

Australian/
New Zealand
Standard

Stationary source emissions

Part 3: Determination of odour concentration by dynamic olfactometry



AS/NZS 4323.3:2001

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Clean Air Society of Australia and New Zealand
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PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee EV-007, Methods for Examination of Air.

The Standard is based on a CEN pre-draft of the same title, produced by CEN/TC 264, Air Quality, Working Group 2, Odours. The quality criteria were validated in an interlaboratory comparison for olfactometry in 1996.

Area source sampling is not covered in this Standard as it is considered such an important area, that it warrants a future Standard in its own right. AS 4323.1, *Stationary source emissions, Part 1: Selection of sampling positions* should be referenced when sampling for odour from stacks or flues.

The objective of this Standard is to provide a method for the determination of the odour concentration of a gaseous sample using dynamic olfactometry with a panel of human assessors being the sensors.

The term 'informative' has been used in this Standard to define the application of the appendix to which it applies. An 'informative' appendix is only for information and guidance.

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STANDARDS AUSTRALIA/STANDARDS NEW ZEALAND

Australian/New Zealand Standard Stationary source emissions

Part 3: Determination of odour concentration by dynamic olfactometry

1 SCOPE

This Standard specifies a method for the measurement of odour concentration of pure substances, defined and undefined mixtures of gaseous odorants in air or nitrogen, using dynamic olfactometry with a panel of human assessors being the sensors. The unit of measurement is the odour unit ou. 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 ou. The odour concentration is then expressed in terms of multiples of the detection threshold. The range of measurement is typically from 10^1 to 10^7 ou (including pre-dilution).

The relation between emissions, dispersion, exposure and annoyance is not within the scope of this Standard.

2 APPLICATION

2.1 General

The primary application of this Standard is to provide a common basis for evaluation of odorant emissions.

2.2 Inclusions

The characterization of odour emissions requires detailed measurement of the gas velocity that shall be performed according to the relevant Standards included in the normative references (see Clause 3).

The field of application includes the following:

- (a) The measurement of the mass concentration at the detection threshold of pure odorous substances in grams per cubic metre.
- (b) The measurement of the odour concentration of mixtures of odorants in odour units (ou).
- (c) 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.
- (d) The sampling of odorants from emissions of high humidity and temperature (up to 200°C).
- (e) The determination of effectiveness of end-of-pipe devices used to reduce odour emissions.

2.3 Exclusions

The field of application does not include:

- (a) The measurement of odours potentially released by particles of odorous solids or droplets of odorous fluids suspended in emissions.

- (b) The measuring strategy to be applied in case of variable emission rates.
- (c) The measurement of the relationship between odour stimulus and assessor response above detection threshold.
- (d) Direct measurement of hedonic tone (or (un)pleasantness) or direct assessment of potential annoyance.
- (e) Field panel methods.
- (f) Measurement of recognition thresholds (identification thresholds).

The ultimate purpose 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, and 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.

3 REFERENCED DOCUMENTS

The following documents are referred to in this Standard:

AS

- 4323 Stationary source emissions
- 4323.1 Part 1: Selection of sampling positions

ISO

- 5725 Accuracy (trueness and precision) of measurement methods and results
- 5725-1 Part 1: General principles and definitions
- 5725-2 Part 2: Basic method for the determination of repeatability and reproducibility of a standard measurement method
- 5725-4 Part 4: Basic method for determination of the trueness of a standard measurement method
- 9096 Stationary source emissions—Determination of concentration and mass flow rate of particulate material in gas-carrying ducts—Manual gravimetric method
- 9169 Air quality—Determination of performance characteristics of measurement methods
- 10396 Stationary source emissions—Sampling for the automated determination of gas concentrations
- 10780 Stationary source emissions—Measurement of velocity and volume flow rate of gas streams in ducts

4 DEFINITIONS

For the purpose of this Standard, the definitions below apply.

4.1 Accepted reference value

A value that serves as an agreed upon reference for comparison, and which is derived as a consensus value, based on collaborative experimental work under the auspices of a scientific or engineering group.

4.2 Accuracy

Closeness of agreement between test result and the accepted reference value.

NOTE: The term 'accuracy', when applied to a set of observed values, describes a combination of random components and a common systematic error or bias component.

4.3 Adaptation (sensory)

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

4.4 Anosmia

Lack of sensitivity to olfactory stimuli.

4.5 Assessor

Somebody who participates in odour testing.

