BS EN 45544-1:2015

BSI Standards Publication

Workplace atmospheres — Electrical apparatus used for the direct detection and direct concentration measurement of toxic gases and vapours

Part 1: General requirements and test methods

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National foreword

This British Standard is the UK implementation of EN 45544-1:2015. It supersedes BS EN 45544-1:2000 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee EXL/31/1, Gas detectors.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Atmosphères des lieux de travail - Appareillage électrique utilisé pour la détection directe des vapeurs et gaz toxiques et le mesurage direct de leur concentration - Partie 1: Exigences générales et méthodes d'essai

Arbeitsplatzatmosphäre - Elektrische Geräte für die direkte Detektion und direkte Konzentrationsmessung toxischer Gase und Dämpfe - Teil 1: Allgemeine Anforderungen und Prüfverfahren

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Foreword

This document (EN 45544-1:2015) has been prepared by CEN/CENELEC Joint Working Group Continuous Measuring Instruments (JWG CMI).

The following dates are fixed:

• latest date by which this document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2015-11-24
• latest date by which the national standards conflicting with this document have to be withdrawn	(dow)	2017-11-24

This document supersedes EN 45544-1:1999.

Introduction

National laws and regulations based on European Directives require the assessment of the potential exposure of a worker to chemical agents in workplace atmospheres.

EN 45544, *Workplace atmospheres – Electrical apparatus used for the direct detection and direct concentration measurement of toxic gases and vapours*, consists of the following parts:

— *Part 1: General requirements and test methods;*

— *Part 2: Performance requirements for apparatus used for exposure measurement;*

— *Part 3: Performance requirements for apparatus used for general gas detection;*

— *Part 4: Guide for selection, installation, use and maintenance.*

EN 45544 series is based on EN 482 which specifies general performance requirements for procedures for measuring the concentration of chemical agents in workplace atmospheres. These performance requirements are intended to apply under environmental conditions present at the workplace. However, because a wide range of environmental conditions are encountered in practice, this document specifies requirements that have to be fulfilled by measuring procedures when tested under prescribed laboratory conditions.

EN 45544-2 details the performance requirements outlined in EN 482 specifically for electrical apparatus used for the direct detection and direct concentration measurement of toxic gases and vapours intended for exposure measurement.

EN 45544-3 details the performance requirements for general gas detection apparatus, e.g. safety warning, leak detection. The measuring range will be defined by the manufacturer. In general, the requirements for accuracy will be higher for EN 45544-2 apparatus than for EN 45544-3 apparatus.

The same apparatus may be used for applications covered by EN 45544-2 and EN 45544-3.

EN 45544 series will help manufacturers, test laboratories and users of apparatus to adopt a consistent approach to, and provide a framework for, the assessment of performance criteria. It is the manufacturer's primary responsibility to ensure that the apparatus meets the requirements laid down in this European Standard, including environmental influences, which can be expected to affect performance.

For a given measurement task, the range over which the requirements for the relative expanded uncertainty have to be met depends on the limit value. However, for most chemical agents the limit values have not been harmonized at the European level. Therefore, it was decided to use a reference value (standard test gas concentration) instead of the limit value for the performance tests. The list of standard test gas volume fractions is given in Annex A. The values chosen are equal to or close to the limit values used in different European countries but are intended to be used only for type testing apparatus without any legal implications.

Electrical apparatus used for the direct detection and direct concentration measurement of toxic gases and vapours generate readings in clean air (zero readings), which vary with environmental conditions and time. This standard therefore includes test methods and requirements for acceptable variations in zero readings which are additional to the general requirements of EN 482.

1 Scope

This European Standard specifies general requirements and test methods for the determination of the performance characteristics of personal, portable, transportable and fixed, continuous duty electrical apparatus used for the direct detection and direct concentration measurement of toxic gases and vapours in workplace atmospheres.

This European Standard is applicable to apparatus whose primary purpose is to provide an indication, alarm and/or other output function to give a warning of the presence of a toxic gas or vapour in the atmosphere and, in some cases, to initiate automatic or manual protective actions. It is applicable to apparatus in which the sensor automatically generates an electrical signal when gas is present.

This European Standard is not applicable to apparatus:

- used for the measurement of oxygen;
- used only in laboratories for analysis or measurement;
- used only for process measurement purposes;
- used in car parks or tunnels;
- used in the domestic environment;
- used in environmental air pollution monitoring;
- used for the measurement of combustible gases and vapours related to the risk of explosion.

It also does not apply to open-path (line of sight) area monitors.

For apparatus used for sensing the presence of multiple gases this standard applies only to the detection of toxic gas or vapour.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 482, *Workplace exposure - General requirements for the performance of procedures for the measurement of chemical agents*

EN 45544-2:2015, *Workplace atmospheres - Electrical apparatus used for the direct detection and direct concentration measurement of toxic gases and vapours - Part 2: Performance requirements for apparatus used for exposure measurement*

EN 45544-3:2015, *Workplace atmospheres - Electrical apparatus used for the direct detection and direct concentration measurement of toxic gases and vapours - Part 3: Performance requirements for apparatus used for general gas detection*

EN 50270, *Electromagnetic compatibility - Electrical apparatus for the detection and measurement of combustible gases, toxic gases or oxygen*

EN 50271, *Electrical apparatus for the detection and measurement of combustible gases, toxic gases or oxygen - Requirements and tests for apparatus using software and/or digital technologies*

EN 60068-2-6, *Environmental testing - Part 2-6: Tests - Test Fc: Vibration (sinusoidal) (IEC 60068-2-6)*

EN 60079-0, *Explosive atmospheres - Equipment - General requirements (IEC 60079-0)*

EN ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories (ISO/IEC 17025)*

3 Terms and definitions

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

3.1
toxic gas
general term for any gas or vapour that can be harmful to human health toxic. The term “gas” is used for both gases and vapours

3.2
clean air
air that is free of gases or vapours which the sensor is sensitive to or which influence the performance of the sensor

3.3
ambient air
normal atmosphere surrounding the apparatus

3.4
poisons
substances that lead to temporary or permanent change of performance, particularly loss of sensitivity, of the sensing element

3.5
standard test gas
test gas with a composition specified for each apparatus and gas to be used for all tests unless otherwise stated

3.6
mask for calibration and test
device that can be attached to the apparatus to present a test gas to the sensor in a reproducible manner

3.7
volume fraction (V/V)
quotient of the volume of a specified component and the sum of the volumes of all components of a gas mixture before mixing

Note 1 to entry The volume fraction and volume concentration take the same value if, at the same state conditions, the sum of the component volumes before mixing and the volume of the mixture are equal. However, because the mixing of two or more gases at the same state conditions is usually accompanied by a slight contraction or, less frequently, a slight expansion, this is not generally the case.

3.8
limit value
occupational exposure limit of the time-weighted average of the concentration of a chemical agent in the air within the breathing zone of a worker in relation to a specified reference period

[SOURCE: Council Directive 98/24/EC Art. 2(d) [1]]

Note 1 to entry Limit values are mostly set for reference periods of 8 h, but can also be set for shorter periods or concentration excursions, e.g. short-term exposure limit (STEL). Limit values for gases and vapours are stated in terms independent of temperature and air pressure variables in ml/m^3 and in terms dependent on those variables in mg/m^3 for a temperature of 20 °C and a pressure of 101,3 kPa.

3.9
time weighted average (TWA) concentration
concentration of gas in air integrated over time and divided by the specified reference period

3.10
fixed apparatus
apparatus which is intended to have all parts permanently installed

3.11
transportable apparatus
apparatus not intended to be a portable apparatus, but which can readily be moved from one place to another

3.12
portable apparatus
apparatus that has been designed to be readily carried from place to place and to be used whilst being carried

Note 1 to entry Portable apparatus is generally battery powered.

3.13
personal apparatus
portable apparatus attached to a person, that monitors the atmosphere in their breathing zone so that their exposure to toxic gases or vapours can be determined

Note 1 to entry Also known as a personal monitor.

3.14
continuous duty apparatus
apparatus that is powered for long periods of time, but may have either continuous or intermittent sensing

3.15
gas detection transmitter
fixed gas detection apparatus that provides a conditioned electronic signal or output indication to a generally accepted industry standard, intended to be utilized with seperate control units, or signal processing data acquisition, central monitoring and similar systems which typically process information from various locations and sources including, but not limited to, gas detection apparatus

EXAMPLE An example of a generally accepted industry standard for an electronic signal or output indication is 4–20 mA.

3.16
control unit
apparatus intended to provide display indication, alarm functions, output contacts and/or alarm signal outputs when operated with remote sensor(s)

3.17
separate control unit
control unit intended to be utilized with gas detection transmitter(s)

3.18
apparatus with integral sensor(s)
apparatus intended to provide display indication, alarm functions, output contacts and/or alarm signal outputs where the sensor is an integral part of the apparatus

3.19
diffusion apparatus
apparatus in which the transfer of gas from the atmosphere to the gas sensor takes place without aspirated flow

3.20
aspirated apparatus
apparatus which samples the atmosphere by drawing it to the sensor

EXAMPLE A hand operated or electric pump can draw gas to the sensor

3.21
automatically aspirated apparatus
aspirated apparatus with an integral pump

3.22
alarm-only apparatus
apparatus having an alarm but not having a display or other device to indicate the measured gas concentration

3.23
sensing element
part of the sensor which is sensitive to the gas/vapour to be measured

3.24
sensor
assembly in which the sensing element is housed and which can also contain associated circuit components

3.25
measuring principle
type of physical or physico-chemical detection principle and the measurement procedure to determine the measured value

3.26
remote sensor
sensor which is not an integral part of the apparatus. A remote sensor is connected to a control unit or to a gas detection transmitter

3.27
alarm set point
setting of the apparatus at which the measured concentration will cause the apparatus to initiate an indication, alarm or other output function

3.28
TWA alarm set point
setting of the apparatus at which the measured time weighted average concentration will cause the apparatus to initiate an indication, alarm or other output function

3.29
latching alarm
alarm that, once activated, requires deliberate action for deactivation

3.30
fault signal
audible, visible or other type of output, different from the alarm signal which permits, directly or indirectly, a warning or indication that the apparatus is not working satisfactorily

3.31
sample line
means by which the gas being sampled is conveyed to the sensor including accessories

EXAMPLE *(of accessories)* Filter, water trap

3.32
sampling probe
separate sample line which is attached to the apparatus as required

Note 1 to entry It can be supplied with or without the apparatus. It is usually short (e.g. of the order of 1 m) and rigid, although it can be telescopic. It can also be connected by a flexible tube to the apparatus.

3.33
field calibration kit
means of calibrating or adjusting the apparatus

EXAMPLE This can be a mask for calibration and test (see 3.6).

Note 1 to entry The field calibration kit can also be used for verifying the operation of the apparatus.

