



BSI Standards Publication

Air quality - Determination of odour concentration by dynamic olfactometry

National foreword

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28 April 2006	Implementation of CEN corrigendum January 2006: replacement of Tables D.1 and E.1, and Equations 36 and 43
31 May 2019	Standard corrected to fix formatting errors

English version

Air quality - Determination of odour concentration by dynamic olfactometry

Qualité de l'air - Détermination de la concentration d'une odeur par olfactométrie dynamique

Luftbeschaffenheit - Bestimmung der Geruchsstoffkonzentration mit dynamischer Olfaktometrie

This European Standard was approved by CEN on 6 December 2002.

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Foreword

This document (EN 13725:2003) has been prepared by Technical Committee CEN/TC 264 "Air quality", the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by October 2003, and conflicting national standards shall be withdrawn at the latest by October 2003.

Annex A is normative. Annexes B, C, D, E, F, G, H, I and J are informative.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Slovakia, Spain, Sweden, Switzerland and the United Kingdom.

Introduction

This European Standard and its quality criteria were validated in an Interlaboratory Comparison for Olfactometry (ICO) in 1996, that was funded by the participating laboratories.

Sampling aspects are included in the structure of this Standard, although further research is necessary to complete this issue. Due to lack of financial support, no progress has been made on this point. Improvements in sampling may be the subject of a future revision of this European Standard.

1 Scope

This European Standard specifies a method for the objective determination of the odour concentration of a gaseous sample using dynamic olfactometry with human assessors and the emission rate of odours emanating from point sources, area sources with outward flow and area sources without outward flow. The primary application is to provide a common basis for evaluation of odour emissions in the member states of the European Union.

This European Standard is applicable to the measurement of odour concentration of pure substances, defined mixtures and undefined mixtures of gaseous odorants in air or nitrogen, using dynamic olfactometry with a panel of human assessors being the sensor. The unit of measurement is the European odour unit per cubic metre: $\text{ou}_\text{E}/\text{m}^3$. The odour concentration is measured by determining the dilution factor required to reach the detection threshold. The odour concentration at the detection threshold is by definition $1 \text{ ou}_\text{E}/\text{m}^3$. The odour concentration is then expressed in terms of multiples of the detection threshold. The range of measurement is typically from $10^1 \text{ ou}_\text{E}/\text{m}^3$ to $10^7 \text{ ou}_\text{E}/\text{m}^3$ (including pre-dilution).

The field of application of this European Standard includes:

- the measurement of the mass concentration at the detection threshold of pure odorous substances in g/m^3 ;
- the measurement of the odour concentration of mixtures of odorants in $\text{ou}_\text{E}/\text{m}^3$;
- the measurement of the emission rate of odorous emissions from point sources and surface sources (with and without an outward flow), including pre-dilution during sampling;
- the sampling of odorants from emissions of high humidity and temperature (up to 200°C);
- the determination of effectiveness of end-of-pipe devices used to reduce odour emissions.

The characterisation of odour emissions requires detailed measurement of the gas velocity, that shall be performed according to the relevant standards included in the normative references.

This European Standard is not applicable to:

- the measurement of odours potentially released by particles of odorous solids or droplets of odorous fluids suspended in emissions;
- the measuring strategy to be applied in case of variable emission rates;
- the measurement of the relationship between odour stimulus and assessor response above detection threshold;
- direct measurement of hedonic tone (or (un)pleasantness) or direct assessment of potential annoyance;
- field panel methods;
- measurement of recognition thresholds;

— measurement of identification thresholds.

Although the ultimate application of odour measurement is in reducing odour nuisance, the relation between measured thresholds of odour according to this standard and the occurrence of odour nuisance is highly complex. It is profoundly influenced by the atmospheric processes determining the dispersion of odours, the quality of the odour (hedonic tone) and finally by the receptor characteristics of those exposed to the odour. These characteristics not only vary strongly between individuals, but also in time within one individual. The relation between emissions, dispersion, exposure and annoyance is not within the scope of this European Standard.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text, and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

ISO 10780, *Stationary source emissions - Measurement of velocity and volume flowrate of gas streams in ducts*.

3 Terms, definitions and symbols

3.1 Terms and definitions

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

3.1.1

accepted reference value

value that serves as an agreed upon reference for comparison, and which is derived as a consensus or certified value, based on collaborative experimental work under the auspices of a scientific or engineering group (derived from ISO 5725-1)

3.1.2

accuracy

closeness of agreement between test result and the accepted reference value

[ISO 5725-1]

NOTE The term 'accuracy', when applied to a set of test results, involves a combination of random components and a common systematic error or bias component.