4.6 Bias

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

NOTE: Bias is often called 'systematic error'

4.7 Certified reference material, CRM

A 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.

4.8 Delayed olfactometry

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

4.9 Detection threshold, (for a reference material)

The lowest odorant concentration which has a probability of 0.5 of eliciting, with certainty, the correct perception that an odour is present. This concentration will be too low for the odorant to be recognized.

4.10 Detection threshold (for an environmental sample)

The highest dilution factor at which the sample has a probability of 0.5 of eliciting with certainty, the correct perception that an odour is present. This dilution factor will be too high for the sample to be recognized.

4.11 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 and un-aerated compost piles.

4.12 Dilution factor

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

4.13 Dilution series

The 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:

- (a) One series of presentations 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).
- (b) A repeated pattern of presentations according to the procedure described for forced choice/probability mode.

4.14 Direct olfactometry

Measurement of odour concentrations without any time-lag between the sampling (operation) and the measurements. It is equivalent to dynamic sampling or on-line olfactometry.

4.15 Dynamic olfactometer

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

4.16 Dynamic olfactometry

Olfactometry using a dynamic olfactometer.

4.17 Dynamic sampling

Sampling in direct olfactometry.

4.18 Expected value

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

4.19 Forced choice method

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.

4.20 Fugitive sources

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

4.21 Group threshold

Detection threshold applying to a group of assessors.

4.22 Individual threshold

Detection threshold applying to an individual.

4.23 Individual threshold estimate, *ITE*

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

4.24 Instability

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

4.25 Instrumental dilution range

Range between the minimum and maximum dilution factor.

4.26 Instrumental fall time

Time taken for the reading to pass from (by convention) 90% to (by convention) 10% of the final change in output signal reading.

4.27 Instrumental lag time

Time taken to reach 10% (by convention) of the final change in instrument reading.

4.28 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).

4.29 Instrumental rise time

Time taken for the reading to pass from (by convention) 10% to (by convention) 90% of the final change in output signal reading.

4.30 Lower detection limit, *LDL*

Lowest value of the air quality characteristic which, with 95% probability, can be distinguished from a zero sample.

4.31 Maximum dilution factor

Maximum settable dilution factor of the olfactometer; an instrument property.

4.32 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).

4.33 Measuring range

The 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.

4.34 Minimum dilution factor

Minimum settable dilution factor of the olfactometer; an instrument property.

4.35 Neutral gas

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

NOTE: Nitrogen is only used to predilute the sample itself. For the olfactometer the neutral gas used to dilute the sample and present a reference is air.

4.36 Objective method

Any method in which the effects of personal opinions are minimized.

4.37 Odorant

A substance which stimulates a human olfactory system so that an odour is perceived.

4.38 Odorant flow rate

The odorant flow rate is the quantity of odorous substances passing through a defined area at each time unit. 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 $ou.m^3/h$ (or $ou.m^3/min$ or $ou.m^3/s$, respectively.)

NOTE: The odorant (emission) flow rate is the quantity equivalent to the emission mass or volume flow rate, for example in dispersion models.

4.39 Odorous gas

Gas that contains odorants.

4.40 Odour

Organoleptic attribute perceptible by the olfactory organ on sniffing certain volatile substances.

4.41 Odour abatement efficiency

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

4.42 Odour concentration

The number of odour units.

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.

4.43 Odour detection

To become aware of the sensation resulting from adequate stimulation of the olfactory system.

4.44 Odour intensity

The intensity of an odour sensation which is triggered by an odour stimulus. The perceived strength of the odour sensation increases with increasing concentration, as a logarithmic or power function.

4.45 Odour unit

One odour unit (ou) is that concentration of odorant(s) at standard conditions that elicits a physiological response from a panel (detection threshold) equivalent to that elicited by one Reference Odour Mass (ROM), evaporated in one cubic metre of neutral gas at standard conditions.

4.46 Olfactometer

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

4.47 Olfactometry

Measurement of the response of assessors to olfactory stimuli.

4.48 Olfactory

Pertaining to the sense of smell.

4.49 Olfactory receptor

Specific part of the olfactory system which responds to an odorant.

4.50 Olfactory stimulus

That which can excite an olfactory receptor.

4.51 Operator

Person directly involved in operating the olfactometer and instructing the panel in olfactometry.

4.52 Panel

A group of panel members.

