, it is necessary to breathe supply air as long as required to recover.

10.4.4.3 Step two: Performance test

For the performance test, the panel members rate the intensity of two acetone concentrations. The provided concentrations of the two acetone samples and the corresponding pi-values are known only to the panel leader (see [Clause 9](#)) but not to the panel members.

Step two is based on the same procedure as step three (see [10.4.4.4](#)) using acetone samples.

After completion of the rating of each unknown acetone sample the panel leader checks whether the reported pi-values of the panel members match the provided pi-value within a range of ± 2 pi. If the discrepancy exceeds ± 2 pi, the panel leader informs the panel member but does not explain whether the rating of the sample was too high or too low. The panel members get the immediate chance to rate the unknown acetone sample once more. The option for reassessing the acetone references is permitted only once per concentration.

If the second attempt also fails to be within ± 2 pi, the panel member shall be excluded from the whole test run. After the final assessment of each acetone reference concentration, the panel leader informs the panel members about the pi-value of the actually provided acetone reference concentrations.

10.4.4.4 Step three: Assessment

The procedure for each panel member and each unknown sample is as follows:

- a) sniffing at the unknown sample;
- b) deciding to which pi value of the comparative scale the sniffed sample matches best;
- c) comparing of the unknown pi value to the chosen value of the comparative scale;
 - 1) if it matches the unknown pi value exactly, the pi value is already determined;
 - 2) if it does not match, the panel member shall continue the procedure from a) or b) until he can decide for a pi value on the pi scale in whole numbers;
- d) reporting the determined pi-value;
- e) return to the recovery room.

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 perceived intensity with comparative scale value is considered satisfactory if the half width of the 90 % confidence interval of the mean does not exceed 2,0 pi (see [Annex D](#)).

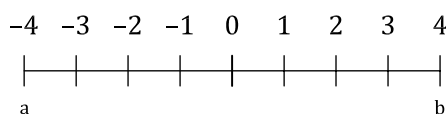
10.5 Determination of the hedonic tone

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

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

- "Assuming that you, daily for several hours, are exposed to the air from the unknown sample, how pleasant is the air quality?"

To determine the hedonic tone, the odour is assessed on a 9-level scale ranging from "extremely pleasant" (+4) to "extremely unpleasant" (−4) ([Figure 5](#)).



Key

- a extremely unpleasant
 0 neither pleasant nor unpleasant
 b extremely pleasant

Figure 5 — 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 [Annex A](#)).

To achieve the required standard deviation, a large untrained panel of minimum 15 members, shall be used. In order to achieve the 90 % confidence interval a panel size of 25 members is

recommended. In case the requirement for the confidence interval is not reached, it shall be documented in the test report.

NOTE If the hedonic of the sample air is to be assessed as supplementary information to the perceived intensity (see [Annex D](#)), it is possible to use the same group of trained panel members (trained on perceived intensity).

The procedure for assessing the hedonic tone is as follows:

- a) The first panel member sniffs 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 of the first assessment is possible.
- c) After the completed assessment, the result is recorded.
- d) The assessment should not exceed 90 s per panel member. If a panel member is unable to achieve an assessment value within the 90 s, the panel member can reassess after 5 min.
- e) The second panel member sniffs the unknown air sample, and so on.

11 Data analysis

11.1 Calculation of mean value and standard deviation

To achieve a desired accuracy in sensory testing with panels, the mean value of the generated olfactory data should range with a certain probability within previously defined limits. A confidence interval can be calculated for this. The calculation of the confidence interval is based on the observed values, and the limits within which the true mean value could lie are defined.

For the scales used in this standard, it can be assumed that they approximate to a normal distribution. The mean value $\bar{x}$ is calculated with [Formula \(2\)](#):

$$\bar{x} = \frac{1}{n} \sum_{i=1}^n x_i \quad (2)$$

where

$\bar{x}$ is the mean value;

x_i is the panel member's scale value;

n is the number of panel members.