3.1.3

(sensory) adaptation

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

[ISO 5492]

3.1.4

anosmia

lack of sensitivity to olfactory stimuli

[ISO 5492]

3.1.5

assessor

somebody who participates in odour testing

3.1.6

bias

difference between the expectation of the test results and an accepted reference value

[ISO 5725-1]

NOTE Bias is often called 'systematic error'.

3.1.7

certified reference material, CRM

reference material of which one or more property values are certified by a technically valid procedure accompanied by or traceable to a certificate or other documentation which is issued by a certifying body

[ISO 5725-4]

3.1.8

decision limit

output signal value above which it can be affirmed, with a probability of $1 - \alpha$ of at least 95 %, that the measured sample is different from a zero sample

NOTE A zero sample has 5 % probability of causing an output signal above the decision limit (derived from ISO 6879).

3.1.9

delayed olfactometry

measurement of an odour with a time-lag between sampling and measurement. The odour sample is preserved in an appropriate container

3.1.10

detection threshold (for a reference material)

odorant concentration which has a probability of 0,5 of being detected under the conditions of the test

3.1.11

detection threshold (for an environmental sample)

dilution factor at which the sample has a probability of 0,5 of being detected under the conditions of the test

3.1.12

diffuse sources

sources with defined dimensions (mostly surface sources) which do not have a defined waste air flow, such as waste dumps, lagoons, fields after manure spreading, un-aerated compost piles

3.1.13

dilution factor

dilution factor is the ratio between flow or volume after dilution and the flow or volume of the odorous gas

3.1.14

dilution series

presentation of a sequence of dilutions to one panel member in order to obtain one Individual Threshold Estimate (see Figure 1)

NOTE One dilution series can consist of:

One series of presentations, at odour concentrations in ascending or random order, where, when sorted in order of descending concentrations, a significant change from consistently TRUE responses to a FALSE response occurs (see also Figure 1).

3.1.15

direct olfactometry

measurement of odour concentrations without any time-lag between the sampling (operation) and the measurements; equivalent to dynamic sampling or on-line olfactometry

3.1.16**dynamic olfactometer**

dynamic olfactometer delivers a flow of mixtures of odorous and neutral gas with known dilution factors in a common outlet

3.1.17**dynamic olfactometry**

olfactometry using a dynamic olfactometer

3.1.18**dynamic dilution**

dilution achieved by mixing two known flows of gas, odorous sample and neutral gas, respectively. The rate of dilution is calculated from the flow rates

3.1.19**European Odour unit**

that amount of odorant(s) that, when evaporated into 1 cubic metre of neutral gas at standard conditions, elicits a physiological response from a panel (detection threshold) equivalent to that elicited by one European Reference Odour Mass (EROM), evaporated in one cubic metre of neutral gas at standard conditions

3.1.20**European Reference Odour Mass , EROM**

accepted reference value for the European odour unit, equal to a defined mass of a certified reference material. One EROM is equivalent to 123 µg n-butanol (CAS-Nr. 71-36-3). Evaporated in 1 cubic metre of neutral gas this produces a concentration of 0,040 µmol/mol

3.1.21**expanded uncertainty**

quantity defining an interval about the result of a measurement that may be expected to encompass a large fraction of the distribution of values that could reasonably be attributed to the measurand

[ENV 13005]

3.1.22**expected value**

value approached by the average value with an increasing number of measurement values

3.1.23**forced choice method**

for this standard the following definition applies: An olfactometric method in which assessors are forced to make a choice out of two or more air flows, one of which is the diluted sample, even if no difference is observed

3.1.24**fugitive sources**

elusive or difficult to identify sources releasing undefined quantities of odorants e.g. valve and flange leakage, passive ventilation apertures etc.

3.1.25**geometric mean**

antilog of the arithmetic average of the logarithms of a set of values or $\sqrt[n]{y_1 \cdot y_2 \cdot \dots \cdot y_n}$

NOTE The formula contains an n -root (not to be confused with a square root).

3.1.26**group threshold**

detection threshold applying to a group of assessors

3.1.27

identification threshold

see recognition threshold

3.1.28

individual threshold

detection threshold applying to an individual

3.1.29

individual threshold estimate, ITE

detection threshold applying to an individual estimated on the basis of one dilution series

3.1.30

instability

change of a characteristic over a stated period of time, consisting of a systematic part (drift) and a random part (dispersion)

[ISO 9169]

3.1.31

instrumental dilution range

range between the minimum and maximum dilution factor

3.1.32

instrumental lag time

time taken for the output signal to reach 10 % (by convention) of the final change in reading (derived from ISO 6879)

3.1.33

instrumental response time

time taken for an instrument to respond to an abrupt change in value of the air quality characteristic. It is the sum of the lag time and rise time (rising mode) or lag time and fall time (falling mode) (derived from ISO 6879)