3.34
special tool
tool required to gain access to or to adjust the apparatus controls

Note 1 to entry The design of the tool is intended to discourage unauthorized interference with the apparatus.

3.35
stabilization
state when three successive observations taken at 1 min intervals in clean air or test gas under constant conditions indicate no changes greater than ± lower limit of measurement for EN 45544-2 apparatus or ± 1 % of the specified measuring range for EN 45544-3 apparatus

3.36
final indication
indication given by the apparatus after stabilization

3.37
indication range
range of measured values of gas concentration over which the apparatus is capable of indicating

Note 1 to entry See Figure 1.

3.38
zero scale indication
smallest value of the measured quantity within the indication range

Note 1 to entry This is typically zero.

Note 2 to entry See Figure 1.

3.39
full scale indication
largest value of the measured quantity within the indication range

Note 1 to entry See Figure 1.

3.40
measuring range
range of measured values of gas concentration over which the accuracy of the apparatus lies within specified limits

Note 1 to entry For apparatus conforming to EN 45544–2, the requirements for expanded uncertainty in Table 1 of EN 482 are met. For apparatus conforming to EN 45544–3, the requirements for accuracy in EN 45544–3 are met. The measuring range is a subset of the indication range.

Note 2 to entry See Figure 1.

3.41
lower limit of measurement
smallest value of the measured quantity within the measuring range

Note 1 to entry See Figure 1.

3.42
upper limit of measurement
largest value of the measured quantity within the measuring range

Note 1 to entry Indications below the lower limit of measurement or above the upper limit of measurement will not necessarily meet the uncertainty requirements of this standard.

Note 2 to entry See Figure 1.

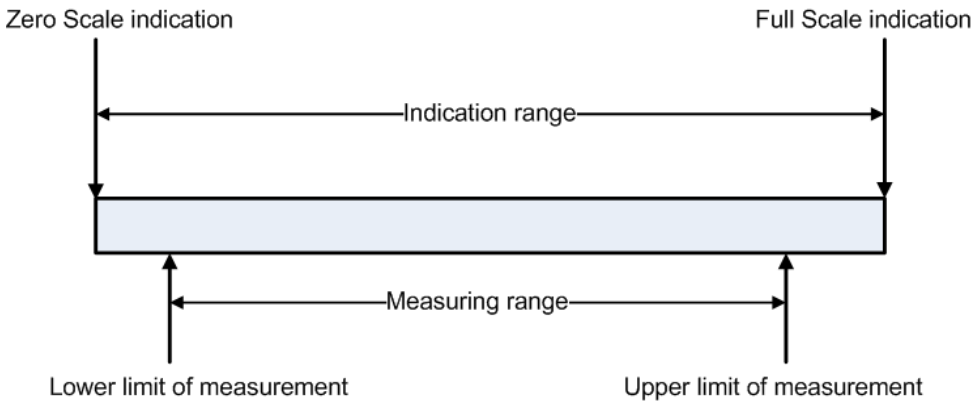

Figure 1 — Instrument scale showing ranges, indications and limits

3.43
expanded uncertainty
quantity defining an interval around a result of a measurement, expected to encompass a large fraction of the distribution of values that could reasonably be attributed to the measurand

3.44
coverage factor (k)
numerical factor used as a multiplier of the combined standard uncertainty in order to obtain an expanded uncertainty

Note 1 to entry EN 482:2012 specifies k = 2.

3.45
non-random uncertainty
uncertainty associated with non-random errors

3.46
random uncertainty
uncertainty associated with random errors

3.47
zero uncertainty
quantity defining an interval about the zero that might be expected to encompass a large fraction of the distribution of values that could reasonably be attributed to the measurement in clean air

In Figure 2, the mean value of the measured values in clean air is not equal to the zero scale indication to illustrate that there can be an offset due to drift. The mean value can be above or below the zero scale indication

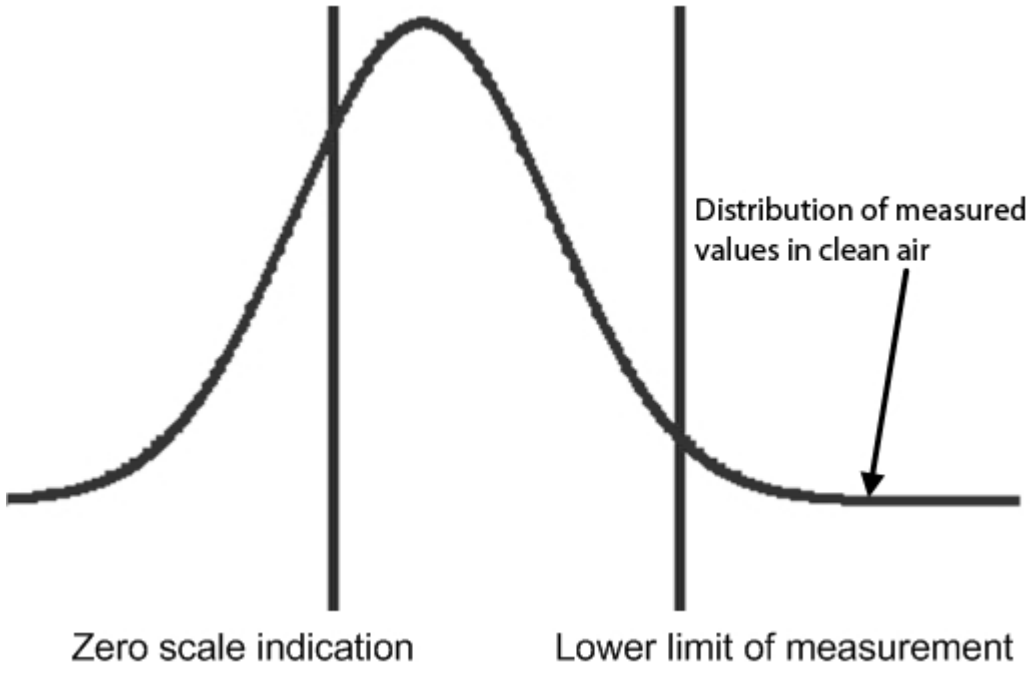

Figure 2 — Example of zero uncertainty

3.48
drift
variation in the apparatus indication with time at any fixed gas volume fraction under constant ambient conditions

3.49
time of recovery (t_x)
time interval, with the apparatus in a warmed-up condition, between the time when an instantaneous decrease in volume fraction is produced at the apparatus inlet and the time when the response reaches a stated indication of x % of the initial indication

Note 1 to entry For alarm only apparatus the stated indication can be represented by the de-activation of the alarm set at a stated value.

3.50
time of response (t_x)
time interval, with the apparatus in a warmed-up condition between the time when an instantaneous increase in volume fraction is produced at the apparatus inlet and the time when the response reaches a stated indication of x % of the final indication

Note 1 to entry For alarm only apparatus the stated indication can be represented by the activation of the alarm set at a stated value.

3.51
warm-up time
time interval, with the apparatus in a stated atmosphere, between the time when the apparatus is switched on and the time when the indication reaches and remains within the stated tolerances

Note 1 to entry See Figure 3.

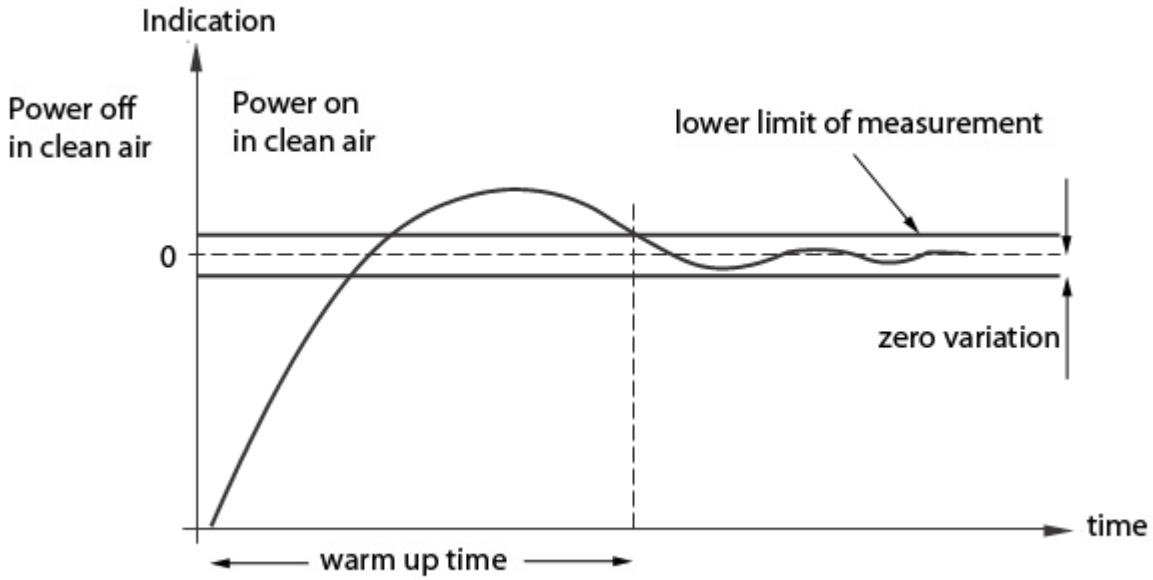

Figure 3 — Example of warm-up time in clean air

3.52
calibration
procedure which establishes the relationship between a measured value and the volume fraction of a test gas

3.53
adjustment
procedure carried out to minimize the deviation of the measured value from the test gas volume fraction

Note 1 to entry When the apparatus is adjusted to give an indication of zero in clean air, the procedure is called 'zero adjustment'.

3.54
special state
all states of the apparatus other than those in which monitoring of gas concentration and/or alarming takes place, for example warm-up, calibration mode or fault condition

4 General requirements

4.1 Introduction

Electrical assemblies and components shall conform to the construction requirements of 4.2, where applicable.

In addition, parts of the gas detection apparatus intended for use in potentially explosive atmospheres shall employ materials, and comply with the construction and explosion protection as specified in the EN 60079 series of standards.

4.2 Construction

4.2.1 General

Each apparatus shall be constructed in such a manner that regular functional checks can be easily undertaken by the user and that it can be equipped with suitable devices for application of test gas (field calibration kit).

Gas detection apparatus or parts thereof (e.g. remote sensors) specifically intended for use in the presence of corrosive vapours or gases, or which can produce corrosive by-products as a result of the detection process (e.g. catalytic oxidation or other chemical process), shall be constructed of materials known to be resistant to corrosion by such substances.

All materials and components used in the construction of the apparatus shall be used within the manufacturer's ratings or limitations unless otherwise specified by appropriate safety standards.

For aspirated apparatus, inlet and outlet ports shall be unambiguously marked to ensure the correct connection of any sample and exhaust lines.