The standard deviation s is calculated with [Formula \(3\)](#)

$$s = \sqrt{\frac{1}{n-1} \sum_{i=1}^n (x_i - \bar{x})^2} \quad (3)$$

where

s is the standard deviation;

$\bar{x}$ is the mean value;

x_i is the panel member's scale value;

n is the number of panel members.

11.2 Accuracy of sensory testing

The two-sided confidence interval for the true mean μ is the random interval around the estimated mean value $\bar{x}$ that contains μ with a probability of $(1-\alpha)$, see [Formula \(4\)](#)

$$P\left(\mu \in \left[\bar{x} \pm \frac{s}{\sqrt{n}} t_{(1-\alpha/2);n-1}\right]\right) = (1-\alpha) \quad (4)$$

where

- $t_{(1-\alpha/2);n-1}$ is the t-value for the $(1-\alpha/2)$ percentile of the t-distribution;
- n is the number of panel members;
- α is the probability of error;
- P is the probability;
- μ is the true mean;
- $\bar{x}$ is the mean estimator;
- s is the estimated standard deviation.

The specific interval bounds are now calculated on the basis of the panel member assessments in accordance with [Formula \(5\)](#):

$$\bar{x} - \frac{s}{\sqrt{n}} t_{(1-\alpha/2);n-1}; \bar{x} + \frac{s}{\sqrt{n}} t_{(1-\alpha/2);n-1} \quad (5)$$

The width of the confidence interval is dictated by the number n of panel members, the standard deviation s , the assessments of the panel and the probability of error α . For sensory testing in accordance with this standard, a probability of error of $\alpha = 0,10$ is adopted. The values for $t_{(1-\alpha/2);n-1}$ are listed in Table D.3 ([Annex D](#)).

With an increasing number of panel members, the confidence interval becomes narrower, i. e. the mean assessment of the odour's sensory features becomes more accurate.

12 Test report

The test report shall include at least the following information:

- a) test laboratory;
 - 1) name and address of the laboratory;
 - 2) date of the test;
 - 3) name of the responsible person;
 - 4) description of the equipment and methods used based on ISO 16000-28 (emission test chamber, clean air system, odour sampling device (sample containers, sample presentation system), comparative scale (reference odour, levels of concentrations presented) analytical instrumentation, standard generation and calibration).
- b) test specimen description;
 - 1) type of product (and brand name if appropriate);
 - 2) 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 specimen preparation (hour, day, month and year);
 - 2) method of preparation, including thickness and substrate; additional for liquid products, the substrate, the amount per unit area and/or the thickness and other relevant information.
- d) experimental conditions and procedures;
- 1) emission test chamber conditions (temperature, relative humidity, air change rate, supply air flow rate at the funnel outlet, background odour);
 - 2) test specimen area and loading ratio;
 - 3) test room and recovery room (background odour, temperature, relative humidity, air change rate of the test room);
 - 4) sensory test method selection (acceptability/perceived intensity/hedonic tone);
 - 5) if applicable, comparative scale (corresponding deviations of the concentration levels presented, calibration device);
 - 6) odour sampling procedure (background odour of the sample container, sampling time);
 - 7) odour sample presentation (air flow rate at the funnel outlet, background odour of the sample presentation system);
 - 8) sensory odour panel (panel size).
- e) results (depending on the selected method following [Clause 10](#));
- 1) method 1 — acceptability
 - i) arithmetic mean of the acceptability assessments;
 - ii) if required, PD value;
 - iii) uncertainty (confidence interval).
 - 2) method 2 — perceived intensity:
 - i) arithmetic mean of the perceived intensity assessments;
 - ii) uncertainty (confidence interval).
 - 3) method 3 — hedonic tone:
 - i) arithmetic mean of the hedonic tone assessments;
 - ii) uncertainty (confidence interval).

Annex A (informative)

Training procedure for the comparative scale

A.1 Training procedure for perceived intensity assessment using a comparative scale

The evaluation of perceived intensity using a comparative scale according to [10.4](#) requires that the panel members shall be trained. The goal of the training is to familiarize the panel members with the assessment method and the reference substance. A prerequisite for the training is the testing of the olfactory function of the panel members.