3.1.34

instrumental rise time (fall time)

time taken for the reading to pass from (by convention) 10 % to (by convention) 90 % of the final change in output signal reading (derived from ISO 6879). For instruments where transient oscillations occur in the approach to the final output signal reading, the rise time is the time taken for the instrument reading to pass from (by convention) 10 % of the final change in instrument reading until the oscillations fall to less than (by convention) 10 % of the final change in instrument reading

3.1.35

maximum dilution factor

maximum settable dilution factor of the olfactometer; an instrument property

3.1.36

measurement

the presentation to all panel members of those dilution series necessary to produce sufficient data to calculate the odour concentration for one sample (see Figure 1)

3.1.37

measuring range

measuring range comprises all odour concentrations which can be measured by a specific olfactometer. It depends on the minimum and maximum dilution factor and the step factor. The numerical values defining the measuring range are the minimum dilution factor multiplied with the step factor to the power 1,5 and the maximum dilution factor divided by the step factor to the power 1,5

3.1.38

minimum dilution factor

minimum settable dilution factor of the olfactometer; an instrument property

3.1.39**neutral gas**

air or nitrogen that is treated in such a way that it is as odourless as technically possible and that does, according to panel members, not interfere with the odour under investigation

SAFETY WARNING Nitrogen is only used to predilute the sample itself. For the olfactometer the neutral gas used to dilute the sample and present a reference shall be air.

3.1.40**objective method**

any method in which the effects of personal opinions are minimised

[ISO 5492]

3.1.41**odorant**

substance which stimulates a human olfactory system so that an odour is perceived (Hangartner, M, 1989, see Bibliography)

3.1.42**odour flow rate**

odour flow rate is the quantity of European odour units which crosses a given surface divided by time. It is the product of the odour concentration c_{od} , the outlet velocity v and the outlet area A or the product of the odour concentration c_{od} and the pertinent volume flow rate $\dot{V}$. Its unit is ou_E/h (or ou_E/min or ou_E/s, respectively)

NOTE The odour (emission) flow rate, expressed in units ou_E/s, is the quantity equivalent to the emission mass flow rate, expressed in kg/s, as used in dispersion models for example.

3.1.43**odorous gas**

gas that contains odorants

3.1.44**odour**

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

[ISO 5492]

3.1.45**odour abatement efficiency**

reduction of the odour concentration or the odour flow rate due to an abatement technique, expressed as a fraction (or percentage) of the odour concentration in or the odour flow rate of the untreated gas stream

3.1.46**odour concentration**

number of European odour units in a cubic metre of gas at standard conditions

NOTE The odour concentration is not a linear measure for the intensity of an odour. Steven's Law describes the a-linear relation between odour stimulus and its perceived intensity. When using odour concentrations in dispersion modelling, the issue is complicated by the effects of the averaging time of the dispersion model, further complicating the use of the odour concentration as a direct measure for dose. To define a 'no nuisance level', the entire method of dosage evaluation, including the dispersion model, will yield a 'dose'. The relation between this 'dose' and its effect (odour annoyance) should be validated in practical situations to be a useful predictive tool for occurrence of odour nuisance.

3.1.47**odour detection**

to become aware of the sensation resulting from adequate stimulation of the olfactory system

3.1.48**odour panel**

see panel

3.1.49

odour unit

one odour unit is the amount of (a mixture of) odorants present in one cubic metre of odorous gas (under standard conditions) at the panel threshold

NOTE See also "European odour unit".

3.1.50

odour threshold

see panel threshold

3.1.51

odourless gas

see neutral gas

3.1.52

olfactometer

apparatus in which a sample of odorous gas is diluted with neutral gas in a defined ratio and presented to assessors

3.1.53

olfactometry

measurement of the response of assessors to olfactory stimuli

[ISO 5492]

3.1.54

olfactory

pertaining to the sense of smell

[ISO 5492]

3.1.55

olfactory receptor

specific part of the olfactory system which responds to an odorant (derived from ISO 5492)

3.1.56

olfactory stimulus

that which can excite an olfactory receptor (derived from ISO 5492)

3.1.57

on-line olfactometry

see direct olfactometry

3.1.58

operator

person directly involved in operating the olfactometer and instructing the panel in olfactometry

3.1.59

panel

group of panel members

3.1.60

panel member

assessor who is qualified to judge samples of odorous gas, using dynamic olfactometry within the scope of this standard

3.1.61**panel screening**

procedure to determine if the performance of panel members is in compliance with selection criteria. See also panel selection

3.1.62**panel selection**

procedure to determine which assessors are qualified as panel members

3.1.63**panel threshold**

detection threshold applying to a panel

3.1.64**perception**

awareness of the effects of single or multiple sensory stimuli

[ISO 5492]

3.1.65**performance testing**

determination of laboratory testing performance on reference materials against specified quality criteria

3.1.66**point source**

discrete stationary source of emission of waste gases to atmosphere through canalised ducts of defined dimension and air flow rate (e.g. chimneys, vents)

3.1.67**population (detection) threshold**

detection threshold applying to the general population, if this population is not specified

3.1.68**precision**

closeness of agreement between independent test results obtained under prescribed conditions

[ISO 5725-1]

NOTE Precision depends only on the distribution of random errors and does not relate to the true value or the accepted reference value. The measure of precision is usually expressed in terms of imprecision and computed as a standard deviation of the test results. Higher imprecision is reflected by a larger standard deviation. 'Independent test results' means results obtained in a manner not influenced by any previous result on the same or similar material.