4.53 Panel member

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

4.54 Panel screening

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

4.55 Panel selection

Procedure to determine which assessors are qualified as panel members.

4.56 Panel threshold

Detection threshold applying to a panel.

4.57 Perception

Awareness of the effects of single or multiple sensory stimuli.

4.58 Population (detection) threshold

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

4.59 Precision

Closeness of agreement between independent test results obtained under prescribed conditions.

NOTE: Precision depends only on the distribution of random errors and does not relate to 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.

4.60 Presentation

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

4.61 Presentation series

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

4.62 Presented gas flow

The gas flow presented to the assessor. It may be—

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

4.63 Proficiency testing

The system for objectively testing laboratory results by an external agency.

4.64 Quality

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

4.65 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.

4.66 Random error

Unpredictable errors which average to zero.

4.67 Recognition threshold

The odour concentration which has a probability of 0.5 of being recognized under the conditions of the test (definition not applied in this Standard).

4.68 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.

4.69 Reference odour mass, ROM

The accepted reference value for the odour unit, equal to a defined mass of a certified reference material.

One ROM is equivalent to 132 µg n-butanol (CAS 71-36-3) which evaporated in 1 cubic metre of neutral gas at standard conditions produces a concentration of 40 ppb (µmol/mol).

4.70 Repeatability

Precision under repeatability conditions.

4.71 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.

4.72 Repeatability limit

The 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.

NOTE: In this Standard the test result is the decimal logarithm of the panel threshold.

4.73 Reproducibility

Precision under reproducibility conditions.

4.74 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.

4.75 Reproducibility limit

The 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.

NOTE: In this standard the test result is the decimal logarithm of the panel threshold.

4.76 Responsible person

Person with ultimate responsibility for olfactometry in a laboratory.

4.77 Round

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

4.78 Sample

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.

4.79 Sensory fatigue

Form of adaptation in which a decrease in sensitivity occurs.

4.80 Sensory reference

The presented gas flow to which the diluted sample is compared.

4.81 Smell

To detect or to attempt to detect an odorant.

4.82 Standard conditions for olfactometry

A temperature of 0°C (273 K) and normal atmospheric pressure (101.3 kPa) on a wet basis.

4.83 Static olfactometer

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

4.84 Static sampling

Sampling in delayed olfactometry.

4.85 Step factor

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

4.86 Subjective method

Any method in which the personal opinions are taken into consideration.

4.87 Substance

Species of matter of definite chemical composition.

4.88 Test result

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

4.89 Traceability

The 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.