The full training program comprises a set of tests over five days. The success of the training is assessed by means of the odour 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 performance test is implemented before each test (see [10.4](#)) and serves as a regular monitor of the training of the panel. A freshen-up-training course (two days) consists of, e.g., the requirements for days 4 and 5 in [Table A.1](#).

A full training for a panel member shall be conducted when:

- new members are introduced to the panel.

A freshen-up-training course shall be conducted:

- once a year;
- a panel member has not performed any tests for more than three months and fails the performance test;
- a panel member fails the performance tests during three consecutive assessments or shows other significant deviations.

An overview of the training programme is provided in [Table A.1](#). The training lasts approximately 2–3 h per day.

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 concentrations well-distributed over the entire pi-scale. After each individual assessment, the panel members are informed of the actual pi-values. All panel members are given the opportunity to sniff the acetone concentration again with the knowledge of the actual pi value.

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

Training day	Topic	Task
Day 1	Presentation of the training programme Familiarization	8 samples of air with different acetone concentrations
Day 2	Training Familiarization with assessment of building products	4 samples of air with different acetone concentrations sample air from 4 different materials
Day 3	Training Familiarization with the testing procedure	2 samples of air with different acetone concentrations (in accordance with the performance test) sample air from 6 different materials
Day 4	Testing cycle to determine the results of the training programme	2 samples of air with different acetone concentrations (performance test) 4 samples of air with different acetone concentrations sample air from 2 different materials
Day 5	Testing cycle to determine the results of the training programme Evaluation of the training programme	2 samples of air with different acetone concentrations (performance test) 4 samples of air with different acetone concentrations sample air from 2 different materials

On day two, the training starts with four unknown acetone concentrations. After each assessment, the panel members are informed of the actual pi-values. Afterwards, they are requested to assess odour samples from different building products. This part of the training should familiarize the panel members with the assessment of unknown odours by means of the comparative scale. Since the true pi-value of the odour sample is unknown, the assessments of the individual panel members are compared with the mean value of the evaluation of the entire panel. The panel members are informed of each mean value of the panel and sniff the unknown sample and the comparative scale again.

On the third day of training, the tests are performed as they are in the actual odour tests according to 10.4. This means that the first two samples of acetone concentrations are provided for odour assessment.

After completion of the rating of each unknown acetone sample, the panel leader checks whether the reported pi-values of the panel members match the provided pi-value within a range of ± 2 pi. If the discrepancy exceeds ± 2 pi, the panel leader informs the panel member but does not explain whether the rating of the sample was too high or too low. The panel members get the immediate chance to rate the unknown acetone sample once more. The option for reassessing the acetone references is permitted only once per concentration. Afterwards the panel members are informed of the actual pi value.

Subsequently the unknown samples are tested. The panel members are informed of each mean value of the panel and can, if necessary, sniff the unknown sample and the comparative scale again.

On the fourth and fifth day, the pi values are only given during the first two assessments (see 10.4). The panel members are reminded that assessments made on the final two days decide upon the success of

the training programme of each panel member. The evaluation of the whole training is based on the four acetone concentrations and the two odour samples assessed on each of these days.

A.2 Evaluation of the training programme

The panel leader documents the assessments and achievements of each panel member over the entire course of the training programme. There is a clear intention to motivate the panel members through the discussion about their individual performance progress. If a panel member does not show any improvement in the first three days of training, they 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 A.1](#), which shows the deviation of the test from the present p_i value and the range of tolerance.

