



UL 62990-1

STANDARD FOR SAFETY

Workplace Atmospheres – Part 1: Gas Detectors – Performance Requirements of Detectors for Toxic Gases

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UL Standard for Safety for Workplace Atmospheres – Part 1: Gas Detectors – Performance Requirements of Detectors for Toxic Gases, UL 62990-1

First Edition, Dated February 3, 2023

Summary of Topics

Adoption of IEC 62990-1, Workplace Atmospheres – Part 1: Gas Detectors – Performance Requirements of Detectors for Toxic Gases, (first edition and Corrigendum 1, issued by IEC June 2019) as a new IEC-based UL Standard, UL 62990-1 with US Differences.

As noted in the Commitment for Amendments statement located on the back side of the title page, UL and FM are committed to updating this harmonized standard jointly.

The new requirements are substantially in accordance with Proposal(s) on this subject dated March 25, 2022 and September 9, 2022.

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FM Approvals LLC
ANSI/FM 62990-1-2023
First Edition



ULSE Inc.
UL 62990-1
First Edition

Workplace Atmospheres – Part 1: Gas Detectors – Performance Requirements of Detectors for Toxic Gases

February 3, 2023

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ANSI/UL 62990-1-2023

Commitment for Amendments

This standard is issued jointly by FM Approvals LLC and ULSE Inc.(UL). Comments or proposals for revisions on any part of the standard may be submitted to FM Approvals or UL at any time. FM and UL will issue revisions to this standard by means of a new edition or revised or additional pages bearing their date of issue.

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The most recent designation of ANSI/FM 62990-1 as an American National Standard (ANSI) occurred on February 3, 2023.

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This ANSI/UL Standard for Safety consists of the First Edition.

The most recent designation of ANSI/UL 62990-1 as an American National Standard (ANSI) occurred on February 3, 2023. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page (front and back), or the Preface. The National Difference Page and IEC Foreword are also excluded from the ANSI approval of IEC-based standards.

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PREFACE

This is the harmonized FM and UL standard for Workplace Atmospheres – Part 1: Gas Detectors – Performance Requirements of Detectors for Toxic Gases. It is the first edition of FM 62990-1 and the first edition of UL 62990-1.

This harmonized standard is based on IEC Publication 62990-1: first edition, Workplace Atmospheres – Part 1: Gas Detectors – Performance Requirements of Detectors for Toxic Gases, issued June 2019 and corrigendum 1. IEC publication 62990-1 is copyrighted by the IEC.

This harmonized standard was prepared by FM Approvals LLC (FM) and ULSE Inc. (UL).

This standard is considered suitable for use for conformity assessment within the stated scope of the standard.

Application of Standard

Where reference is made to a specific number of samples to be tested, the specified number is to be considered a minimum quantity.

Note: Although the intended primary application of this standard is stated in its scope, it is important to note that it remains the responsibility of the users of the standard to judge its suitability for their particular purpose.

Level of Harmonization

This standard adopts the IEC text with national differences.

This standard is published as an identical standard for FM and UL.

An identical standard is a standard that is exactly the same in technical content except for national differences resulting from conflicts in codes and governmental regulations. Presentation is word for word except for editorial changes.

All national differences from the IEC text are included in the FM and UL versions of the standard. While the technical content is the same in each organization's version, the format and presentation may differ.

Interpretations

The interpretation by the standards development organization of an identical or equivalent standard is based on the literal text to determine compliance with the standard in accordance with the procedural rules of the standards development organization. If more than one interpretation of the literal text has been identified, a revision is to be proposed as soon as possible to each of the standards development organizations to more accurately reflect the intent.

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For FM, the text, figures, and tables of International Electrotechnical Commission Publication 62990-1, Workplace Atmospheres – Part 1: Gas Detectors – Performance Requirements of Detectors for Toxic Gases, copyright 2019, are used in this standard with the consent of the International Electrotechnical Commission. The IEC Foreword and Introduction are not a part of the requirements of this standard but are included for information purposes only.

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National Differences

National Differences from the text of International Electrotechnical Commission (IEC) Publication 62990-1, Workplace Atmospheres – Part 1: Gas Detectors – Performance Requirements of Detectors for Toxic Gases, copyright 2019, are indicated by notations (differences) and are presented in bold text.

There are five types of National Differences as noted below. The difference type is noted on the first line of the National Difference in the standard. The standard may not include all types of these National Differences.

D1 – These are National Differences which are based on **basic safety principles and requirements**, elimination of which would compromise safety for consumers and users of products.