4.2.2 Indicating devices

4.2.2.1 General

Readily distinguishable indications shall be provided to show that the apparatus is energized, in alarm or in a special state.

Portable apparatus shall provide visual and audible indications for both faults and alarms.

If audible indications are provided for transportable or fixed apparatus, alarms shall be indicated as a minimum requirement.

For fixed apparatus the indications may be shown at the control unit.

Within the measuring range, the resolution of the display and all other devices for indication of the measured value shall be at least 1 % of the upper limit of the measuring range.

For EN 45544-2 apparatus the resolution shall be 10 % of the volume fraction of the standard test gas or better.

NOTE See also 5.2.7.

Measured values on the display and all other devices for indication of the measured value shall be identical within their tolerances.

Any measurements under or over the indication range shall be clearly indicated.

If the apparatus has more than one indication range, the range selected shall be clearly identified.

If only one indicating light is provided for signalling alarms and special states, it shall be coloured red.

If separate indicating lights are used or if a multi-coloured indicating light is provided, the colours shall be used in the following order of priority ((a) being highest priority):

a) alarm indicators shall be coloured RED;

b) special state indicators shall be coloured YELLOW;

c) power supply indicators shall be coloured GREEN.

In addition to the colour requirements, the indicator lights shall be adequately labelled to show their functions.

4.2.2.2 Dead bands

Measured values within the measuring range shall be indicated.

Measured values below the lower limit of measurement may be indicated as:

a) zero;

b) another indication that the measured value is below the lower limit of measurement; or

c) the measured value.

For personal, portable and transportable apparatus, the following additional requirement applies: if the measured value is below −5 % of the upper limit of measurement, the apparatus shall indicate the measured value or shall provide a fault signal.

All apparatus shall provide a fault signal at measured values below −10 % of the upper limit of measurement.

It shall be possible for the user to configure the apparatus such that any dead band is permanently disabled when in measuring mode. In calibration mode, any dead band shall be automatically disabled.

4.2.3 Alarm output functions

Alarm set points and TWA alarm set points shall not be adjustable outside the indication range.

If more than one alarm set point is provided the alarm with the highest set point shall be latching and require a deliberate manual action to reset. All other alarms and TWA alarms shall be configurable to be latching or non-latching.

Alarms shall remain in operation while the alarm condition is still present. An audible alarm may be silenced if this audible alarm is not the only alarm signal.

If it is possible to temporarily de-activate alarm devices, output contacts or alarm signal outputs, this deactivation shall be indicated by a signal. For fixed apparatus, this shall include a contact or other transmittable output signal. The output signal or contacts are not required if the alarms are automatically re-enabled within 15 min.

EXAMPLE It might be necessary to de-activate alarm devices for calibration purposes.

For personal and portable apparatus, the sound output of audible alarms shall not be less than 70 dB(A) at 0,3 m from the apparatus.

4.3 Fault signals

For fixed and transportable apparatus a transmittable fault signal shall be provided in the following cases:

– failure of power;

– open circuit or short circuit (i.e. loop failure) in one or more of the wires to any remote sensor.

It shall be distinguishable from any alarm signal.

Under-range values (e.g. caused by drift) shall be indicated by a fault signal in accordance with 4.2.2.2.

Automatically aspirated apparatus shall be provided with an integral flow-indicating device that produces a fault signal in the event of low flow.

For apparatus where the sensor can be disconnected without opening the housing, the apparatus shall provide a fault signal in the event of a disconnection of the sensor.

4.4 Adjustments

All adjustment devices shall be designed so as to discourage unauthorised or inadvertent interference with the apparatus.

EXAMPLE Examples would include procedural devices, in the case of a keyboard instrument, or mechanical devices such as a cover requiring the use of a special tool.

Fixed apparatus housed in explosion-protected enclosures shall be designed so that any facilities for field adjustments, resetting or similar functions shall not degrade the explosion protection of the apparatus.

The adjustments of the zero and signal amplification shall be so designed that adjustments of one will not affect the other. If this is not possible, an appropriate adjustment sequence shall be defined and described in the instruction manual.

NOTE See 4.10v.

The equipment shall not perform an automatic zero adjustment during start-up. If equipment prompts the user for zero adjustment during start-up and the user makes no selection, the 'No' option shall be automatically selected after a maximum period of 15 s.

4.5 Battery-powered apparatus

Apparatus powered with integral batteries shall be provided with an indication of low battery condition.

4.6 Gas detection transmitter for use with separate control units

A specification shall be supplied with the apparatus that describes the relationship that the gas concentration, detected by the apparatus, has with the corresponding output signal or indication (transfer function). The specification shall be detailed to the extent that the accuracy of this transfer function can be verified. As a minimum, the specification shall include data showing the relationship between the output signal and the gas concentrations corresponding to 0 %, 10 %, 30 %, 50 %, 70 %, 90 % and 100 % of the indicating range. Full-scale output and status signals shall also be included in the specification.

EXAMPLE Fault and inhibit are examples of status signals.

Where necessary, equipment shall be provided with the apparatus to interpret the output signal or indication, which will enable the accuracy of the transfer function to be verified.

4.7 Separate control units for use with gas detection transmitters

A specification shall be supplied with the apparatus that describes the relationship the input signal has with the calculated gas concentration (transfer function). Such specification shall be detailed to the extent that the accuracy of this transfer function can be verified. As a minimum, the specification shall include data showing the relationship between the input signal and the gas concentrations corresponding to 0 %, 10 %, 30 %, 50 %, 70 %, 90 % and 100 % of the indicating range. Required inputs for full-scale indication and status signals shall also be included in the specification.

EXAMPLE Fault and inhibit are examples of status signals.

Where necessary, equipment shall be provided by the manufacturer to provide the input signals, which will enable the accuracy of the transfer function to be verified.

4.8 Apparatus using software and/or digital technologies

The apparatus shall conform to EN 50271.

4.9 Labelling and marking

4.9.1 General

The apparatus shall be marked legibly and indelibly with a minimum of the following:

a) name and address of the manufacturer;

b) designation of series or type;

c) serial number;

d) year of manufacture (may be encoded within the serial number);

e) “EN 45544-2” and/or “EN 45544-3” (to represent conformity with one or both of these standards). If due to size constraints this information cannot be put onto the apparatus, it shall be included in the instruction manual;

f) If applicable, the marking shall conform to the additional marking requirements of EN 60079-0.

4.9.2 Identification of the gas to be detected

Personal, portable and transportable apparatus shall be labelled with the gas(es) to be detected or the gas(es) shall be indicated on a display.

4.10 Instruction manual

At least one instruction manual shall be provided with the gas detection apparatus that contains complete, clear and accurate instructions. It shall include, at least, the following information:

a) complete instructions, drawings and diagrams for safe and proper operation, installation and servicing of the apparatus;

b) adjustment procedures;

c) recommendations for:

   1) the procedure for initial and routine calibration;

   2) the calibration gas, including warning notes concerning the hazards associated with the calibration gases;

   3) humidity and application time(s) of the calibration gas(es).

   4) the calibration period. If the calibration period is longer than 6 months it shall also be stated that conformity to this standard is only given for a 6 months period;

   5) methods for verification of the response time;

   NOTE This could be instructions for use of a field calibration kit.

d) for personal and portable apparatus, the requirement and method for performing a functional check with gas before each day of use;

e) instructions for the use of the field calibration kit including sample flow rate limits, if provided;

f) operational details including, where applicable, the following:

   1) intended use;

   2) whether the apparatus is intended to be used in potentially explosive atmospheres;

   3) measuring principles and description of the apparatus functions;

   4) times of response t_{90} and t_{50}; times of recovery t_{10} and t_{50} and information on how they vary with temperature and humidity;

5) for instruments measuring TWA concentration, the reference period(s);

6) temperature limits;

7) humidity limits and transient effects from humidity changes, if any;

8) pressure limits and, if appropriate, correction factor for pressure dependence;

9) supply voltage limits;

10) maximum power consumption;

11) relevant characteristics and construction details of required interconnecting cables;

12) for battery operated apparatus, battery type(s) and operating time(s) until low battery condition;

13) nominal orientation and orientation limits;

14) safety-related significance of the measuring sequence in non-continuous operation and possibilities of adapting the measuring sequence to the monitoring tasks;

15) warm-up time;

16) stabilization time;

17) gas mixtures expressly prohibited by the manufacturer;

18) ingress protection (IP), if claimed;

19) response factors, where appropriate, of the gases for which the apparatus is suitable;

20) information on apparatus drift;

21) the gases for which the apparatus is suitable, and its specified indication and measuring range(s), including, in particular, the lower limit of measurement;

22) measurement accuracy under operating conditions outside the specification of this standard, if applicable (see 5.1);

23) description of any dead band and method for its activation/deactivation

g) details of storage life and limitations for the apparatus, replacement parts and accessories, including, where applicable, the following limits:

1) temperature;

2) humidity;

3) pressure;

4) time;

h) information on the adverse effects of poisons and interfering gases or substances and oxygen-enriched or deficient atmospheres on the proper performance (and, in the case of oxygen-enriched atmospheres,

on electrical safety) of the apparatus; it shall be stated, if known, whether the stated interfering gases in the presence of the gas to be measured are additive, subtractive or synergistic;

i) for aspirated apparatus, the minimum and maximum flow rates and pressure, or, for automatically aspirated apparatus, the nominal flow rate and the flow rate where the low flow signal is set or, if adjustable, the range of flow rates where the low flow signal can be set;

j) for aspirated apparatus, tubing type, maximum length and size for proper operation;

k) for aspirated apparatus, instructions for ensuring that the sample lines are intact and that proper flow is established;

l) statements of the nature and significance of all alarms and fault signals, including low battery indication, the duration of such alarms and signals (if time-limited or non-latching), and any provisions that may be made for silencing or resetting such alarms and signals, as applicable;

m) details of any method for the determination of the possible sources of a malfunction and any corrective procedures (i.e. trouble-shooting procedures);

n) a statement that alarm devices, outputs or contacts are of the non-latching types, where applicable (see 4.2.3);

o) for battery-operated apparatus, installation and maintenance instructions for the batteries;

p) if applicable, instructions for replacement of the sensor;

q) a recommended replacement parts list;

r) where optional accessories are supplied, the manufacturer shall list such accessories and state their effects on the apparatus characteristics (including time of response and sensitivity), and provide means for their identification;

EXAMPLE Collecting cones, weather-protecting devices and selective filters are all examples of optional accessories. Part numbers included in the manual is an example of a means for their identification.

s) information about the type testing of the apparatus in accordance with this standard including the gases and measuring range and the accessories for which compliance is claimed and the test laboratory. Details of any special conditions of use;

t) warning notes concerning the limitations of a sampling probe, where provided;

u) action to take when the apparatus is subjected to a gas concentration above the measuring range if there is an influence on sensor properties such as sensitivity or response time;

v) where the nature of the apparatus (such as nonlinear responses or mandatory sequence of zero and span adjustment) requires additional instructions or special information that are alternative to, or in addition to, the requirements of 4.9 and 4.10 a) to u), the instructions or information shall be provided.