3.1.69**presentation**

one presentation is the presentation of one dilution to one assessor (see Figure 1)

3.1.70**presentation series**

presentation of one dilution to all panel members in one round (see Figure 1)

3.1.71**presented gas flow**

gas flow presented to the assessor. It may be:

- a diluted odour sample;
- neutral gas (e.g. as a blank or reference air)

3.1.72

proficiency testing

determination of laboratory testing performance by means of interlaboratory comparisons

[EN 45020]

3.1.73

quality

totality of features and characteristics of a product or service that bear on its ability to satisfy stated or implied needs

[ISO 6879]

3.1.74

quality assurance

all those planned and systematic actions necessary to provide adequate confidence that a product, process or service will satisfy given requirements for quality

[ISO 6879]

3.1.75

random error

unpredictable errors which average to zero

[ISO 5492]

3.1.76

recognition threshold

odour concentration which has a probability of 0,5 of being recognised under the conditions of the test (definition not applied in this standard)

3.1.77

reference material

substance or mixture of substances, the composition of which is known within specified limits, and one or more of the properties of which is sufficiently well established to be used for the calibration of an apparatus, the assessment of a measuring method, or for assigning values to materials (derived from ISO 6879)

3.1.78

reference value

see accepted reference value

3.1.79

repeatability

precision under repeatability conditions

[ISO 5725-1]

3.1.80

repeatability conditions

conditions where independent test results are obtained with the same method on identical test material in the same laboratory by the same operator using the same equipment within short intervals of time

[ISO 5725-1]

3.1.81

repeatability limit

value less than or equal to which the absolute difference between two test results obtained under repeatability conditions may be expected to be with a probability of 0,95 (derived from ISO 5725-1)

3.1.82**reproducibility**

precision under reproducibility conditions

[ISO 5725-1]

3.1.83**reproducibility conditions**

conditions where test results are obtained with the same method on identical test material in different laboratories with different operators using different equipment

[ISO 5725-1]

3.1.84**reproducibility limit**

value less than or equal to which absolute difference between two test results obtained under reproducibility conditions may be expected to be with a probability of 0,95 (derived from ISO 5725-1)

3.1.85**responsible person**

person, who is ultimately responsible for the total of olfactometry in a laboratory

3.1.86**round**

one round is the presentation of one dilution series to all assessors

3.1.87**sample**

in the context of this standard, the sample is the odorous gas sample. It is an amount of gas which is assumed to be representative of the gas mass or gas flow under investigation, and which is examined for odour concentration [ISO 6879]

3.1.88**sensory fatigue**

form of adaptation in which a decrease in sensitivity occurs

[ISO 5492]

3.1.89**sensory reference**

presented gas flow to which the diluted sample is compared

3.1.90**single measurement**

identical to Measurement, see also test result

3.1.91**to smell**

to detect or to attempt to detect an odorant

3.1.92**standard conditions for olfactometry**

at room temperature (293 K), normal atmospheric pressure (101,3 kPa) on a wet basis (derived from ISO 10780)

NOTE This applies both to olfactometric measurements and volume flow rates of emissions. The conditions were chosen by convention, to reflect typical conditions for smell perception.

3.1.93

static olfactometer

static olfactometer dilutes by mixing two known volumes of gas, odorous sample and neutral gas, respectively. The rate of dilution is calculated from the volumes

3.1.94

static dilution

dilution achieved by mixing two known volumes of gas, odorous sample and neutral gas, respectively. The rate of dilution is calculated from the volumes

3.1.95

step factor

factor by which each dilution factor in a dilution series differs from adjacent dilutions

3.1.96

subjective method

any method in which the personal opinions are taken into consideration

[ISO 5492]

3.1.97

substance

species of matter of definite chemical composition (Hangartner, M, 1989, see Bibliography)

3.1.98

test result

value of a characteristic obtained by completely carrying out a specific measurement, once

[ISO 5725-1]

NOTE In this standard the test result for one odour concentration measurement is the logarithm of the odour concentration: $\log_{10}(C_{od})$. This conversion to logarithms is required for statistical calculations on specific parameters, as indicated in 3.2.