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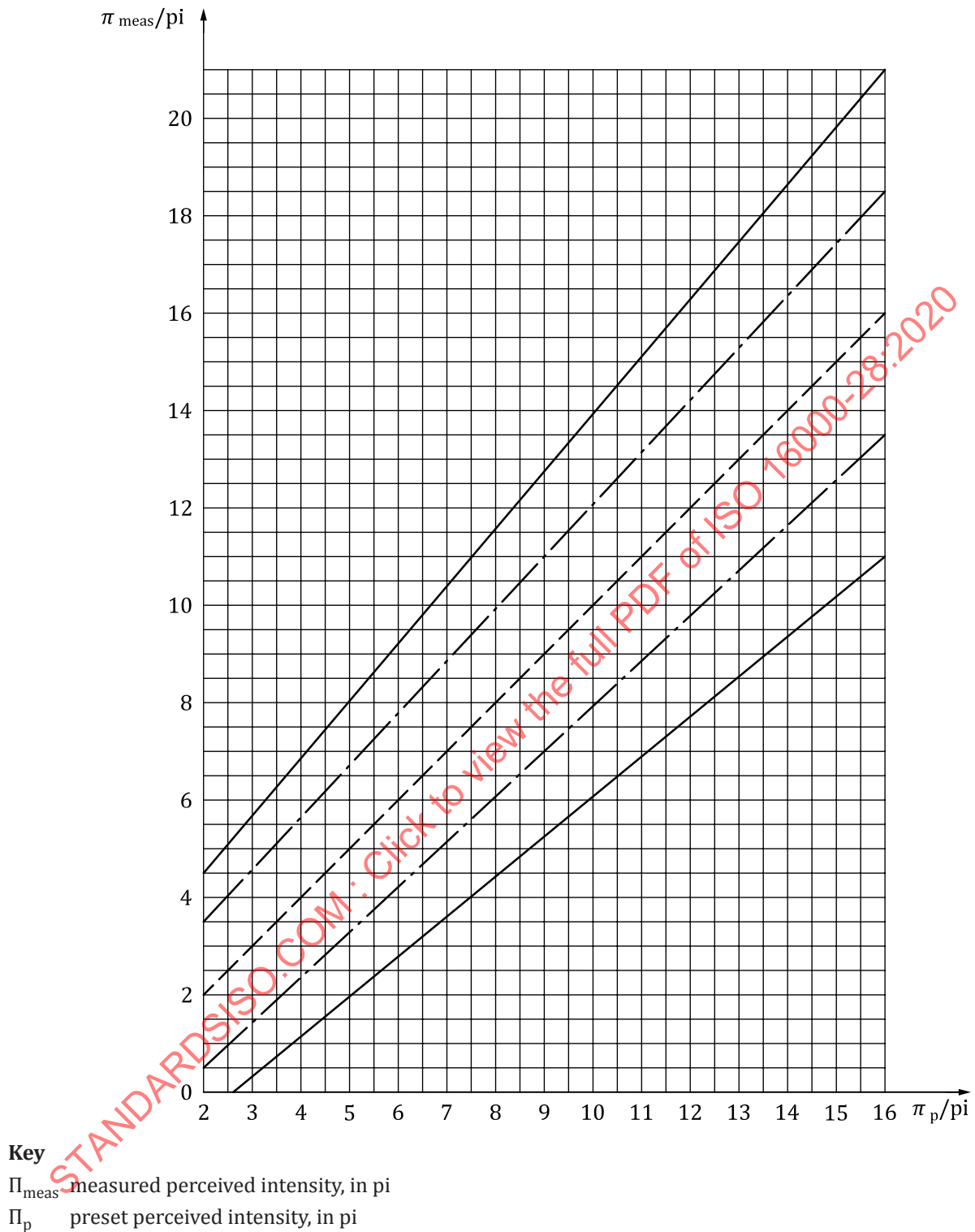


Figure A.1 — Tolerance zone for perceived intensities measured by panel members

If the assessment is on the dashed line, the evaluation conforms to the present 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 B (informative)