5 Test methods

5.1 General requirements for tests

Apparatus shall be fully tested for all the gases for which compliance with this European Standard is claimed.

Where an apparatus manufacturer makes any claims in the instruction manual regarding any special features of construction or extended performance that exceed the minimum requirements of this standard, all such claims shall be verified and the test procedures shall be extended or supplemented, where necessary, to verify the claimed performance.

EXAMPLE Extended performance can include operation over an extended temperature range.

When verifying a manufacturer's claimed performance or special features of construction, the minimum requirements of this standard and EN 45544-2 or EN 45544-3 shall be met and the manufacturer's claimed extended performance shall be verified. Any extended or supplemented tests shall be agreed between the manufacturer and test laboratory and described in the test report.

5.2 Samples and sequence of tests

5.2.1 Test samples

For the purpose of type testing, the tests shall be performed on three apparatus. The EMC test (5.4.7.3) may be performed on only one of the three apparatus.

An additional set of three apparatus may be used for the stability test, 5.4.8.

If an apparatus ceases to function during the test sequence, then the test laboratory shall decide which tests have to be repeated with a replacement apparatus. The decision and its justification shall be described in the test report.

5.2.2 Sequence

The apparatus shall be subjected to all of the tests applicable to that type of apparatus, as specified in 5.4. Test 5.4.2 (unpowered storage) shall be conducted prior to all other tests. The remainder of the tests may be performed in any order. The sequence of tests performed during type testing shall be recorded. A recommended sequence is given in Annex B.

If a modified design of an apparatus that has previously been tested in accordance with this standard is to be tested then the test laboratory shall decide which tests have to be repeated with the modified apparatus. The decision and its justification shall be described in the test report.

5.2.3 Gas detection transmitters

For gas detection transmitters the following tests shall be performed: 5.4.2 - 5.4.4.1, 5.4.5, 5.4.6.2 - 5.4.6.6, 5.4.6.8 - 5.4.6.11, 5.4.7 - 5.4.9 (if applicable) using the parameters of the transfer function.

5.2.4 Separate control units

For separate control units the following tests shall be performed: 5.4.2, 5.4.3, 5.4.4.1, 5.4.5.1, 5.4.6.1, 5.4.6.2, 5.4.6.4 - 5.4.6.6, 5.4.6.9, 5.4.7.2- 5.4.7.4 and 5.4.9 using the parameters of the transfer function pertinent to the specific type of gas detector.

5.2.5 Test of compliance with general requirements

Tests shall also be performed, where applicable, to ensure that the apparatus conforms to the requirements of Clause 4. The requirements for these tests are generally self-evident, except that for short-circuit requirements in 4.3, ballast resistors shall be substituted for each wire connecting the control unit to any remote sensor. The values of these resistors shall be those declared, in the instruction manual, to be the maximum line resistances allowing conformity with this European Standard. The device used for the short circuit shall be of negligible resistance and shall be applied to convenient points in the circuit, at the sensor ends of the ballast resistors.

5.2.6 Apparatus with selectable range

For apparatus having more than one selectable indicating range for a gas, each range shall be tested. For the second and subsequent ranges, the necessary amount of testing shall be agreed upon between the manufacturer and the test laboratory.

For EN 45544-2 apparatus, the most sensitive range which includes the value specified in Annex A, shall be tested in accordance with the whole of 5.4 and the calibration curves of the other ranges shall be tested in accordance with 5.4.3.2, as a minimum.

For EN 45544-3 apparatus, the most sensitive range shall be tested in accordance with the whole of 5.4 and the calibration curves of the other ranges shall be tested in accordance with 5.4.3.2, as a minimum. The least sensitive range shall also be tested in accordance with 5.4.6.9.

If the sensor changes with a range change, the apparatus shall be tested in accordance with the whole of 5.4 in the most sensitive range of each sensor.

5.2.7 Preparation of apparatus before each particular test

Dead bands shall be disabled.

The resolution of the device indicating the measured value used for the purpose of type testing shall be at least 10 % of the indication for each test gas concentration. The resolution when clean air is applied shall be equal to or better than the resolution at the lowest test gas concentration.

NOTE The resolution of indication devices which fulfil requirements of 4.2.2.1 may not be sufficient for type testing. It may then be necessary to increase the number of decimal places indicated or provide suitable points for additional indicating or recording devices described below.

If necessary, the manufacturer shall identify suitable points for connecting indicating or recording devices with sufficient resolution for the purpose of testing the compliance of the apparatus with this standard. The indication on the display and other output devices of the apparatus shall be consistent with the results obtained by the indicating or recording devices.

The apparatus shall be prepared and mounted for typical use, in accordance with the manufacturer's instruction manual, including all necessary interconnections, initial adjustments and initial calibrations. Adjustments may be made, where appropriate, at the beginning of each test.

Once a particular test has begun, further adjustments shall not be made except where specifically permitted by the particular test procedure.

In particular, the following points shall be noted:

a) Apparatus having remote sensors

For the purpose of the tests in 5.4, where reference is made to exposure of the sensor to the test conditions, the entire remote sensor (including any or all normally attached protective mechanical parts) shall be exposed. The exact configuration of the equipment, including use of or removal of optional accessories, shall be included in the test report.

For apparatus having connection facilities for more than one remote sensor, only one remote sensor needs to be subjected to the tests. The replacement of all but one sensor by resistors yielding the worst case load conditions for the test in question shall be permitted. The worst case load conditions shall be determined by the testing laboratory within the limits specified in the instruction manual.

For apparatus having remote sensor(s), all tests shall be performed with resistances connected in the detector circuit to simulate the maximum line resistance specified by the apparatus manufacturer, except where minimum line resistance offers a more stringent test in the judgement of the test laboratory.

b) Apparatus having integral sensors

The entire apparatus shall be exposed to the test conditions (not including test gases) without removal of any normally attached parts. The exact configuration of the equipment, including use of or removal of optional accessories, shall be included in the test report.

Tests 5.4.6.3, 5.4.6.5 and 5.4.6.6 shall be performed without and with any sampling probe.

c) Alarm-only apparatus

Readings shall be taken using an external indicating or recording device connected to test points as specified in the third paragraph of this clause.

The use of optional extra protective mechanical parts (e.g. carrying case) shall be agreed between the manufacturer and the test laboratory.

If used, optional accessories shall be either attached or removed according to which condition will give the most unfavourable result for the test being conducted. The exact configuration of the equipment, including use of or removal of optional accessories, shall be included in the test report.

EXAMPLE Weather protection is an example of an optional accessory.

5.2.8 Mask for calibration and test

When a mask is used for calibration or for the application of test gas to the sensor, the design and operation of the mask, in particular the pressure and velocity inside the mask, shall not influence the response of the apparatus or the results obtained.

A suitable mask may be provided with the apparatus together with details of suggested pressure and flow rate for application of calibration gases to the apparatus.

If a suitable mask is provided with the apparatus then this mask may be used.

5.3 Normal conditions for test

5.3.1 General

The test conditions specified in 5.3.2 to 5.3.11 shall be used for all tests, unless otherwise stated in the particular test.

5.3.2 Test gas(es)

The test gases shall be mixtures of clean air with the gas for which the apparatus is intended to be used.

If clean air cannot be used because of instability of the standard test gas then nitrogen shall be used as the balance gas. If the sensor characteristics are affected by the balance gas the test procedure shall be agreed between the manufacturer and the test laboratory and specified in the test report.

The tolerance on the nominal volume fraction of all test gases shall not exceed ± 10 %. The volume fractions of all test gases shall be known to a relative expanded uncertainty of ± 5 %.

For EN 45544-2 apparatus, the standard test gas shall have a volume fraction equal to the value specified in normative Annex A. For gases not included in Annex A, a value agreed between the manufacturer and the test laboratory considering the Limit Values shall be used and specified in the test report.

For EN 45544-3 apparatus, the standard test gas to be used shall have a volume fraction equal to the middle of the measuring range.

5.3.3 Flow rate for test gases

When the apparatus is exposed to the test gases, the flow rate of the gases shall be in accordance with the manufacturer's instructions.

5.3.4 Power supply

a) Fixed AC or DC powered apparatus shall be operated within 2 % of the manufacturer's recommended supply voltage and frequency.

b) Battery-powered apparatus shall be equipped with new or fully charged batteries at the commencement of each test. For long-term testing, it is permissible to energize the unit from a stabilized power supply. The temperature test (5.4.5.1) shall be performed with the battery supply.

NOTE Long term testing is deemed to last longer than the operating time with fully charged batteries.

5.3.5 Temperature

The ambient air and test gas shall be held at a constant temperature ± 2 °C within the range of 15 °C to 25 °C throughout the duration of each test.

5.3.6 Pressure

The tests shall be performed at pressures between 86 kPa and 108 kPa, with a maximum variation of ± 1 kPa throughout the duration of each short-term test. For long-term tests, the influence of pressure changes shall be taken into account, using the results of the pressure test (5.4.5.2).

5.3.7 Humidity

The relative humidity (r.h.) of the ambient air shall be within the range stated in the instruction manual throughout each test.

It is recommended that the relative humidity is between 30 % to 80 % r.h.

The relative humidity (r.h.) of the clean air and test gases shall be controlled to be within 40 % to 60 % r.h. throughout each test. The pressure test (5.4.5.2) shall be performed with clean air and test gases having a constant volume fraction of water vapour.

The use of dry gases is permitted for types of apparatus where the test results are not affected by relative humidity.

For short applications of test gases, the use of dry gases is permitted if agreed between the manufacturer and the test laboratory. The properties of the sensor shall be taken into account.

EXAMPLE Drying out is an example of a property of the sensor.

5.3.8 Stabilization

In each instance where the apparatus is subjected to a different test condition, the apparatus shall be allowed to stabilize under these new conditions before measurements are taken.

5.3.9 Orientation

The apparatus shall be tested in the orientation recommended in the instruction manual.

5.3.10 Communications options

For apparatus having wired or wireless communications options used during normal gas detection operation, tests in 5.4.3, 5.4.5.1, 5.4.6.2, 5.4.6.5, 5.4.6.6 and 5.4.7.3 shall be performed with all communication ports connected. The maximum transaction rate, cabling characteristics and activity level specified in the instruction manual shall be employed.

5.3.11 Gas detection apparatus as part of systems

For gas detection apparatus which are part of systems, tests in 5.4.3, 5.4.5.1, 5.4.6.2, 5.4.6.5, 5.4.6.6, 5.4.7.2 and 5.4.7.3 shall be performed with the maximum system communications transaction rate and activity level. This shall correspond to the largest and most complex system configuration permitted by the instruction manual.