D2 – These are National Differences from IEC requirements based on existing **safety practices**. These requirements reflect national safety practices, where empirical substantiation (for the IEC or national requirement) is not available or the text has not been included in the IEC standard.

DC – These are National Differences based on the **component standards** and will not be deleted until a particular component standard is harmonized with the IEC component standard.

DE – These are National Differences based on **editorial comments or corrections**.

DR – These are National Differences based on the **national regulatory requirements**.

Each national difference contains a description of what the national difference entails. Typically one of the following words is used to explain how the text of the national difference is to be applied to the base IEC text:

Each national difference contains a description of what the national difference entails. Typically one of the following words is used to explain how the text of the national difference is to be applied to the base IEC text:

Addition / Add - An addition entails adding a complete new numbered clause, subclause, table, figure, or annex. Addition is not meant to include adding select words to the base IEC text.

Deletion / Delete - A deletion entails complete deletion of an entire numbered clause, subclause, table, figure, or annex without any replacement text.

Modification / Modify - A modification is an altering of the existing base IEC text such as the addition, replacement or deletion of certain words or the replacement of an entire clause, subclause, table, figure, or annex of the base IEC text.

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FOREWORD

INTERNATIONAL ELECTROTECHNICAL COMMISSION

WORKPLACE ATMOSPHERES – Part 1: Gas detectors – Performance requirements of detectors for toxic gases

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.

2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.

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International Standard ISO/IEC 62990-1 has been prepared by Joint Working Group (JWG) 45 of IEC technical committee 31: Equipment for explosive atmospheres and ISO technical committee 146: Air quality, sub-committee 2: Workplace atmospheres.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
31/1463/FDIS	31/1480/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the ISO/IEC 62990 series, published under the general title *Workplace atmospheres*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

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INTRODUCTION

This part of ISO/IEC 62990 specifies general requirements for construction, testing and performance of equipment intended to measure the concentration of toxic gas and vapour in workplace atmospheres and other industrial and commercial applications. The performance requirements are intended to apply under environmental conditions present at the site of operation. However, because a wide range of environmental conditions are encountered in practise, this document specifies requirements that have to be fulfilled by equipment when tested under prescribed laboratory conditions.

This document applies to the following types of equipment: Health Monitoring (HM) and Safety Monitoring (SM). For a given measurement task of Type HM equipment the range over which the requirements must be met depends on the occupational exposure limit value. However, for most toxic gases and vapours the occupational exposure limit values have not been harmonized at the international level. Therefore, it was decided to use a reference value instead of the occupational exposure limit value for the performance tests. The list of reference values is given in Annex A. The reference values chosen are equal to or close to the occupational exposure limit values used in different countries but are intended to be used only for type testing equipment without any legal implications.

Electrical equipment used for the direct detection and direct concentration measurement of toxic gases and vapours generate readings in clean air (nominally zero), which vary with environmental conditions and time. This document therefore includes test methods and requirements for acceptable variations in measured values at application of zero gas and of defined test gases.

For gas detection equipment including additional function for detecting flammable gas and/or oxygen, consideration should be given to the relevant standards.

General requirements for construction, testing and performance of gas detectors for flammable gases and vapours are set out in IEC 60079-29-1, *Explosive atmospheres – Part 29-1: Gas detectors – Performance requirements of detectors for flammable gases*.

General requirements for construction, testing and performance of open path detectors for flammable gases are set out in IEC 60079-29-4, *Explosive atmospheres – Part 29-4: Gas detectors – Performance requirements of open path detectors for flammable gases*.

Guidance for the selection, installation, use and maintenance of gas detecting equipment is set out in IEC 60079-29-2: *Explosive atmospheres – Part 29-2, Gas detectors – Selection, installation, use and maintenance of detectors for flammable gases and oxygen*.

101.DV DR Modification of Introduction, fifth, sixth and seventh paragraphs as follows:

Replace “IEC 60079-29” with “UL 60079-29”.

Guidance for functional safety of fixed gas detection systems is set out in IEC 60079-29-3: *Explosive atmospheres – Part 29-3, Gas detectors – Guidance on functional safety of fixed gas detection systems*.

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WORKPLACE ATMOSPHERES – Part 1: Gas detectors – Performance requirements of detectors for toxic gases

1 Scope

This part of ISO/IEC 62990 specifies general requirements for design, function and performance, and describes the test methods that apply to portable, transportable, and fixed equipment for the detection and concentration measurement of toxic gases and vapours in workplace atmospheres and other industrial and commercial applications.

1DV.1 DR *Modification of Clause 1, first paragraph as follows:*

Replace “part of ISO/IEC 62990” with “standard” and add the following to the end of the sentence “with maintenance performed by a competent (qualified) service technician.”