3.1.99

traceability

property of the result of a measurement that can be related through an unbroken chain of comparisons to appropriate reference materials, generally national or international reference materials, using measurement standards of successively increasing accuracy

3.1.100

trueness

closeness of agreement between the average value obtained from a large series of test results and an accepted reference value

[ISO 5725-1]

NOTE The measure of trueness usually is expressed in terms of bias.

3.1.101

true value

see accepted reference value

3.1.102

yes/no method

olfactometric method in which assessors are asked to judge whether an odour is detected or not

3.1.103

zero sample

substance or mixture of substances resembling, as closely as possible, the matrix of the actual air sample to be measured, but characterized by a value of the air quality characteristic which is not detectable by the method used

[ISO 6879]

NOTE In practice, the value of the air quality characteristic is considered to be zero.

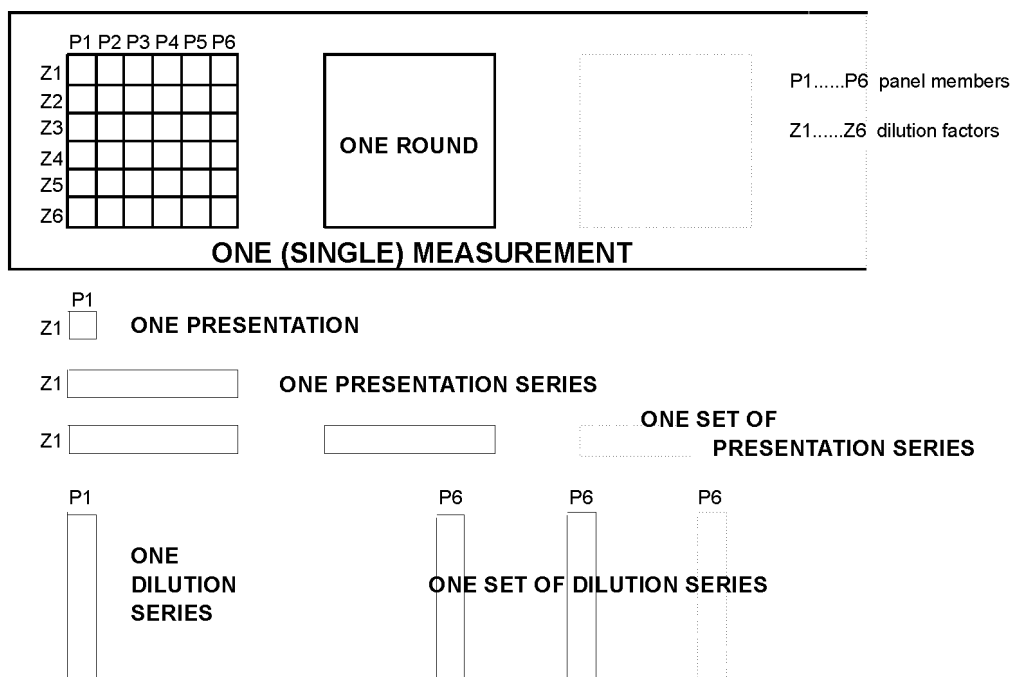


Figure 1 - Diagram of various terms describing the elements of one (single) measurement for yes/no method and forced choice method

3.2 Symbols and units

The symbols used in this standard are listed in the table below. Those parameters that are calculated from test results obtained after $\log_{10}$ conversion of the underlying test results, see 5.3, are marked in the last column.

Table 1 — Symbols and units

Symbol	Description	Unit	Conversion of test results to log ₁₀ required?
A	Area	m ²	
A_d	Accuracy of dilution instruments		
A_{od}	Accuracy of the odour measurement		
A_w	Statistical factor for calculation of accuracy		
$A_{w,d}$	Statistical factor for calculation of accuracy of dilution		
B	Laboratory component of bias		
C_{od}	Odour concentration	ou _E /m ³	
$C_{od, clean}$	Odour concentration in treated gas	ou _E /m ³	
$C_{od, crude}$	Odour concentration in untreated gas	ou _E /m ³	
CRM	Certified Reference Material		
d_w	Trueness expressed as the estimate of within-laboratory bias		
$d_{w,d}$	Trueness expressed as the estimate of the dilution setting bias		
D_{50}	The dose of odorant that 50 % of a population that can detect as a sensory stimulus.		
e	Random error of test result		
$EROM$	European Reference Odour Mass	µg n-butanol	
F_s	Step factor		
I_d	Instability of a dilution	%	
$ITE_{substance}$	Individual Threshold Estimate for a known substance	mg/m ³	
m	Expected value		
m_D	Expected value of the difference of the averages of odour concentrations	ou _E /m ³	yes
n	Number of test results		
o_j	Observation number j (instrumental calibration)		
ou_E	European odour unit		
p	Number of panel members		
p_s	Absolute pressure in stack	kPa	
q_{od}	Odour flow rate	ou _E /s	
$q_{od, clean}$	Odour flow rate of treated gas	ou _E /s	
$q_{od, crude}$	Odour flow rate of untreated gas	ou _E /s	
R	Limit value for reproducibility		
r	Limit value for repeatability		
r_d	Limit value for repeatability of dilution		
s_D	Standard deviation of differences		yes
$s_{I,d}$	Standard deviation for the calculation of instability		
s_{ITE}	Standard deviation of individual threshold estimates		yes
s_{zero}	Standard deviation of measurement results for zero samples for determination of the decision limit		yes
s_r	Standard deviation for calculation of repeatability		yes
s_R	Reproducibility standard deviation		yes
$s_{r,d}$	Standard deviation for calculation of repeatability of dilution		
t	Statistical factor (Students' t)		