4.90 Trueness

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

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

4.91 Yes/no method

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

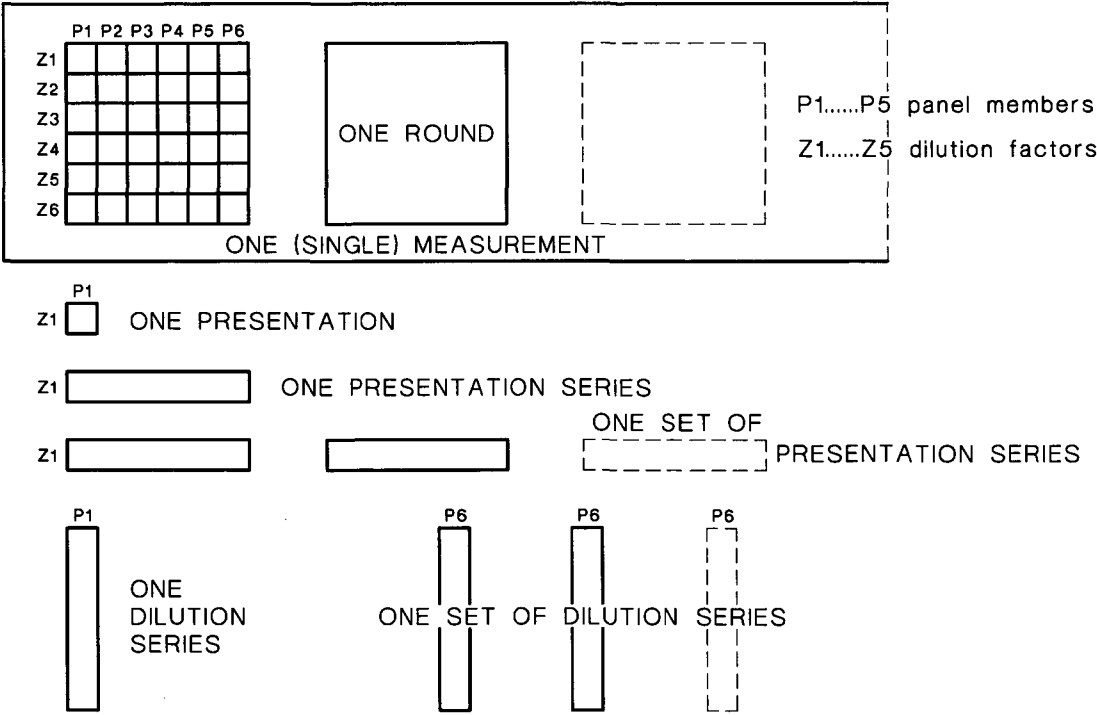


FIGURE 1 SCHEME OF VARIOUS TERMS DESCRIBING THE ELEMENTS OF ONE (SINGLE) MEASUREMENT FOR YES/NO METHOD AND FORCED CHOICE METHOD

5 NOTATION

The quantity symbols given in Table 1 are used in this Standard.

TABLE 1
NOTATION

Symbol	Description	Unit
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
$c_{od, clean}$	Odour concentration in treated gas	ou
$c_{od, crude}$	Odour concentration in untreated gas	ou
d_w	Trueness expressed as the estimate of within-laboratory bias	
$d_{w,d}$	Trueness expressed as the estimate of the dilution setting bias	
e	Random error of test result	
ROM	Reference Odour Mass	μg n-butanol
$f_{observed}$	Observed fraction of true responses at one dilution for forced choice/probability presentation mode	
$f_{corrected}$	Fraction of true responses at one dilution for forced choice/probability presentation mode, corrected for the probability of guessing the correct response	
F_s	Step factor	
I_d	Instability of a dilution	%
$ITE_{substance}$	Individual Threshold Estimate for a known substance	mg/m^3
LDL	Lower detection limit	ou
m	Expected value	
m_D	Expected value of the difference of the averages of odour concentrations	ou
n	Number of test results	
o_j	Observation number j (instrumental calibration)	
ou	odour unit	
p	Number of panel members	
P_s	Absolute pressure in stack	kPa
q_{od}	Odorant flow rate	$ou.m^3/s$
$q_{od, clean}$	Odorant flow rate of treated gas	$ou.m^3/s$
$q_{od, crude}$	Odorant flow rate of untreated gas	$ou.m^3/s$
R	Limit value for reproducibility	
r	Limit value for repeatability	
r_d	Limit value for repeatability of dilution	
s_D	Standard deviation of differences	
$s_{I,d}$	Standard deviation for the calculation of instability	
s_{ITE}	Standard deviation of individual threshold estimates	

(continued)

TABLE 1 (continued)

Symbol	Description	Unit
s_{LDL}	Standard deviation of measurement results for blanks for calculation of lower detection limit	
s_R	Reproducibility standard deviation	
$s_{r,d}$	Standard deviation for calculation of repeatability of dilution	
t	Statistical factor (Students' t)	
V	Volume	m^3
$\dot{V}$	Volume flow rate	m^3/s
$\dot{V}_{R,0}$	Volume flow rate at standard conditions	m^3/s
y_i	Value of test result i	
$y_{i,d}$	Value of a test result of a dilution setting	
$y_{i,D}$	Value of test result of differences	
y	Average of test results (in general)	
y_D	Difference of the averages of test results	
y_{ITE}	Average of individual threshold estimates	
y_{LDL}	Average of test results of blanks	
y_w	Average of test results of one laboratory	
$y_{w,d}$	Average of test results of a dilution setting	
Z	Dilution factor	
Z_{50}	Dilution factor at the 50% detection threshold	
Z_d	Approximate value of the dilution factor at the individual perception threshold, as used in forced choice/probability mode	
Z_{ITE}	Individual threshold estimate, expressed as a dilution factor	
Z_{ITE}	Geometric mean of Z_{ITE} of all panel members in one measurement	
Z_{ITE}	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	
δ	Bias of a test method	
ΔZ	Panel screening parameter	
δ_w	Within-laboratory bias of a test method	
$\delta_{w,d}$	Within-laboratory bias of a test method for dilutions	
μ	Accepted reference value	
μ_d	Reference value for a dilution setting	
η_{od}	Odour abatement efficiency	%

6 THE UNIT OF MEASUREMENT

One odour unit (ou) is that concentration of odorant(s) at standard conditions that elicits a physiological response from a panel (detection threshold) equivalent to that elicited by one Reference Odour Mass (ROM), evaporated in one cubic metre of neutral gas at standard conditions.