This document is applicable to continuously sensing equipment whose primary purpose is to provide an indication, alarm and/or other output function the purpose of which is to indicate the presence of a toxic gas or vapour in the atmosphere and in some cases to initiate automatic or manual protective action(s). It is applicable to equipment in which the sensor generates an electrical signal when gas is present.

This document applies to two types of equipment:

- Type HM (Health Monitoring) ‘occupational exposure’ equipment:

For occupational exposure measurement, the performance requirements are focused on uncertainty of measurement of gas concentrations in the region of Occupational Exposure Limit Values (OELV). The upper limit of measurement will be defined by the manufacturer in accordance with [4.2.1](#).

- Type SM (Safety Monitoring) ‘general gas detection’ equipment:

For general gas detection applications (e.g. safety warning, leak detection), the performance requirements are focused on alarm signalling. The upper limit of measurement will be defined by the manufacturer according to the intended use of the equipment.

In general, the requirements for accuracy will be higher for Type HM equipment than for Type SM equipment. The same equipment may meet the requirements of both Type HM and Type SM.

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

This document is not applicable to equipment:

- with samplers and concentrators such as sorbents or paper tape having an irreversible indication;
- used for the measurement of gases and vapours related to the risk of explosion;
- used for the measurement of oxygen;

- used only in laboratories for analysis or measurement;
- used only for process measurement purposes;
- used in the domestic environment;
- used in environmental air pollution monitoring;
- used for open-path (line of sight) area gas measurement;
- used for ventilation control in car parks or tunnels.

1ADV.1 DR Addition of the following:

Where references are made to IEC standards, the reference requirements found in these standards shall apply as modified by any applicable US National Differences for the standard (see Clause 2).

2 Normative references

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

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

IEC 60079-0, *Explosive atmospheres – Part 0: Equipment – General requirements*

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

IEC 61000-4-29, *Electromagnetic compatibility (EMC) – Part 4-29: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations on d.c. input power port immunity tests*

IEC 61000-6-3, *Electromagnetic compatibility (EMC) – Part 6-3: Generic standards – Emission standard for residential, commercial and light-industrial environments*

IEC 61000-6-4, *Electromagnetic compatibility (EMC) – Part 6-4: Generic standards – Emission standard for industrial environments*

IEC 61326-1, *Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 1: General requirements*

2DV DR Modification of Clause 2 references as follows:

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*¹

¹ The US adoption is identical to the international standard.

UL 60079-0, *Explosive Atmospheres – Part 0: Equipment – General requirements*

3 Terms and definitions

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

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

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

3.1

gas properties

3.1.1

ambient air

normal atmosphere surrounding the equipment

3.1.2

clean air

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

3.1.3

occupational exposure limit value

OELV

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

Note 1 to entry: The term "limit value" is often used as a synonym for "occupational exposure limit value", but the term "occupational exposure limit value" is preferred because there is more than one limit value (e.g., biological limit value and occupational exposure limit value).

Note 2 to entry: Occupational exposure limit values (OELVs) are often set for reference periods of 8 h, but can also be set for shorter periods or concentration excursions.

[SOURCE: ISO 18158:2016, 2.1.5.4, modified (Note 2 to entry is shortened)]

3.1.4

reference value

<for type HM equipment> value used as the basis to specify requirements such as measuring range, resolution and alarm set point

Note 1 to entry: The term reference value is used in this document because for most toxic gases and vapours the occupational exposure limit values have not been harmonized at the International level.

3.1.5

poisons

<for sensing elements> substances that lead to temporary or permanent change of performance, particularly loss of sensitivity of the sensing element

3.1.6

toxic gas

gas or vapour that can be harmful to human health and/or the performance of persons due to its physical or physico-chemical properties

Note 1 to entry: For the purpose of this document, the term “toxic gas” includes “toxic vapours”.

3.1.7

volume fraction

quotient of the volume of a specified component and the sum of the volumes of all components of a gas mixture before mixing, all volumes referring to the pressure and the temperature of the gas mixture

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.

3.1.8

zero gas

gas recommended by the manufacturer, which is free of toxic gases and interfering and contaminating substances, the purpose of which is calibration or adjustment of the equipment zero

3.1.9

standard test gas

test gas with a composition specified for each item of equipment and gas and/or vapour to be used for all tests unless otherwise stated

3.1.10

time-weighted average concentration

TWA concentration

concentration of gas in air averaged over a reference period

3.1.11

reference period

specified period of time for which the occupational exposure limit value of a chemical agent applies

Note 1 to entry: The reference period is usually 8 h for long-term measurements and 15 min for short-term measurements.