Table 1 — Symbols and units (*continued*)

Symbol	Description	Unit	Conversion of test results to log ₁₀ required?
V	Volume	m ³	
$\dot{V}$	Volume flow rate	m ³ /s	
$\dot{V}_{R,20}$	Volume flow rate at standard conditions	m ³ /s	
y_i	Value of test result i		yes
$y_{i,d}$	Value of a test result of a dilution setting		
$y_{i,D}$	Value of test result of differences		yes
$\bar{y}$	Average of test results (in general)		yes
$\bar{y}_D$	Difference of the averages of test results		yes
$\bar{y}_{ITE}$	Average of individual threshold estimates		yes
$\bar{y}_{zero}$	Average of test results of zero samples		yes
$\bar{y}_w$	Average of test results of one laboratory		yes
$\bar{y}_{w,d}$	Average of test results of a dilution setting		
Z	Dilution factor		
Z_{50}	Dilution factor at the 50 % detection threshold		
Z_{ITE}	Individual threshold estimate, expressed as a dilution factor		
$\bar{Z}_{ITE}$	Geometric mean of Z_{ITE} of all panel members in one measurement		
$\bar{Z}_{ITE,pan}$	Geometric mean of Z_{ITE} of all valid panel members in one measurement, after retrospective screening		
Z_{max}	Maximum dilution factor of dilution instrument		
Z_{min}	Minimum dilution factor of dilution instrument		
ΔZ	Panel screening parameter		
δ	Bias of a test method		
δ_w	Within-laboratory bias of a test method		
$\delta_{w,d}$	Within-laboratory bias of a test method for dilutions		
η_{od}	Odour abatement efficiency	%	
μ	Accepted reference value		yes
μ_d	Reference value for a dilution setting		

3.3 The unit of measurement

The European odour unit [ou_E] is that amount of odorant(s) that, when evaporated into 1 m³ of neutral gas at standard conditions, elicits a physiological response from a panel (detection threshold) equivalent to that elicited by one European Reference Odour Mass (EROM), evaporated in 1 m³ of neutral gas at standard conditions.

One EROM, evaporated into 1 m³ of neutral gas at standard conditions, is the mass of substance that will elicit the D₅₀ physiological response (detection threshold), assessed by an odour panel in conformity with this standard, and has, by definition, a concentration of 1 ou_E/m³.

For n-butanol (CAS-Nr. 71-36-3) one EROM is 123 µg. Evaporated in 1 m³ of neutral gas, at standard conditions, this produces a concentration of 0,040 µmol/mol (which is equal to a volume fraction of 40 parts per billion).

There is one relationship between the ou_E for the reference odorant and that for any mixture of odorants. This relationship is defined only at the D₅₀ physiological response level (detection threshold), where:

$$1 \text{ EROM} \equiv 123 \text{ } \mu\text{g n-butanol} \equiv 1 \text{ ou}_E \text{ for the mixture of odorants.}$$

This linkage is the basis of traceability of odour units for any odorant to that of the reference odorant. It effectively expresses odour concentrations in terms of 'n-butanol mass equivalents'.

The odour concentration can only be assessed at a presented concentration of 1 ou_E/m³. As a consequence the odour concentration is expressed as a multiple of one ou_E in 1 m³ of neutral gas. The odour concentration, in ou_E/m³, can be used in the same manner as mass concentrations (kg/m³).

NOTE 1 The odour unit is a difficult unit to define, because it relates a physiological effect to the stimulus that caused it. The stimulus, in this case, can be a multitude of substances. In that sense the odour unit is very similar to the LD₅₀, as used in toxicology assessments, indicating the dose that causes a lethal effect in 50 % of a well-defined test population. The physiological reaction is the unifying reaction that can be caused by a wide range of substances, at an equally wide range of dosages. The potential of a certain amount of a substance to cause the physiological effect can be expressed as a multiple of the dose that would cause an effect in 50 % of a population. The concept underlying the definition and use of the unit are highly analogous to that of the odour unit. In odour research the D₅₀ could be described as the dose that 50 % of a population can detect as a sensory stimulus.