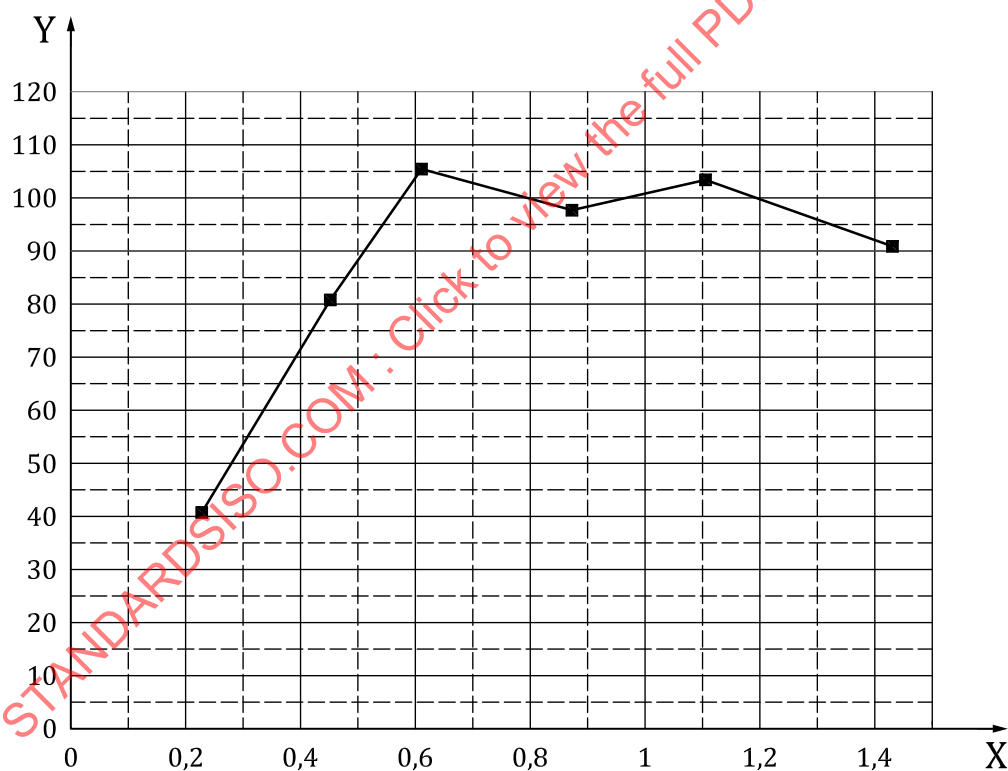
General conditions for sensory testing

B.1 Explanation of the flow rate during sensory testing

According to [17] a resting human being breathes about 15 times per min and inhales a volume of 7,5 l/min. This means that a human being has an average inhalation volume of 0,5 l. At least this volume shall be provided to the panel member during tests.

The assessment of the perceived air quality in relation to the flow rate at the panel member's nose at funnel outlet was investigated [18]. The flow rate varied from 0,2 l/s to 1,5 l/s (Figure B.1).

The investigation showed that the assessment of the perceived air quality only becomes constant in terms of measurement accuracy from a flow rate of approximately 0,5 l/s to 0,6 l/s at the funnel outlet. At lower flow rates, an accurate assessment of the perceived air quality was not possible. The measurements showed useful flow rates of 0,6 l/s to 1 l/s at the funnel outlet.



Key

X flow rate, in l/s

Y assessed relative air quality, in relation to the actual value in %

Figure B.1 — Effect of flow rate on the assessment of perceived air quality, as per to [18]