[SOURCE: ISO 18158:2016, 2.1.5.7, modified (term “biological agent” deleted as not relevant to the current document)]

3.2

types of equipment

3.2.1

alarm-only equipment

equipment with an alarm but not having an indication of measured value

3.2.2

aspirated equipment

equipment that samples the gas by drawing it to the gas sensor

Note 1 to entry: A hand operated or electric pump is often used to draw gas to the sensor.

3.2.3

automatically aspirated equipment

aspirated equipment with an integral pump or separate pump, which is connected directly to the equipment

3.2.4

continuous duty equipment

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

Note 1 to entry: Within this document, all equipment is regarded as continuous duty.

3.2.5

diffusion equipment

equipment in which the transfer of gas from the atmosphere to the sensor takes place without aspirated flow

3.2.6

fixed equipment

equipment fastened to a support, or otherwise secured in a specific location when energized

3.2.7

portable equipment

equipment intended to be carried by a person during its operation

Note 1 to entry: Portable equipment is battery powered and includes, but is not limited to

a) hand-held equipment, typically less than 1 kg, which requires use of only one hand to operate,

b) personal monitors, similar in size and mass to the hand-held equipment, that are continuously operating while they are attached to the user, and

c) larger equipment that can be operated by the user while it is carried either by hand, by a shoulder strap or carrying harness and which may or may not have a hand directed probe.

3.2.8

transportable equipment

equipment not intended to be carried by a person during operation, nor intended for fixed installation

3.2.9

gas detection transmitter

fixed gas detection equipment that provide a conditioned electronic signal or output indication to a generally accepted industry standard (such as 4-20 mA), intended to be utilized with separate gas detection 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 equipment

3.2.10

gas detection control unit

equipment intended to provide display indication, alarm functions, output contacts or alarm signal outputs or any combination when operated with remote sensor(s)

3.2.11

separate gas detection control unit

equipment intended to provide display indication, alarm functions, output contacts or alarm signal outputs or any combination when operated with gas detection transmitter(s)

3.2.12

equipment with integral sensor(s)

equipment that provides display indication, alarm functions, output contacts and/or alarm signal outputs using a sensor which is within or directly assembled to the equipment housing

3.2.13

accessory

component which can be fitted to the equipment for special purpose

EXAMPLE: External gas pump, sampling probe, hoses, collecting cone, weather protection device.

3.3

sensors

3.3.1

sensing element

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

3.3.2

sensor

assembly in which the sensing element is housed and that may also contain associated circuit components

3.3.3

integral sensor

sensor which is within or directly assembled to the equipment housing

3.3.4

remote sensor

sensor which is installed separately, but is connected to a gas detection control unit, gas detection transmitter, or to transportable or portable equipment

3.4

supply of gas to equipment

3.4.1

sample line

means by which the gas being sampled is conveyed to the sensor

Note 1 to entry: Accessories such as filter or water trap are often included in the sample line.

3.4.2

sampling probe

separate accessory sample line which is optionally attached to the equipment

Note 1 to entry: It is usually short (e.g. of the order of 1 m) and rigid, although it can be telescopic. In some cases, it is connected by a flexible tube to the equipment.

3.4.3

adjustment

procedure carried out to minimize the deviation of the measured value from the test gas concentration

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

3.4.4

calibration

procedure which establishes the relationship between a measured value and the concentration of a test gas

Note 1 to entry: If the deviation at calibration is too high, usually an adjustment will be carried out subsequently.

3.4.5

field calibration kit

means of presenting test gas to the equipment for the purpose of calibrating, adjusting or verifying the operation of the equipment

Note 1 to entry: The field calibration kit can be used for verifying the operation of the alarms if the concentration of the test gas is above the alarm set-point.

Note 2 to entry: A mask for calibration and test is an example of a field calibration kit.

3.4.6

mask for calibration and test

device that can be attached to the equipment to present a test gas to the sensor in a reproducible manner

3.5

signals and alarms

3.5.1

alarm set point

setting of the equipment at which the measured concentration will cause the equipment to initiate an indication, alarm or other output function

3.5.2

TWA alarm set point

setting of the equipment at which the measured time-weighted average concentration will cause the equipment to initiate an indication, alarm or other output function

3.5.3

indication

representation of the measured value on an output or display

Note 1 to entry: The indication may be affected by suppression of indication, filtering or averaging.