5.4 Tests

5.4.1 General

Stabilize the apparatus, including the battery when fitted, prior to the commencement of the tests, unless otherwise stated.

Take one reading in clean air and in the standard test gas before and after each test, unless otherwise stated.

The values of the indications used for verification of compliance with the performance requirements shall be taken after stabilization (see 3.36), unless otherwise stated.

If, however, the sensor characteristics do not allow the apparatus to stabilize within 7,5 min (see 3.36), then a time shall be agreed between the manufacturer and the test laboratory when the apparatus is deemed to be stabilized. This time shall not exceed 7,5 min and shall be specified in the instruction manual as the stabilization time. This stabilization time shall also be used for calibration and adjustment of the apparatus, and when performing tests 5.4.6.5 and 5.4.6.6.

5.4.2 Unpowered storage

All parts of the apparatus shall be exposed sequentially to the following conditions in ambient air only:

a) a temperature of (−20 ± 3) °C for (24 ± 0,5) h;

b) a temperature of (20 ± 5) °C for (24 ± 0,5) h;

c) a temperature of (40 ± 2) °C for (24 ± 0,5) h;

d) a temperature of (20 ± 5) °C for at least 24 h;

The humidity requirement of 5.3.7 does not apply at the temperature of −20 °C. The humidity of the ambient air shall be such that condensation does not occur.

The above temperatures may be varied only after an agreement has been reached between the manufacturer and test laboratory. Where temperatures other than those listed above are used, they shall be listed in the test report.

5.4.3 Measurement of deviations

5.4.3.1 Zero uncertainty, relative expanded uncertainty and calibration curve for EN 45544-2 apparatus

Each reading shall be taken after a time interval equal to 10 times the time of response t_{50} for test gas application and equal to 10 times the time of recovery t_{50} for clean air application, as specified in the instruction manual.

Expose the apparatus to test gases with volume fractions of 0,1; 0,5; 1; 2; 5 times the standard test gas volume fraction and 90 % of the upper limit of measurement. Test gases with volume fractions outside the indication range shall not be applied. For each test gas volume fraction, expose the apparatus to clean air and then the test gas and repeat this cycle a total of six times.

In the case of gases which are very difficult to handle at low volume fractions, the lowest possible test gas volume fraction below the standard test gas volume fraction shall be used. The lowest test gas volume fraction shall not exceed 0,2 times the standard test gas volume fraction.

Calculate for each test gas volume fraction the relative expanded uncertainty as specified in 6.2.3. Calculate the lower limit of measurement as specified in 6.3 using the readings in clean air taken in conjunction with the test gas volume fractions up to and including two times the standard test gas volume fraction.

5.4.3.2 Calibration curve for EN 45544-3 apparatus

Each reading shall be taken after a time interval equal to 10 times the time of response t_{50} for test gas application and equal to five times the time of recovery t_{10} for clean air application, as specified in the instruction manual.

Expose the apparatus to test gas volume fractions of 0 %, 10 %, 30 %, 50 %, 70 % and 90 % of the upper limit of measurement, starting with the lowest and finishing with the highest volume fraction. This operation shall be performed three consecutive times.

5.4.4 Mechanical tests

5.4.4.1 Vibration

5.4.4.1.1 Test equipment

The vibration test machine shall consist of a vibrating table capable of producing a vibration of variable frequency and amplitude with the test equipment mounted in place, in accordance with EN 60068-2-6 and the following test procedures.

The requirements for ambient temperature (5.3.5) and humidity (5.3.7) need not be fulfilled; the temperature and humidity conditions shall not result in damage to the sensor.

5.4.4.1.2 Procedures

5.4.4.1.2.1 General

The test shall be performed in accordance with EN 60068-2-6.

The apparatus shall be mounted on the vibration table in the same manner as intended for use including any resilient mounts, carrier or holding devices that are provided as standard parts of the apparatus.

The apparatus shall be energized and mounted on the vibration test machine and vibrated successively in each of three planes respectively parallel to each of the three major axes of the apparatus.

The alarm set point shall be set:

– for apparatus specified in EN 45544-2, at 80 % of the standard test gas volume fraction;

– for apparatus specified in EN 45544-3, at 10 % of the indicating range.

If the alarm set point cannot be set at this volume fraction, the alarm set point shall be set as close as possible to this volume fraction.

Before and after the test, measurements shall be taken in clean air and then with standard test gas.

During vibration, the apparatus shall be operated in ambient air. If necessary, clean air may be applied to the sensor in order to obtain a stable reading.

The apparatus shall be vibrated over the frequency range specified at the excursion or constant acceleration peak specified, for a period of 1 h in each of the three mutually perpendicular planes. The frequency shall continuously change exponentially with time and the rate of change of frequency shall be one octave per minute.

5.4.4.1.2.2 Procedure 1

For portable and transportable apparatus, remote sensors, and apparatus with integral sensors, the vibration shall be as follows:

– 10 Hz to 31,5 Hz, 0,5 mm displacement amplitude (1,0 mm peak-peak total excursion);

– 31,5 Hz to 150 Hz, 19,6 m/s^2 acceleration amplitude.

5.4.4.1.2.3 Procedure 2

For control units, the vibration shall be as follows:

– 10 Hz to 31,5 Hz, 0,5 mm displacement amplitude (1,0 mm peak-peak total excursion);

– 31,5 Hz to 100 Hz, 19,6 m/s^2 acceleration amplitude.

5.4.4.2 Drop test

This test shall be performed only on portable and transportable apparatus. If the instruction manual specifies that components of fixed apparatus can be used like portable or transportable apparatus, these components shall be considered to be portable or transportable for this test. If the manufacturer recommends that the apparatus be used in its carrying case, the test shall be performed with the case.

Portable apparatus shall be released, while operating, from a height of (1 ± 0,05) m above a concrete surface and allowed to free fall.

Transportable apparatus with a mass less than 5 kg shall be released, while not operating, from a height of (0,3 ± 0,03) m above a concrete surface and allowed to free fall.

Other transportable apparatus shall be released, while not operating, from a height of (0,1 ± 0,02) m above a concrete surface and allowed to free fall.

The test required above shall be performed three separate times, the portable apparatus being released each time with a different side (surface) facing down at the time of release and the transportable apparatus to be in an orientation for normal transport.

Before and after the test, measurements shall be taken in clean air and then with standard test gas.

5.4.5 Environmental tests

5.4.5.1 Temperature

This test shall be performed in a temperature chamber having the capability of holding the sensor or apparatus at the temperatures specified below within ± 2 °C. The clean air and standard test gas shall be at the same temperature as the atmosphere in the test chamber. The dew point of the test gases shall be below the lowest temperature of the test chamber and kept constant during the test.

While waiting for the apparatus to stabilize at the new temperature, the sensor shall be exposed to the ambient air inside the temperature chamber.

The requirement of 5.3.7 relating to the ambient air does not apply. The humidity of the ambient air shall be such that condensation does not occur.

At each temperature record the indication in clean air and standard test gas and then perform test 5.4.6.2.

Tests shall be carried out:

– For control units:

  at temperatures of 5 °C, 20 °C and 55 °C;

– For personal and portable apparatus:

at temperatures of −10 °C, 5 °C, 20 °C and 40 °C.

– For all other types of apparatus:

at temperatures of −25 °C, 5 °C, 20 °C and 55 °C.

Where the manufacturer specifies another temperature range, the apparatus shall be tested at 20 °C and at the upper and lower limits of this temperature range.

The minimum temperature may need to be increased for substances with low vapour pressures in order to ensure that the appropriate volume fraction of the substance in the test gas may be reached.

5.4.5.2 Pressure

The effects of pressure variation shall be observed by placing the apparatus (including the aspirator for aspirated apparatus) in a test chamber that permits the pressure of the test gases to be varied. The pressure shall be maintained at the levels specified below for 5 min before a reading is accepted or a test is made.

Tests shall be performed at pressures of 80 kPa, 90 kPa, 100 kPa, 110 kPa and 120 kPa.

The pressure shall be changed with a rate less than 20 kPa/h.

The requirement of 5.3.7 relating to the ambient air does not apply. The humidity of the ambient air shall be such that condensation does not occur.

The apparatus shall be exposed sequentially to clean air and then standard test gas at each pressure.

For EN 45544-2 apparatus only, calculate the differences between the measured values in standard test gas for each 10 kPa step, i.e. 80–90 kPa, 90–100 kPa, 100–110 kPa, 110–120 kPa.

5.4.5.3 Humidity

The apparatus shall be allowed to stabilize at 40 °C. After a stabilization time of at least 2 h at (40 ± 1) °C, the equipment shall be calibrated and adjusted as specified in the instruction manual.

NOTE The instruction manual includes the humidity of the test gases and the application times.

The test shall then be performed at relative humidities of 20 %, 50 % and 90 % at 40 °C. At each relative humidity, the apparatus or sensors shall be stabilized in clean air for at least 15 min and then exposed to the standard test gas. The relative humidity levels shall be known to within ± 5 % r.h.

The volume fraction of the standard test gas shall be held constant, or due allowance shall be made for changes in volume fraction due to the pressure of water vapour in the test gas.

For certain gases, it may be necessary to reduce the temperature and/or highest humidity level to a level at which a stable test gas mixture can be prepared. In these circumstances, the instruction manual shall specify the temperature and highest humidity level tested.

5.4.5.4 Air velocity

The effects of air velocity on diffusion apparatus shall be determined by the following test with clean air and standard test gas.

The remote sensors of apparatus with remote sensors and, when practicable, the entire apparatus if the sensors are integral shall be tested in a flow chamber.

For apparatus having integral sensors which are too large to be tested in a flow chamber, other flow equipment for carrying out the test shall be permitted. In this case the “other flow equipment” shall be described in the test report.

The apparatus or sensor shall be operated in the orientation recommended by the manufacturer. If there is no such recommendation, e.g. for portable apparatus, a typical orientation shall be used.

Irrespective of whether a flow chamber or other flow equipment is used, the direction of the air flow with respect to the sensor inlet shall be as follows:

1) flow directed at the sensor;

2) flow directed 180° to 1);

3) flow directed 90° to 1).

Each orientation is given with a tolerance of ± 5°.

Measurements shall be made under no forced ventilation conditions, at (0,5 ± 0,1) m/s, (3 ± 0,3) m/s and at (6 ± 0,6) m/s.

Directions of flow not likely to occur in practice due to the design of the apparatus or expressly prohibited within the instruction manual shall not be tested.

5.4.6 Performance tests

5.4.6.1 Alarm set point(s)

When apparatus is provided with either:

a) user adjustable means of setting either one or more alarm set points; or

b) internally pre-set alarm point(s),

the activation of such alarms by gas at the appropriate set point values shall be verified by using test gas/air mixtures in the following manner:

For apparatus of type a) above with a single alarm set point, set it to a point equivalent to 80 % of the volume fraction of standard test gas.