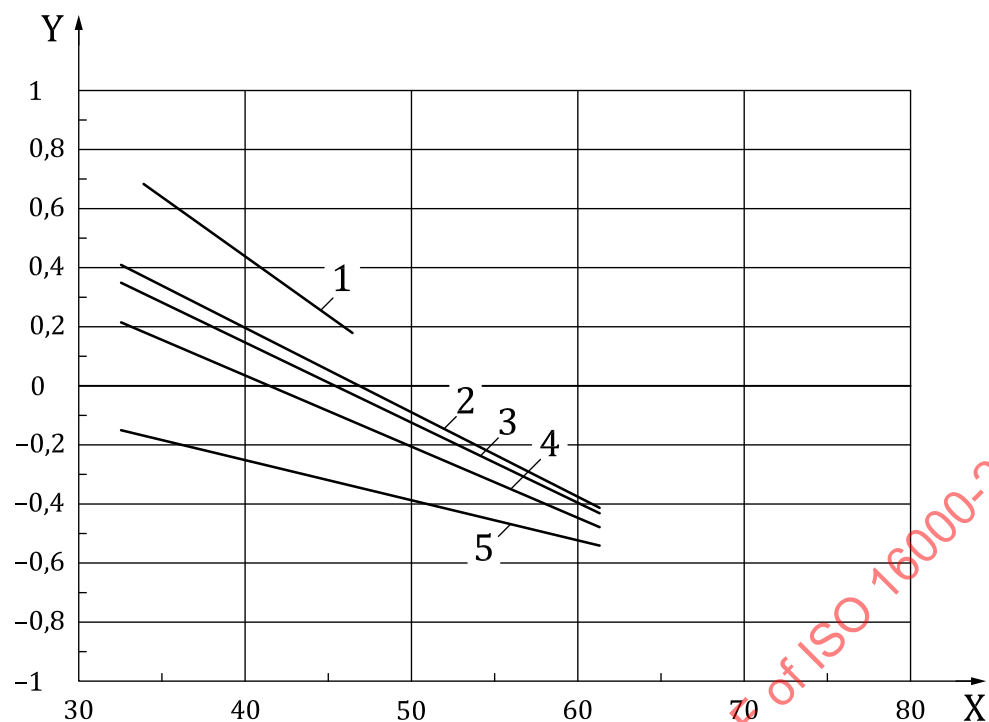
B.2 Effect of thermal condition of the air to the odour determination of air samples

The thermal state (temperature and humidity, or specific enthalpy) of the inhaled air affects the perception of odours. At the time of publication of this standard, there was no awareness of conversions to other air temperatures and humidities. The assessment of the odour should therefore always take place in the thermal comfort range. A temperature of 21 °C to 22 °C is recommended and a temperature range of 20 °C to 25 °C shall be observed. The relative humidity shall be 50 % $\pm$ 10 %. This results in a specific enthalpy of the humid air within the range of 43 kJ/kg $\pm$ 5 kJ/kg.

The thermal state of the perceived air influences the odour assessment. Therefore, this value has to be considered by the assessment method. The effects of temperature and humidity on odour assessment have been demonstrated in various studies. Acceptability declines by a simultaneous increase of enthalpy of the air, no matter whether the increase in enthalpy is due to an increase in temperature or in humidity. This is evident from the study findings of [19], [20] which are presented in [Figure B.2](#). These findings have been confirmed by [21].

The perceived intensity assessed with a category scale declines with increasing specific enthalpy, i.e. the odour is perceived as less strong at high temperatures and humidities than in dry, cold air. This was confirmed by [22]. An excerpt of the study findings are displayed in [Figure B.3](#). The degree of the effect of specific enthalpy varies for each odour compound.

When the perceived intensity is assessed with a comparative scale, the perceived intensity of the odour decreases with increasing relative humidity. In contrary to the assessment based on a category scale, there is no direct dependence on the specific enthalpy. A constant relative humidity and varying temperature showed no significant change in the assessment of intensity despite the increased specific enthalpy^[21]. An excerpt of the findings are presented in [Figure B.4](#).



Key

- X specific enthalpy, in kJ/kg
- Y acceptability
- 1 dry run
- 2 emulsion paint
- 3 carpet
- 4 floor paint/varnish
- 5 sealant

Figure B.2 — Effect of the specific enthalpy of the assessed air on acceptability as per [20]