3.5.4

fault signal

audible, visible or other type of output, different from the alarm signal, permitting, directly or indirectly, a warning or indication that the equipment is not working satisfactorily

3.5.5

latching alarm

alarm that, once activated, requires deliberate action to be deactivated

3.5.6

measured value

calculated concentration of gas and/or vapour that results from processing sensor signal

Note 1 to entry: The measured value may be further processed before indication on output or display (e.g. time-weighted average, suppression of indication, etc.).

3.5.7

measuring principle

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

3.5.8

special state

any state of the equipment other than those in which monitoring of gas concentration and/or alarming is the intent

Note 1 to entry: Special state includes warm-up, calibration mode or fault condition.

3.5.9

indication range

range of measured values of gas concentration over which the equipment is capable of indicating

(see [Figure 1](#).

3.5.9DV DE Modification of Clause 3.5.9 as follows:

Replace “(see Figure 1.” with “SEE [Figure 1](#).”

3.5.10

lower limit of indication

smallest measured value within the indication range

SEE [Figure 1](#))

3.5.10DV DE Modification of Clause 3.5.10 as follows:

Replace “SEE Figure 1)” with “SEE [Figure 1](#).”

3.5.11

upper limit of indication

largest measured value within the indication range

SEE [Figure 1](#).

3.5.12

measuring range

range of measured values of gas concentration over which the accuracy of the equipment lies within specified limits

SEE [Figure 1](#).

3.5.13

lower limit of measurement

smallest measured value within the measuring range

SEE [Figure 1](#).

Note 1 to entry: The lower limit of measurement is always zero for type SM equipment.

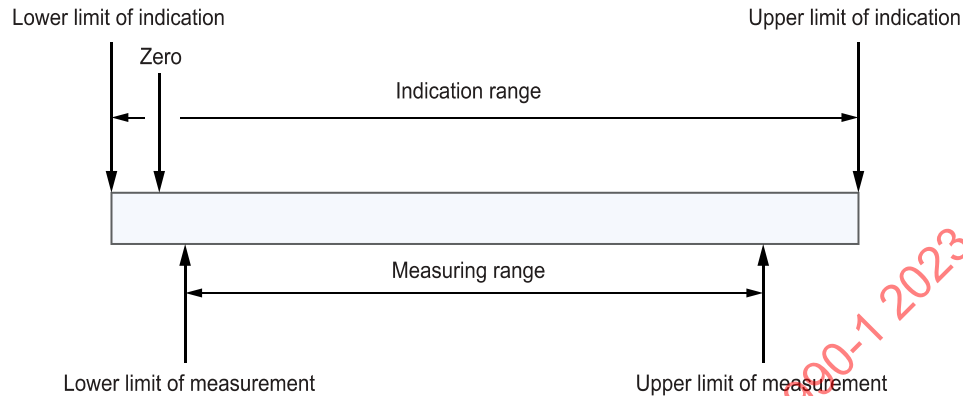
3.5.14

upper limit of measurement

largest measured value within the measuring range

SEE [Figure 1](#).

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



su4312

Figure 1

Relationship between indication range and measuring range

3.6 times

3.6.1 drift

variation in the equipment indication over time at any fixed gas volume fraction (including clean air) under constant ambient conditions

3.6.2

final indication

indication given by the equipment after stabilization

3.6.3

stabilization

state when three successive indications of an equipment at a constant gas volume fraction, taken at 2 minute intervals or twice the respective $t(90)$, whichever is less, indicates no changes greater than $\pm$ the lower limit of measurement for type HM equipment or $\pm 1\%$ of the upper limit of measurement for type SM equipment

3.6.4

time of response

$t(x)$

time interval, with the equipment in a warmed-up condition, between the time when an instantaneous change between clean air and the standard test gas is produced at the equipment inlet, and the time when the indication reaches a stated percentage (x) of the final indication

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

3.6.5

time of recovery $t(x)$

time interval, with the equipment in a warmed-up condition, between the time when an instantaneous change from standard test gas to clean air is produced at the equipment inlet and the time when the indication reaches a stated percentage (x) of the initial indication