For apparatus of type a) above with more than one alarm set point, set all of the alarm set points separately to 80 % of the volume fraction of standard test gas.

If an alarm set point cannot be set at this volume fraction, the alarm set point shall be set as close as possible to this volume fraction.

For apparatus of type a) above with alarm set points which have been set to 80 % of the volume fraction of standard test gas, and for apparatus of type b) above where the pre-set alarm point is in the range 70 % to 80 % of the volume fraction of the standard test gas, the activation of the alarm shall be checked by exposure to standard test gas.

For other apparatus of types a) and b) above, for each alarm which has a set point below 70 % or above 80 % of the volume fraction of the standard test gas, expose the sensor to a test gas/air mixture equivalent to (120 ± 10) % of the volume fraction corresponding to the individual alarm set point.

If a latching alarm is provided, the latching and the manual reset action shall be checked.

5.4.6.2 Time to alarm or alarm reading

This test is part of the temperature test, see 5.4.5.1.

Set the alarm, if available, at 15 % of the upper limit of measurement. Subject the apparatus to a step change from clean air to a test gas with a volume fraction of 75 % of the upper limit of measurement.

If the alarm set point is pre-set by the manufacturer and cannot be changed, a test gas equivalent to five times the pre-set set point shall be used.

Introduce the test gas by means of a mask or a chamber filled with this test gas into which the sensor is rapidly introduced.

Measure the time interval from making the step change to obtaining an alarm or, if no alarm is available or cannot be set to 15 % of the upper limit of measurement, until the measured value reaches 15 % of the upper limit of measurement.

5.4.6.3 Flow rate

This test shall only be performed for aspirated apparatus.

For automatically aspirated apparatus, an adjustable low flow signal shall be set to the minimum set point.

To test the low flow signal, decrease the flow rate of clean air until the low flow signal operates. The apparatus shall then be exposed to standard test gas and the flow rate varied:

– from 130 % of the nominal flow rate or, if this is not possible, from the nominal flow rate,

– to 110 % of the flow rate at which the low flow signal is set.

All other aspirated apparatus shall be tested by varying the flow rate of standard test gas from the maximum to the minimum value as specified in the instruction manual.

5.4.6.4 Warm-up time

Expose the apparatus to clean air and standard test gas until stabilized and record the reading.

Then switch off the apparatus and place in ambient air for a minimum period of 24 h. Then expose the apparatus to clean air for a minimum of 1 h. Switch on the apparatus and record the reading at the end of the warm-up time specified in the instruction manual. Expose the apparatus to standard test gas until stabilized and record the reading.

5.4.6.5 Time of response

The apparatus shall be in its normal operating state, without optional accessories attached to the apparatus for special purposes.

Expose the apparatus to a step change from clean air to standard test gas.

The relative humidity of clean air and standard test gas shall conform to the requirements of 5.3.7 for the relative humidity of the ambient air. The difference in humidity between clean air and test gas shall not be greater than 5 % r.h.

Perform this test for diffusion apparatus using a chamber filled with test gas, which allows the apparatus to be exposed to the step change. An example of such a test chamber is shown in informative Annex C. If the test chamber cannot be used due to the properties of the test gas then a mask may be used.

EXAMPLE Examples of such properties are absorption and stability.

For aspirated apparatus, the step change shall be applied at the gas inlet.

Measure the time intervals t_{50} and t_{90}, from making the step change to obtaining 50 % and 90 % of the final indication.

5.4.6.6 Time of recovery

The apparatus shall be in its normal operating state, without optional accessories attached to the apparatus for special purposes.

Expose the apparatus to a step change from the standard test gas to ambient air or clean air.

The difference in humidity between ambient air, clean air and test gas shall not be greater than 5 % r.h.

Perform this test for diffusion apparatus by applying standard test gas using the mask then suddenly removing the mask.

Perform this test for aspirated apparatus by applying the step change at the gas inlet.

Measure the time intervals t_{10} and t_{50} from making the step change to obtaining 10 % and 50 % of the initial indication.

It is recognized that the time of recovery is not defined for irreversible measuring techniques, and when this is the case, this test shall not be performed.

EXAMPLE Some paper tape instruments are irreversible measuring techniques.

5.4.6.7 Addition of sampling probe (portable and transportable apparatus only)

The apparatus shall first be exposed to clean air and the standard test gas without the sampling probe. The sample probe shall then be added, and the exposures repeated.

5.4.6.8 Field calibration kit

Calibrate the apparatus with clean air and standard test gas using the field calibration kit according to the instruction manual.

Apply clean air and standard test gas to the apparatus as in normal operation.

The relative humidity of clean air and standard test gas shall be in accordance with 5.3.7 for the relative humidity of the ambient air. The difference in humidity between clean air and test gas shall not be greater than 5 % r.h.

EXAMPLE A mask for calibration and test is an example of a field calibration kit.

5.4.6.9 Gas concentrations above the full scale indication

Measurements shall be taken in clean air and standard test gas.

Expose the apparatus to a step change from clean air to test gas with a volume fraction of 2 times the full scale indication and maintain for 10 min for personal and portable apparatus and 30 min for fixed and transportable apparatus.

Expose the apparatus to clean air for 60 min and record the final indication. Expose the apparatus to standard test gas until stabilized and record the indication.

5.4.6.10 Extended operation in test gas

5.4.6.10.1 Personal and portable apparatus

Measurements shall be taken in clean air.

Operate the apparatus for 8 h per day in standard test gas over 3 d or for apparatus with a calibration period less than 3 d until the end of the calibration period. For the rest of each day, the apparatus shall be switched off and placed in ambient air.

For each 8 h period, record the indication after 10 min, at 4 h and at the end of the period.

After the final 8 h period, expose the apparatus to ambient air for 60 min and then record the indication in clean air.

5.4.6.10.2 Fixed and transportable apparatus

Measurements shall be taken in clean air and standard test gas.

Operate the apparatus continuously for 7 d in test gas or for apparatus with a calibration period less than 7 d until the end of the calibration period. The test gas volume fraction shall be (20 ± 2) % of the standard test gas volume fraction.

NOTE A more precise volume fraction is not needed. This test is only to determine the effect on the apparatus of continuous exposure to a background level of toxic gas.

Expose the apparatus to ambient air for 60 min and then record the indication in clean air and standard test gas.

5.4.6.11 Orientation tests

5.4.6.11.1 Personal and portable apparatus

Rotate the apparatus while applying clean air and then standard test gas, through 360° in steps of 45° around each of its three mutually perpendicular axes. Record the stabilized indication in each position.

5.4.6.11.2 Fixed and transportable apparatus

The sensors, or the apparatus having integral sensors, shall be tested within the orientation limits stated in the instruction manual in steps of 15° around each of the three mutually perpendicular axes. If the manufacturer has stated orientation limits of ± 15° or less, the tests shall be performed with an inclination of ± 15° from the nominal orientation. In each orientation apply clean air and standard test gas.

5.4.7 Electrical tests

5.4.7.1 Battery capacity for battery-powered apparatus

The apparatus shall be fitted with new batteries or rechargeable batteries shall be fully charged at the beginning of the test.

Expose the apparatus to clean air for a minimum of 1 h. Switch the apparatus on and perform an initial measurement in clean air and standard test gas. Then the apparatus shall be operated in ambient air for a total period of 7 h, or for a lesser period if specified in the instruction manual. At the end of this period, the apparatus shall be exposed to clean air for 1 h and then a measurement in clean air and standard test gas shall be taken.

The apparatus shall continue to be operated in ambient air. The measurement in clean air and standard test gas shall be repeated 10 min after indication that the low-battery condition has been reached.

For long life batteries, suitable methods for shortening the test period may be agreed between the manufacturer and the test laboratory.

5.4.7.2 Power supply variations

The apparatus shall be set up at nominal supply voltage and, for a.c. powered apparatus, rated frequency. For apparatus with remote sensors, the test shall be performed with both maximum and minimum resistance of the interconnecting cable.

The alarm set point shall be set at 10 % of the upper limit of measurement. If the alarm set point cannot be set at this concentration, the alarm set point shall be set as near as possible to that concentration.

The apparatus shall be exposed to clean air and standard test gas and the reading recorded at 115 %, 100 % and 80 % of nominal supply voltage. Where the instruction manual specifies another supply range, the apparatus shall be tested at the upper and lower limits of that range.

It shall be verified at the minimum supply voltage that all output functions are working properly even at worst case load conditions. The analogue outputs shall be tested at the maximum output level. Relays shall be able to energize at the minimum supply voltage.

5.4.7.3 Electromagnetic compatibility

The apparatus shall be set under normal conditions, in accordance with 5.3, and then shall be subjected to the tests specified in EN 50270. The requirements for ambient temperature (5.3.5) and humidity (5.3.7) need not be fulfilled; the temperature and humidity conditions shall not result in damage to the sensor.

If local legislation for electromagnetic compatibility permits the manufacturer to declare conformity to legal requirements by complying with EN 50270, this test may be omitted.

5.4.7.4 Time-weighted average (TWA) function

5.4.7.4.1 General

The test method of this clause shall only be performed on apparatus that has a TWA function.

5.4.7.4.2 TWA calculation

Apply the following regime over the TWA measuring period using test gas:

— the standard test gas volume fraction for 25 % of the period;

— 50 % of the standard test gas volume fraction for 50 % of the period;

– clean air for 25 % of the period.

Record the indicated value expressed as the time-weighted value of the test gas volume fraction.

5.4.7.4.3 TWA alarm

The apparatus shall be switched on in clean air. When the warm up time has been completed, a test gas with a volume fraction of two times the TWA alarm set point shall be applied until the TWA alarm is activated or the TWA period has elapsed.

5.4.8 Stability

Battery powered apparatus shall be operated for 8 h per working day in ambient air. All other apparatus shall be operated continuously in ambient air.

The apparatus shall be exposed to clean air and the standard test gas for a total of six times over the calibration period that is specified in the instruction manual. The first exposure shall be at the beginning of the calibration period and the last at the end of the calibration period or after 6 months whichever is the shorter. The remaining four exposures shall be approximately evenly distributed over the calibration period.

Record the readings after each exposure to clean air and the standard test gas.

5.4.9 Verification of software and digital components

Design and function of the apparatus using software and/or digital technologies shall be evaluated and tested in accordance with EN 50271.

6 Uncertainty of measurement and lower limit of measurement

6.1 General

The calculations in this clause shall be performed for apparatus that conform to EN 45544-2.

6.2 Method of calculation of uncertainty of measurement

6.2.1 General

Random sources of uncertainty shall be assumed to be normally distributed. Non-random sources of uncertainty, or bias, shall be treated as rectangularly distributed in accordance with EN 482.