The odour concentration of a sample expressed in odour units is the number of times the sample must be diluted to elicit a physiological response from a panel equivalent to that elicited by one ROM evaporated in one cubic metre of neutral gas at standard conditions.

One ROM, evaporated into 1 cubic metre of neutral gas at standard conditions, is the mass of substance that will elicit the D_{50} physiological response (detection threshold), assessed by an panel in conformity with this standard, and has, by definition, a concentration of 1 ou.

For n-butanol (CAS 71-36-3) one ROM is 132 μg . Evaporated in 1 cubic metre of neutral gas, at standard conditions, this produces a concentration of 40 ppb.

There is one relationship between the odour unit for the reference odorant and that for any mixture of odorants. This relationship is defined only at the D_{50} physiological response level (detection threshold), where:

$$\frac{1 \text{ ROM}}{\text{m}^3} \equiv \frac{132 \mu\text{g} \times \text{n-butanol}}{\text{m}^3} \equiv 1 \text{ ou for the mixture of odorants.}$$

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 concentration equivalents'.

The odour concentration can only be assessed at a presented concentration of 1 ou. As a consequence the odour concentration is expressed as a multiple of one ou.

NOTES:

- 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 LD_{50} , 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 D_{50} could be described as the dose that 50% of a population that 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 (4-8 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 regular number of panel members used in olfactometry.

The solution is to standardize 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.

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

To express odour concentrations in a unit that reflects the odour intensity rather than the odour concentration, an approach analogous 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 (base 10) of the odour concentration, multiplied by 10.

NOTE: The relation between the stimulus and the perceived intensity is logarithmic, see Appendix A.

7 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 and varying the concentration by diluting with neutral gas, in order to determine the dilution factor at the 50% detection threshold ($Z_{50} = \overline{Z}_{ITE,pan}$).

At that dilution factor the odour concentration is 1 ou 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 odour unit.

8 PERFORMANCE QUALITY REQUIREMENTS

8.1 General

The most important requirement of this 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 Clause 8 and can only claim compliance with this Standard if it has assessed the quality of its performance by means of proficiency testing.

The performance quality requirements focuses 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 is required to 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 Clause 8.3.

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 Clause 8.4.

The calibration of the sensor of the sensory measurement, in this case the 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 odorants. To confirm this point, interlaboratory testing should be undertaken in order to assess precision. The precision for non-reference odorants shall be compatible with the criteria set for the reference material. For the procedure for interlaboratory comparisons refer to ISO 5725-2.

NOTE: 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, ISO 5725-2 and 5725-4 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. An accepted reference value for odour measurements as such is not available. Accepted reference value for a reference odorant has been defined in Clause 4.1 however to give values to the quality of test results, a measure of accuracy must be assigned.

The term 'accuracy', when applied to a set of observed values, describes a combination of random components and a common systematic error or bias component.

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 a general

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 5725-2 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 may 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 an accepted reference 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.

8.2 Accuracy—statistical model

The general concept and the statistical model for accuracy is described in ISO 5725-1 and ISO 5725-4. The statistical model is applied as below.

A test result y can be described as—

$$y = \mu + \delta + B + e \quad \dots 8.1$$

where

B = laboratory component of bias

e = random error of test result

δ = bias of the test method

μ = accepted reference value

If the bias of the test method is of no interest, as is the case for odour measurements on reference material n-butanol, where the accepted reference value is defined implicitly in the method, or the interest is only one particular laboratory the bias term for a laboratory is given by—

$$\delta_w = \delta + B \quad \dots 8.2$$

where

δ_w = within-laboratory bias

8.3 Overall sensory quality requirements

8.3.1 General

The requirements for the overall quality of the sensory measurement of odour concentrations in one laboratory shall be assessed by proficiency testing to demonstrate and ensure compliance on a regular basis. The procedure and calculations are defined in Clause 8.3.2. The frequency of proficiency 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 (CRMs) for which an accepted reference value is available.

The following accepted reference value shall be used when assessing trueness and precision:

$$1 \text{ ou} \equiv \frac{1 \text{ ROM}}{m^3} = 132 \text{ } \mu\text{g n-butanol/m}^3$$