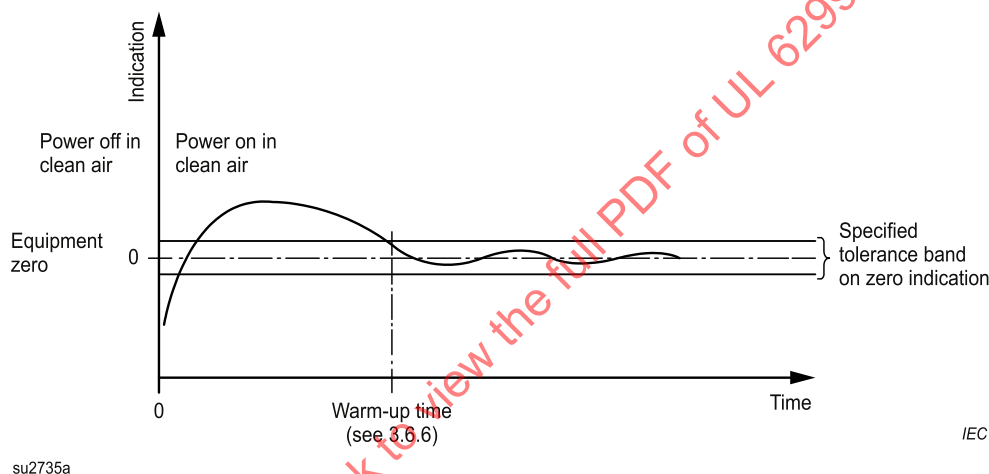
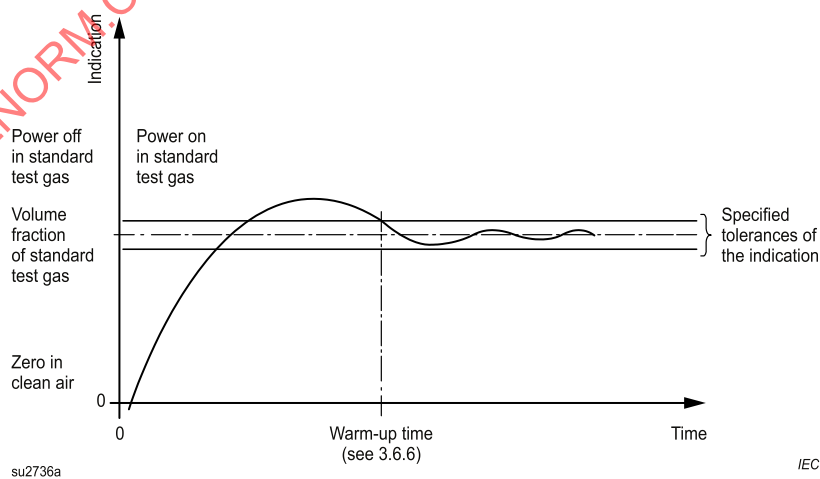
Note 1 to entry: For alarm-only equipment the stated indication can be represented by the de-activation of the alarm set at a stated value.

3.6.6

warm-up time

time interval, with the equipment in a stated atmosphere, between the time when the equipment is switched on and the time when the indication reaches and remains within the stated tolerances

Note 1 to entry: See equipment warm-up time in [Figure 2](#) and [Figure 3](#).

**Figure 2****Warm-up time in clean air (typical)****Figure 3****Warm-up time in standard test gas (typical)**

3.7

uncertainty

3.7.1

expanded uncertainty*U*

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

[SOURCE: ISO 18158:2016, 2.4.2.5]

3.7.2

measurand

particular quantity subject to measurement

[SOURCE: ISO 18158:2016, 2.3.8]

3.7.3

coverage factor*k*

numerical factor used as a multiplier of the combined standard uncertainty in order to obtain an expanded uncertainty

3.7.4

non-random uncertainty

uncertainty associated with non-random errors

3.7.5

random uncertainty

uncertainty associated with random errors

3.7.6

zero uncertainty

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

Note 1 to entry: In [Figure 4](#), the mean value of the measured values in clean air is not equal to zero to illustrate that there can be an offset due to drift. The mean value can be above or below zero.

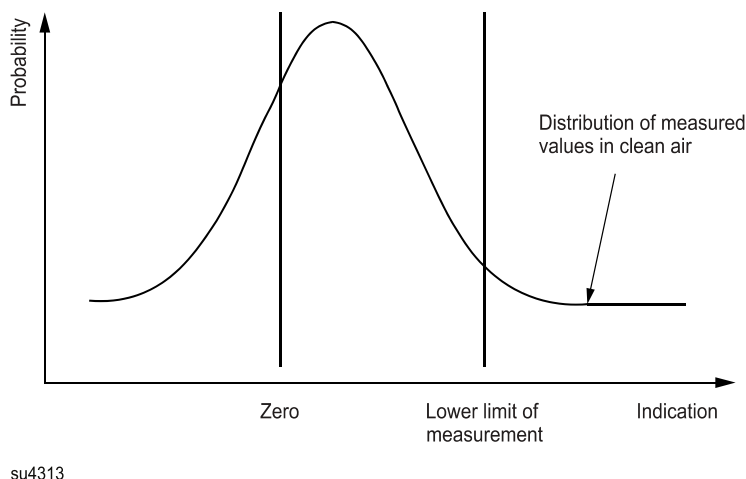


Figure 4
Example of zero uncertainty

3.8 miscellaneous

3.8.1 special tool

tool required to gain access to, or to adjust the equipment controls

Note 1 to entry: The design of the tool is intended to discourage unauthorised interference with the equipment.