NOTE The estimation of the uncertainty of measurement for electrical apparatus used for the direct detection and direct concentration measurement of toxic gases and vapours is derived from a cause and effect analysis identifying individual random and non-random uncertainty components.

A rectangular probability distribution with a range of ± A should be converted into a non-random uncertainty equal to A/√3.

Clause 5 of this document identifies factors which shall be included in the expanded uncertainty estimate. A summary of these is provided in Table 1 below.

Table 1 — Factors to be considered in the expanded uncertainty estimate

Clause	Title	Inclusion	Type of uncertainty	
			Random	Non- random
5.4.2	Unpowered storage	No		
5.4.3	Measurement of deviations	Yes	Yes	Yes
5.4.4.1	Vibration	No		
5.4.4.2	Drop test	No		
5.4.5.1	Temperature	Yes	No	Yes
5.4.5.2	Pressure	Yes	No	Yes
5.4.5.3	Humidity	Yes	No	Yes
5.4.5.4	Air velocity	Yes	No	Yes
5.4.6.1	Alarm set point(s)	No		
5.4.6.2	Time to alarm (reading)	No		
5.4.6.3	Flow rate	Yes	No	Yes
5.4.6.4	Warm-up time	No		
5.4.6.5	Time of response	No		
5.4.6.6	Time of recovery	No		
5.4.6.7	Sampling probe	Yes	No	Yes
5.4.6.8	Field calibration kit	Yes	No	Yes
5.4.6.9	Gas concentrations above the full scale indication	No		
5.4.6.10	Extended operation in test gas	Yes	No	Yes
5.4.6.11	Orientation	Yes	No	Yes
5.4.7.1	Battery capacity	Yes	No	Yes
5.4.7.2	Power supply variations	Yes	No	Yes

5.4.7.3	EMC	No		
5.4.7.4	TWA	No		
5.4.8	Stability	Yes	No	Yes
5.4.9	EN 50271	No		

6.2.2 Sources of uncertainty

6.2.2.1 General

When performing the calculations of 6.2.2.3 to 6.2.2.14, x_{range} and x_{max} shall be calculated for each test sample and the maximum value shall be used in the formula.

However, when performing the calculations of 6.2.2.2, the measured values from all test samples shall be combined to give one value for the uncertainty of each indicating device.

6.2.2.2 Measurement of deviations (from 5.4.3)

The following calculation shall be performed for each indicating device.

All these calculations shall be performed for each test gas concentration combining the values from all test samples.

The uncertainty of the random element of the repeated measurements, u_{rdev}, shall be calculated in accordance with Formula (1):

$$u_{rdev} = \left[\sqrt{\sum_{i=1}^{n} \frac{\left(x_i - \overline{x}\right)^2}{n-1}} \right] * \frac{100}{x_{ref}} \tag{1}$$

where

$x_i = the\ repeated\ measurements$

$\overline{x} = the\ mean\ of\ the\ repeated\ measurements\ at\ the\ test\ gas\ volume\ fraction$

$x_{ref} = the\ volume\ fraction\ of\ the\ test\ gas$

$n = the\ number\ of\ repeated\ measurements\ at\ the\ test\ gas\ volume\ fraction$

The uncertainty of the non-random element of the repeated measurements, u_{nrdev}, is a function of the deviation of the mean of the repeated measurements from the volume fraction of the test gas and the resolution of the indicating device and shall be calculated with Formula (2):

$$u_{nrdev} = \sqrt{\left(\frac{\left|\overline{x} - x_{ref}\right|}{x_{ref} * \sqrt{3}} * 100 \right)^2 + \left(\frac{x_{res}}{2 * \sqrt{3} * x_{ref}} * 100 \right)^2} \tag{2}$$

where

x_{res} = *the resolution of the indicating device*

The uncertainty associated with the measurement of deviations, $u_{deviation}$, shall be calculated in accordance with Formula (3):

$$u_{deviation} = \sqrt{u_{rdev}^2 + u_{nrdev}^2} \tag{3}$$

6.2.2.3 Temperature (from 5.4.5.1)

The non-random uncertainty associated with the influence of temperature, $u_{temperature}$, shall be calculated in accordance with Formula (4):

$$u_{temperature} = \frac{\left|x_{range}\right|}{2 * x_{std} * \sqrt{3}} * 100 \tag{4}$$

where

x_{range} = *the difference between the maximum and minimum values in standard test gas over the entire temperature range*

x_{std} = *the volume fraction of the standard test gas*

6.2.2.4 Pressure (from 5.4.5.2)

The non-random uncertainty associated with the influence of pressure, $u_{pressure}$, shall be calculated in accordance with Formula (5):

$$u_{pressure} = \frac{\left|x_{\max}\right|}{2 * x_{std} * \sqrt{3}} * 100 \tag{5}$$

where

$$x_{\max} = Max\left[\left|x_{120} - x_{110}\right|, \left|x_{110} - x_{100}\right|, \left|x_{100} - x_{90}\right|, \left|x_{90} - x_{80}\right|\right]$$

NOTE The numbers in the formula for x_{max} refer to the differences between the measured values in standard test gas for each 10 kPa step, i.e. 80–90 kPa, 90–100 kPa, 100–110 kPa, 110–120 kPa

x_{std} = *the volume fraction of the standard test gas*

6.2.2.5 Humidity (from 5.4.5.3)

The non-random uncertainty associated with the influence of humidity, $u_{humidity}$, shall be calculated in accordance with Formula (6):

$$u_{humidity} = \frac{\left|x_{range}\right|}{2 * x_{std} * \sqrt{3}} * 100 \quad (6)$$

where

x_{range} = *the difference between the maximum and minimum values in standard test gas over the entire humidity range*

x_{std} = *the volume fraction of the standard test gas*

6.2.2.6 Air velocity (from 5.4.5.4)

The non-random uncertainty associated with the influence of air velocity, $u_{velocity}$, shall be calculated in accordance with Formula (7):

$$u_{velocity} = \frac{\left|x_{range}\right|}{2 * x_{std} * \sqrt{3}} * 100 \quad (7)$$

where

x_{range} = *the difference between the maximum and minimum values in standard test gas over the entire range of air velocities and flow directions*

x_{std} = *the volume fraction of the standard test gas*

6.2.2.7 Flow rate (from 5.4.6.3)

The non-random uncertainty associated with the influence of flow rate, u_{flow}, shall be calculated in accordance with Formula (8):

$$u_{flow} = \frac{\left|x_{range}\right|}{2 * x_{std} * \sqrt{3}} * 100 \quad (8)$$

where

x_{range} = *the difference between the maximum and minimum values in standard test gas over the entire range of flow rates*

x_{std} = *the volume fraction of the standard test gas*

6.2.2.8 Sampling probe (from 5.4.6.7)

The non-random uncertainty associated with the influence of the sampling probe, u_{probe}, shall be calculated in accordance with Formula (9):

$$u_{probe} = \frac{\left|x_{range}\right|}{2 * x_{std} * \sqrt{3}} * 100 \quad (9)$$

where

x_{range} = *the difference in measured values in standard test gas with and without the probe*

x_{std} = *the volume fraction of the standard test gas*

6.2.2.9 Field calibration kit (from 5.4.6.8)

The non-random uncertainty associated with the influence of the manufacturer's field calibration kit, u_{field}, shall be calculated in accordance with Formula (10):

$$u_{field} = \frac{\left|x_{range}\right|}{2 * x_{std} * \sqrt{3}} * 100 \quad (10)$$

where

x_{range} = *the difference in measured values in standard test gas with and without the field calibration kit*

x_{std} = *the volume fraction of the standard test gas*

6.2.2.10 Extended operation in test gas (from 5.4.6.10)

The non-random uncertainty associated with the influence of extended operation in test gas, u_{ext}, shall be calculated in accordance with Formula (11):

$$u_{ext} = \frac{\left|x_{range}\right|}{2 * x_{test} * \sqrt{3}} * 100 \quad (11)$$

where

x_{range} = *the difference between the maximum and minimum values in test gas during the extended operation test*

x_{test} = *the volume fraction of the test gas*

6.2.2.11 Orientation (from 5.4.6.11)

The non-random uncertainty associated with the influence of orientation, $u_{orientation}$, shall be calculated in accordance with Formula (12):

$$u_{orientation} = \frac{x_{range}}{2 * x_{std} * \sqrt{3}} * 100 \quad (12)$$

where

x_{range} = *the difference between the maximum and minimum values in standard test gas over the entire range of orientations*

x_{std} = *the volume fraction of the standard test gas*

6.2.2.12 Battery capacity (from 5.4.7.1)

The non-random uncertainty associated with the influence of battery capacity, $u_{battery}$, shall be calculated in accordance with Formula (13):

$$u_{battery} = \frac{\left|x_{range}\right|}{2 * x_{std} * \sqrt{3}} * 100 \quad (13)$$

where

x_{range} = *the difference in measured values in standard test gas with a fully charged battery and 10 min after the indication of the low battery condition*

x_{std} = *the volume fraction of the standard test gas*

6.2.2.13 Power supply variations (from 5.4.7.2)

The non-random uncertainty associated with the influence of power supply variations, u_{power}, shall be calculated in accordance with Formula (14):

$$u_{power} = \frac{\left|x_{range}\right|}{2 * x_{std} * \sqrt{3}} * 100 \quad (14)$$

where

x_{range} = *the difference between the maximum and minimum values in standard test gas over the entire range of supply voltages*

x_{std} = *the volume fraction of the standard test gas*

6.2.2.14 Stability (from 5.4.8)

The non-random uncertainty associated with the stability, $u_{stability}$, shall be calculated in accordance with Formula (15):

$$u_{stability} = \frac{\left|x_{range}\right|}{2 * x_{std} * \sqrt{3}} * 100 \quad (15)$$

where

x_{range} = *the difference between the maximum and minimum values in standard test gas over the entire calibration period*

x_{std} = *the volume fraction of the standard test gas*

6.2.3 Calculation of relative expanded uncertainty

The following calculation shall be performed for each indicating device.

For each test gas volume fraction, calculate the sum, u_{total}, of the uncertainties, u_i, in accordance with 6.2.2.2 to 6.2.2.14 in accordance with Formula (16):

$$u_{total} = \sqrt{\left(u_1^2 + u_2^2 + \cdots u_n^2\right)} \quad (16)$$

For the uncertainties derived from extended operation in test gas (6.2.2.10) and stability (6.2.2.14), only the uncertainty with the largest value shall be used in the calculation above.

NOTE Extended operation in test gas and stability are complementary tests which estimate the “stability” of the apparatus in test gas or clean air respectively.

For each test gas volume fraction according to 6.2.2.2, calculate the relative expanded uncertainty U using a coverage factor of 2 in accordance with Formula (17):

$$U = 2 * u_{total} \quad (17)$$

6.3 Method of calculation of lower limit of measurement

When performing the calculations, the measured values from all test samples shall be combined to give one value for the lower limit of measurement of each indicating device.