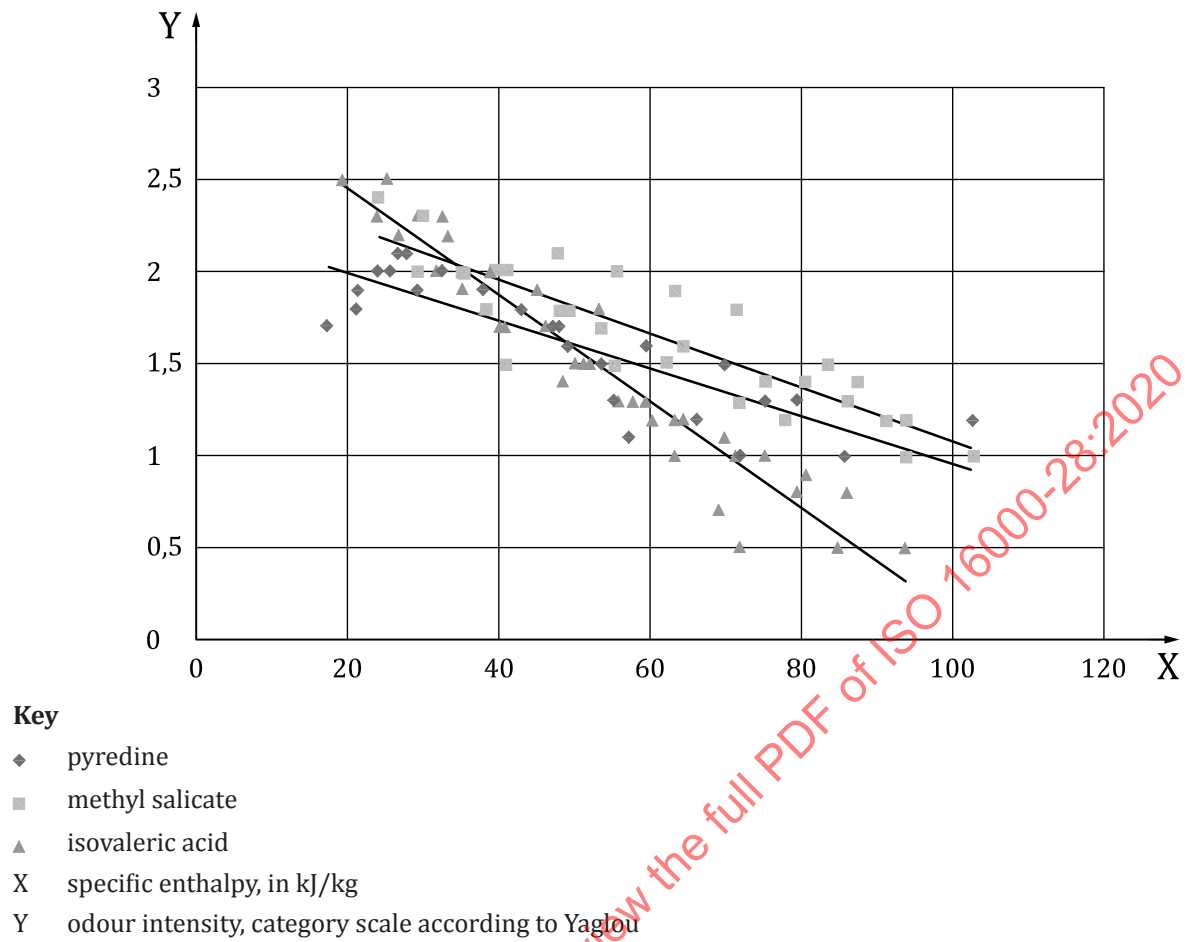
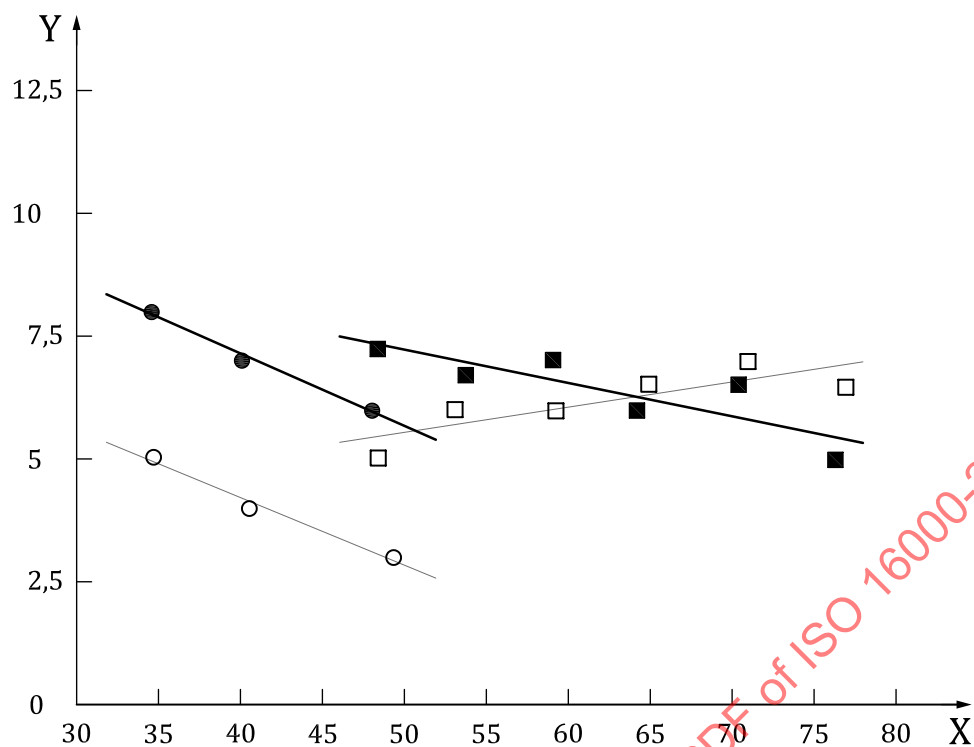