4 General requirements

4.1 Overview

In addition to the requirements of this document, parts of the gas detection equipment intended for use in explosive atmospheres shall comply with the relevant construction and explosion protection requirements as specified in the IEC 60079 series of standards. The ambient temperature and pressure ranges of such equipment conforming to this document shall not exceed the ambient temperature and pressure ranges of the Type(s) of Protection.

4.2 Design

4.2.1 General

For Type HM equipment the upper limit of measurement shall be equal to or greater than 2 times the reference value. (See [Table A.1.](#)) The requirement for the lower limit of measurement is in [6.4.2.](#)

The equipment 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).

4.2.1DV.1 DE Modification of Clause 4.2.1, second paragraph as follows:

Replace “user” with “qualified personnel”.

Toxic gas detection equipment or parts thereof (e.g. remote sensors) shall be constructed of materials known to be resistant to degradation by the environment in which they are intended to be used. Equipment 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.

Materials and components used in the construction of the equipment which are relevant to performance of the equipment shall be used within the material and component manufacturer's ratings or limitations unless otherwise specified by appropriate safety standards. If such material and component ratings are not available, demonstrated functionality of the equipment may be used. All materials along the gas path shall not cause an inaccurate reading due to adsorption and absorption effects of materials in contact with the toxic gas.

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

Any failure of functions of the gas detection equipment not relevant to safety or health shall not adversely affect the functions of the equipment related to safety.

EXAMPLE: Equipment with 4 to 20 mA and Highway Addressable Remote Transducer (HART) Protocol communication where HART communication is defined in the instruction manual as not related to safety. The loss of HART communication is not related to safety.

4.2.2 Indicating devices

4.2.2.1 Indicators

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

Portable equipment shall provide visual and audible indicators for both fault and alarm states. The special state "warm-up" shall be indicated by a visual and/or audible signal. The special states "calibration mode" and "parameterization mode" shall be indicated by a visual signal.

Transportable or fixed equipment shall provide visual indicators for power, special states and alarm states. It is permitted for fixed equipment that the indications related to gas detection transmitters and remote sensors are shown only at the (separate) gas detection control unit.

If audible indicators are provided for transportable or fixed equipment, alarms are required as a minimum.

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

4.2.2.2 Display and other devices for indication of measured values

For equipment with a display to indicate gas concentrations, the gas type, concentration and unit of measurement shall be indicated. It is permissible to mark the gas and unit of measurement adjacent to the display.

Within the measuring range, the resolution of the display and all other devices for indication of the measured value shall be at least 2 % of the upper limit of measurement.

4.2.2.2DV.1 DE Modification of Clause 4.2.2.2, second paragraph as follows:

Replace "display" with "gas reading".

In addition, for Type HM equipment the resolution shall be 10 % of the reference value or better.

NOTE See also [5.2.2](#).

All methods of indication of the measured value shall present the same value within the resolution of each indicator.

Conditions above the upper limit of indication shall be clearly indicated.

4.2.2.3 Suppression of indication and measured values below zero

It shall be possible to configure the equipment such that in measuring mode any kind of suppression of indication is permanently disabled. In calibration mode any kind of suppression of indication shall be automatically disabled.

4.2.2.3DV.1 DE *Modification of Clause 4.2.2.3, first sentence of the first paragraph:*

Delete “permanently”

Measured values within the measuring range shall be indicated.

For HM equipment, measured values below the lower limit of measurement specified in [Table A.1](#) shall be indicated as one of the following:

- a) Zero;
- b) the measured value; or
- c) another indication that the measured value is below the lower limit of measurement.

4.2.2.3DV.2 DE *Replace paragraph 3 itemization with the following:*

“When suppression is enabled:

- a) Zero; or**
- b) other indication that the measured value is below the lower limit of measurement.**

When suppression is disabled:

- a) the measured value.”**

The following additional requirement applies: if the measured value is below minus twice the lower limit of measurement, the equipment shall indicate the negative measured value or shall provide a fault signal. The fault signal shall be indicated prior to measured values below minus four times the lower limit of measurement or –10 % of the upper limit of measurement, whichever is closer to zero.