In the past odour researchers have not used populations of standard test subjects, and have only related the physiological response to the number of dilutions of the dose of a sample to be measured. That practice implies a fundamental inability to compare the dosage of the samples through other means than the population itself. This can only be justified if the researcher is convinced that the samples of the population are sufficiently large to compensate for biological variability within this population. This assumption, however, cannot be fulfilled in the practice of odour measurement. The sample from the population (4 to 8 subjects, more or less randomly chosen) is far too limited a sample to be representative, knowing the variability of sensitivity within the population. This practice does not comply with statistical requirements as used in toxicological experimental design, as the sample size from the population required to be representative is far larger than the usual number of panel members used in olfactometry.

The solution is to standardise the test subjects, used to assess the physiological effect, by selecting panel members with a known sensitivity to an accepted reference material (now n-butanol [CAS -Nr. 71-36-3]). The assumption made is that the sensitivity for the reference will be a predictor for sensitivity to other substances. The dose of other substances and mixtures is then expressed in multiples of the dose that would elicit a physiological reaction equivalent to that of the reference.

NOTE 2 When using odour concentrations one should be aware that the relationship between the *odour intensity* and the *odour concentration* is not linear, and can be a different relationship for different (mixtures of) odorants.

NOTE 3 The relation between the stimulus and the perceived intensity is logarithmic, see B.2. To express odour concentrations in a unit that reflects the odour intensity rather than the odour concentration, an approach in analogy with expressing the sound pressure level in decibels is suggested. The 'odour level' can be expressed in odour-related decibel dB_{od} which is the decimal logarithm (log₁₀) of the odour concentration, multiplied by 10.

4 Principle of measurement

The odour concentration of a gaseous sample of odorants is determined by presenting a panel of selected and screened human subjects with that sample, varying the concentration by diluting with neutral gas, in order to determine the dilution factor at the 50 % detection threshold ($Z_{50} \equiv \bar{Z}_{ITE,pan}$).

At that dilution factor the odour concentration is $1 \text{ ou}_E/\text{m}^3$ by definition. The odour concentration of the examined sample is then expressed as a multiple (equal to the dilution factor at Z_{50}) of one European odour unit per cubic metre [ou_E/m^3] at standard conditions for olfactometry.

5 Performance quality requirements

5.1 General

The most important requirement of this European Standard concerns quality criteria for the overall performance of the sensory measurement method. A testing laboratory shall comply with all the quality criteria specified in this clause and can only claim compliance with this standard if it has assessed the quality of its performance by means of performance testing.

NOTE Performance testing is best done in a proficiency test coordinated by an external organisation.

The requirements for the quality of the performance of a laboratory focus on quality assessment within one laboratory, using reference material. By setting an accepted reference value for the reference material n-butanol in this standard, the reproducibility of results between laboratories is assured implicitly.

The quality criteria a laboratory shall meet to comply with this standard are defined on the basis of parameters describing both trueness and precision. These parameters shall be assessed using reference material. The laboratory shall comply with the quality criteria as defined in 5.3.

The calibration of the dilution equipment shall be done regularly using a tracer gas and a physical/chemical method of analysis. In addition to accuracy and precision the instability is determined. The dilution equipment shall comply with the quality criteria as defined in 5.4.

The calibration of the sensor of the sensory measurement, in this case the odour panel, shall be done on the basis of a reference odorant. Thus traceability to the accepted reference odorant is achieved.

The assumption is made that the performance characteristics as determined on reference materials are transferable to other odours.

NOTE 1 To confirm this point interlaboratory testing should be undertaken, in order to assess precision. The precision for non-reference odorants should be compatible with the criteria set for the reference material. For the procedure for interlaboratory comparisons this standard refers to ISO 5725-2.

NOTE 2 The quality requirements for the performance of the analytical method as a whole and of equipment used to present the sample to the assessor are the core of this standard.

To formulate quality requirements for this sensory measurement, the approach is identical to that for other analytical methods, chemical or physical. To formulate the quality parameters and to set the performance criteria in this standard, the international standard ISO 5725 has been applied to the sensory measurement and the dilution instruments used. To define instability of dilutions produced by olfactometers, ISO 9169 has been applied. As a true value for odour measurements as such is not available, an accepted reference value for a reference odorant has been defined in this standard. To give values to the quality of test results, these are assigned a measure of accuracy (see 3.1).

Two terms are used to describe accuracy: precision and trueness.