The following calculations, Formula (18) to Formula (21), shall be performed for each indicating device.

The random element of the zero uncertainty shall be calculated in accordance with Formula (18):

$$ur_{zero} = \sqrt{\sum_{i=1}^{n} \frac{\left(x_i - \overline{x}\right)^2}{n-1}} \tag{18}$$

where

$x_i = the\ repeated\ zero\ measurements$

$\overline{x} = the\ mean\ of\ the\ repeated\ zero\ measurements$

The non-random element of the zero uncertainty is a function of the deviation of the mean of the repeated measurements from zero and the resolution of the indicating device and shall be calculated in accordance with Formula (19):

$$unr_{zero} = \sqrt{\left(\frac{\overline{x}}{\sqrt{3}}\right)^2 + \left(\frac{x_{res}}{2 * \sqrt{3}}\right)^2} \tag{19}$$

where

$x_{res} = the\ resolution\ of\ the\ indicating\ device$

$\overline{x} = the\ mean\ of\ the\ repeated\ zero\ measurements$

The total zero uncertainty shall then be calculated in accordance with Formula (20):

$$u_{zero} = \sqrt{ur_{zero}^2 + unr_{zero}^2} \tag{20}$$

and the lower limit of measurement, U_{zero}, shall be calculated in accordance with Formula (21), i.e. by 2 times u_{zero} using a coverage factor of 2.

$$U_{zero} = 2 * u_{zero} \tag{21}$$

7 Test report

The test report shall be in accordance with EN ISO/IEC 17025 and in addition shall contain at least the following information:

a) the specification, uncertainty and validation of the test gas mixtures;

b) the test parameters and conditions used (e.g. t_{90}, t_{50}) together with justification of any change from the standard test method;

c) the tests in which dry gases were used;

d) the tests in which a mask for calibration and test is used (see 5.2.8).

Annex A
(normative)

Standard test gas volume fractions for EN 45544-2 apparatus

Table A.1 — Standard test gas volume fractions and minimum requirements for the lower limit of measurement for EN 45544–2 apparatus

Name	CAS Number	Formula	Volume fraction of standard test gas (ppm (V/V))	Lower limit of measurement (ppm (V/V))
Ammonia	7664–41–7	NH_3	20	2
Benzene	71–43–2	C_6H_6	1	0,1
Carbon dioxide	124–38–9	CO_2	5000	500
Carbon monoxide	630–08–0	CO	30[a]	3
Chlorine	7782–50–5	Cl_2	0,5[a]	0,1
Ethylene oxide	75–21–8	CH_2-CH_2-O	1,0[a]	0,1
Hydrogen chloride	7647–01–0	HCl	5	1
Hydrogen cyanide	74–90–8	HCN	5[a]	1
Hydrogen sulfide	7783–06–4	H_2S	5	0,5
Methanol	67–56–1	CH_3OH	200	20
Nitric oxide	10102–43–9	NO	25[a]	2,5
Nitrogen dioxide	10102–44–0	NO_2	3[b]	0,3
Nitrous oxide	10024–97–2	N_2O	100[a]	10
Ozone	10028–15–6	O_3	0,1[a]	0,01
Phosphine	7803–51–2	PH_3	0,1	0,01
2-Propanol	67–63–0	$(CH_3)_2CHOH$	200[a]	20
Silane	7803–62–5	SiH_4	5[a]	0,5
Styrene	100–42–5	$C_6H_5CHCH_2$	20[a]	2
Sulfur dioxide	7446–09–5	SO_2	2[a]	0,2

Tetrahydrofuran	109–99–9	$(C_2H_4)_2O$	50	5
Toluene	108–88–3	$C_6H_5CH_3$	50	5
Vinyl chloride	75–01–4	$CH_2 = CHCl$	3	0,3
Xylene	1330–20–7	$C_6H_4(CH_3)_2$	50	5

[a] No EU IOELV (European Union Indicative Occupational Exposure Limit Value)

[b] Value chosen in order to be able to generate stable test gases

For gases not included in this table, a value agreed between manufacturer and the test laboratory considering the Limit Values shall be used and specified in the test report.

Annex B
(informative)

Sequence of tests

It is recommended that the tests are performed in the following sequence:

Table B.1 — Sequence of tests

	Verification of software and digital components (tested in parallel with other tests)	[5.4.9]
1	Unpowered storage	[5.4.2]
2	Measurement of deviations	[5.4.3]
	Alarm set point(s)	[5.4.6.1]
	Flow rate	[5.4.6.3]
	Warm-up time	[5.4.6.4]
	Time of response	[5.4.6.5]
	Time of recovery	[5.4.6.6]
	Addition of sampling probe	[5.4.6.7]
	Field calibration kit	[5.4.6.8]
	Orientation	[5.4.6.11]
	Battery capacity	[5.4.7.1]
	Power supply variations	[5.4.7.2]
	Electromagnetic compatibility	[5.4.7.3]
	TWA function	[5.4.7.4]
3	Temperature	[5.4.5.1]
	Pressure	[5.4.5.2]
	Humidity	[5.4.5.3]
	Air velocity	[5.4.5.4]
4	Vibration	[5.4.4.1]
	Drop test	[5.4.4.2]
5	Stability	[5.4.8]
6	Extended operation in standard test gas	[5.4.6.10]
	Gas concentrations above the full scale indication	[5.4.6.9]

Annex C
(informative)

Example of a test chamber

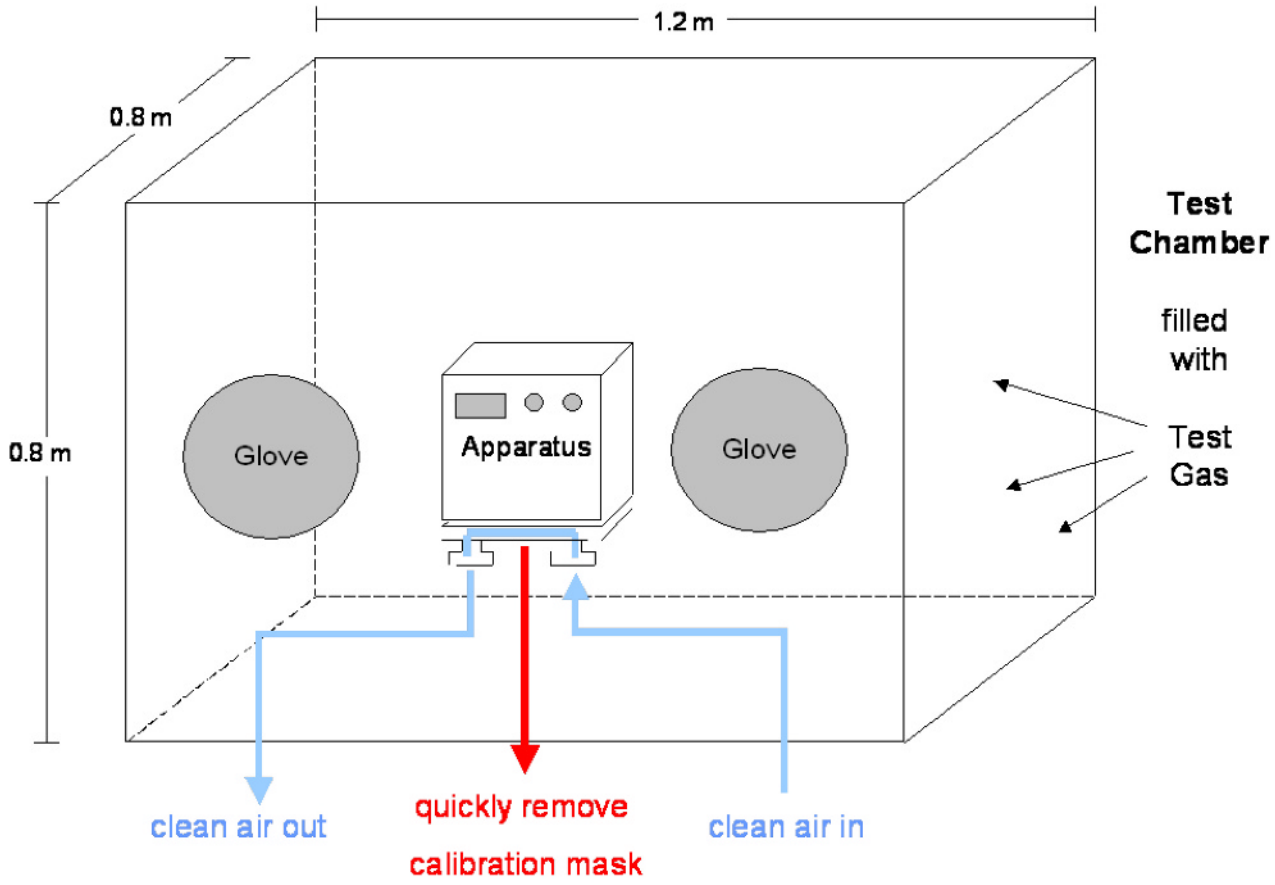

Figure C.1 — Example of a test chamber

Annex D
(informative)

Table of significant changes in comparison to EN 45544-1:1999

	Type		
	Minor and editorial changes	**Extension**	**Substantial change**
Introduction modified: EN 45544 Part 2 and Part 3 renamed and their scope changed. Part 2 defines requirements for apparatus used for exposure measurement according to EN 482. Part 3 defines requirements for apparatus used for general gas detection.			X
Modification of the scope: not applicable to apparatus used in car parks and tunnels and open-path (line of sight) area monitors.		X	
Normative references: EN 50271 added; EN 60073 deleted; ISO 3534–1, ISO 6141, ISO 6142, ISO 6143 deleted; EN 60079–0 added, EN ISO/IEC 17025 added.			X
Definitions modified and extended. In particular, definitions of uncertainty and lower limit of measurement modified and figures added.			X
General requirements modified and extended. In particular, new clauses on: Dead bands; gas detection transmitter for use with separate control units; separate control units for use with gas detection transmitter; apparatus using software and/or digital technologies.			X
Test methods and test conditions revised. In particular: Test methods are aligned as far as possible with EN 50104 and EN 60079–29–1. Tests to be performed on three apparatus while the EMC test may be performed on only one of the three apparatus. A new test clause on EN 50271 introduced. Specific test conditions introduced which are related to communications options for apparatus having wired or wireless communications options and for gas detection apparatus as part of systems.			X

Extensive, new clause on calculation of uncertainty and lower limit of measurement based on current version of EN 482 introduced.			X
Annex A (normative) Number of gases reduced and test gas volume fractions modified in Table A.1.			X
New Annex B (informative) showing recommended sequence of tests.	X		
New Annex C (informative) showing example of a test chamber.		X	

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