Figure B.3 — Effect of the specific enthalpy of the assessed air on the assessment of intensity with a category scale, as per [22]



Key

○	carpet	$\phi = \text{const.}$
●	acetone	$\phi = \text{const.}$
□	carpet	$\vartheta = \text{const.}$
■	acetone	$\vartheta = \text{const.}$

Figure B.4 — Effect of specific enthalpy of the assessed air on the assessment of intensity with a comparative scale of acetone samples, as per [21]

Annex C (informative)

Sampling containers (bags) and sampling and presentation device

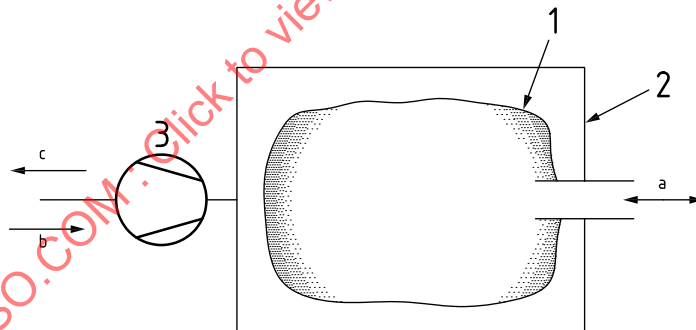
C.1 Sampling and presentation device

A schematic of a sampling/presentation apparatus can be found in [Figure C.1](#).

- Principle of sampling mode: A vacuum is created in an airtight box to let the sample air flow into the sampling container.
- Principle of presentation mode: An over-pressure is created in the box to compress the sampling container and let the sample air flow out.

This kind of sampling system guarantees that the sample air does not come into contact with the pump/fan. Inlet and outlet shall be made of odourless, inert materials such as stainless steel, polytetrafluoroethylene or glass.

For presenting the sample the air flow must be constant and in the range of 0,6 l/s to 1,0 l/s (see [6.3.2](#)). Typical bag sizes are between 50 l and 300 l. The required sample volume depends on the number of panel members, the type of presentation (continuous or on-demand presentation) and the type of assessment (acceptability, hedonic tone, perceived intensity). Several bags may be used for one assessment.



Key

- 1 sampling bag
- 2 casing
- 3 fan
- a sample in or out
- b defating
- c filling

Figure C.1 — Schematice of a sampling/presentation apparatus^[16]

C.2 Sample containers

C.2.1 General requirements

Materials for sample containers are susceptible to contamination and should generally be stored in clean atmosphere.