The need to consider precision arises because tests performed on presumably identical materials in presumably identical circumstances do not, in general, yield identical results. This is attributed to unavoidable random errors, inherent in every test procedure. Two measures of precision, termed repeatability and reproducibility have been found necessary and, for many practical cases, useful for describing the variability of a measurement method. Repeatability is a measure for the quality of the

measurements within one laboratory, whereas reproducibility is a measure for the quality of test results when comparing results of different laboratories.

Repeatability conditions as defined in ISO 5725 cannot be achieved for olfactometry, strictly speaking. The measurements take a relatively long time, so that a series of repeated measurements can stretch over more than one day. Also, due to practical considerations, the composition of the panel can change between sessions. As these variations occur in the analytical practice they are accepted, and considered to fall within *repeatability conditions*.

The trueness of a measurement method is of interest when it is possible to conceive of a true value for the property being measured. The trueness of the measurement method can be investigated by comparing the accepted reference value with the level of the results given by the measurement method. Trueness is normally expressed in terms of bias. The general term accuracy is used to refer to trueness and precision combined.

5.2 Accuracy - statistical model

The general concept and the statistical model for accuracy is described in ISO 5725-1:1994, clause 5 and ISO 5725-4:1994, 4.1. The statistical model is applied in this standard as follows.

A test result y can be described as:

$$y = \mu + \delta + B + e \quad (1)$$

where

B is the laboratory component of bias;

e is the random error of test result;

δ is the bias of the test method;

μ is the accepted reference value.

For odour measurements on reference material n-butanol, where the accepted reference value is defined implicitly in the method, the bias of the test method is not of interest. In this case the laboratory bias, δ_w , is given by:

$$\delta_w = \delta + B \quad (2)$$

so the model may be written as

$$y = \mu + \delta_w + e \quad (3)$$

where δ_w is the within-laboratory bias.

5.3 Overall sensory quality requirements

5.3.1 General

The requirements for the overall quality of the sensory measurement of odour concentrations in one laboratory shall be assessed by performance testing to demonstrate and ensure compliance on a regular basis. The procedure and calculations are defined in 5.3.2.3. The frequency of performance testing shall be determined taking into account the performance history of the laboratory, but shall be no less than once a year.

Compliance with the quality criteria shall be determined on the basis of test results obtained for certified reference materials for which an accepted reference value is available.

For the purpose of this standard the European Reference Odour Mass (EROM) shall be used as the accepted reference value when assessing trueness and precision. The value of the EROM shall not be used as a basis for

correcting measurement results on the basis of the relation between the actual panel threshold and the accepted reference value.

To determine whether a laboratory complies with this European Standard only criteria applying to accuracy, trueness and precision for reference materials are considered. In addition, the precision expressed as repeatability for non-reference odorants can be assessed and should comply with the same criterion as set for the reference odorant.

For environmental odours, however, an accepted reference value is not available. This implies that for non-reference odorants, such as environmental odours, only precision can be tested. Trueness cannot be determined in these cases.

If a laboratory complies with the overall sensory quality criteria for the reference material, this standard assumes that this quality level is transferable to other, environmental, odours (van Harreveld, Heeres 1995, see Bibliography).

NOTE 1 To confirm this assumption on environmental odours, interlaboratory comparisons should be conducted to assess precision and compare precision with that obtained for reference material.

When conducting inter-laboratory comparisons the precision shall be assessed in terms of repeatability and reproducibility and in terms of trueness (laboratory bias). These values for a laboratory shall be compatible with the values found for the reference material.

When calculating statistical parameters the decimal logarithms of the measured odour concentration values shall be used. To obtain a value of non-logarithmic units, the value can be re-converted into its antilog. For assessing instrumental quality requirements a logarithmic conversion shall not be used.

NOTE 2 Examples of the calculations for performance testing are given in annex D.

NOTE 3 The frequency distribution for detection thresholds for an odorant is log-normal. The exponential nature of the data can be understood by realising that thresholds are determined by presenting an odour panel with a sequence of dilutions that are a fixed factor apart. The multiplication of dilution factors can be expressed on a linear scale after logarithmic transformation.

NOTE 4 It is useful to plot test results obtained on reference material on quality control charts, enabling a visual check to assess whether the quality is sufficiently under control.

5.3.2 Quality criteria for the performance within one laboratory on reference material (odorant)

5.3.2.1 Quality criterion for accuracy

The accuracy reflects both the trueness (expressed as bias) and the precision (random error). The test variable for accuracy is A_{od} .

To assess if a laboratory complies with the accuracy criterion, the 95 % confidence interval for the within-laboratory bias δ_w is first calculated as:

$$d_w - A_w \cdot r \leq \delta_w \leq d_w + A_w \cdot r \quad (4)$$

where

$$A_w = \sqrt{\frac{1}{2 \cdot n}} \quad (5)$$