4.2.2.3DV.3 DE Replace paragraph 4 and bulleted items with the following:

“The following additional requirement applies: if the measured value is below minus twice the lower limit of measurement, the equipment shall provide at least one of the following:

- indicate the negative measured value;
- provide another indication that the measured value is below this limit.
- provide a fault signal. The fault signal shall be indicated prior to measured values below minus four times the lower limit of measurement or -10% of the upper limit of measurement, whichever is closer to zero.”

For SM equipment, measured values below half of the reference value in [Table A.1](#) or below 5% of the upper limit of measurement, whichever is closer to zero shall be indicated as one of the following:

- a) zero;
- b) the measured value; or
- c) another indication that the measured value is below the limit specified above.

4.2.2.3DV.4 DE Replace paragraph 5 itemization with the following:

“When suppression is enabled:

- a) Zero; or
- b) other indication that the measured value is below the lower limit of measurement.

When suppression is disabled:

- a) the measured value.”

The following additional requirement applies: if the measured value is below minus half of the reference value in [Table A.1](#) or below -5% of the upper limit of measurement, whichever is closer to zero the equipment shall indicate the negative measured value or shall provide a fault signal. The fault signal shall be indicated for measured values below -10% of the upper limit of measurement.

4.2.2.3DV.5 DE Replace paragraph 6 with the following:

The following additional requirement applies: if the measured value is below minus half of the reference value in [Table A.1](#) or below -5% of the upper limit of measurement, whichever is closer to zero, the equipment shall provide at least one of the following:

- indicate the negative measured value;
- provide another indication that the measured value is below minus half of the reference value in [Table A.1](#) or -5% of the upper limit of measurement.

- **provide a fault signal. The fault signal shall be indicated for measured values below –10 % of the upper limit of measurement.**

NOTE This range of measurements is outside the range of [5.4](#); therefore, the indication might not be within the accuracy requirements of [5.4](#).

4.2.2.4 Indicator light

If only one indicator light is provided for signalling alarms, special states and other indications, it shall be coloured red. If separate indicator lights are used or if a multi-coloured indicator light is provided, the colours shall be used in the following order of priority ((a) being highest priority):

- a) alarms indicating the presence of a gas concentration beyond an alarm set point shall be coloured RED;
- b) equipment special state indicators shall be coloured YELLOW;
- c) power supply indicators shall be coloured GREEN.

If a multi-coloured indicator light is provided, the equipment shall provide an additional indication by means other than colour.

If there is more than one indicator light of the same colour with different functions, the lights shall be labelled to show their functions. Text, marks, and icons on a screen display describing the indicator lights are permissible in place of printed labels.

4.2.3 Alarm signal

4.2.3.1 Alarm settings

The audible and visual alarm settings for the equipment shall not be ambiguous. If the equipment has more than one indication range per given gas, the equipment shall not automatically change any existing alarm settings when changing the indication range.

4.2.3.2 Alarm output functions

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

Alarms shall be latching as a factory default setting and require a deliberate manual action to reset. If two or more alarm set points are provided, the lower may be non-latching. It is permitted that all alarms are configurable to be latching or non-latching.

NOTE The factory setting may deviate from the factory default setting upon user request.

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

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 equipment, 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 minutes.

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

4.2.3.2DV DE Modification of Clause 4.2.3.2, fourth paragraph to replace with the following:

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 equipment, the special state signal shall be capable of transmitting to remote equipment. The output signal or contacts are not required if the alarms are automatically re-enable within 15 minutes.

4.2.4 Fault signals

Externally powered equipment shall provide a fault signal in the event of failure of power to the equipment.

Externally powered equipment shall provide a fault signal when the supply voltage falls below the manufacturer's specified lower supply voltage fault limit.

A short-circuit or open-circuit in connections to any remote sensor or gas detection transmitter shall be indicated by a fault signal. It is permitted for the equipment to enter the "special state" calibration under the short-circuit or open-circuit condition if this calibration activation procedure is specified in the instruction manual. The equipment shall exit the "special state" calibration condition automatically within 15 minutes.

Under the above conditions the equipment may also indicate alarm.

Measured values below zero (e.g. caused by drift) shall be indicated by a fault signal in accordance with the conditions of [4.2.2.3](#).

Equipment where the sensor can be replaced without opening the housing shall provide a fault signal if the sensor is not re-connected within 15 minutes.

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

4.2.5 Adjustments

All adjustment functions shall be designed to discourage unauthorized or inadvertent interference with the equipment.

EXAMPLES: Procedural devices, in the case of a keyboard instrument, or mechanical devices such as a cover requiring the use of a special tool.

Fixed explosion-protected equipment housed in explosion-protected enclosures shall be designed so that, if any facilities for adjustment are necessary for routine recalibration and for resetting or like functions, these facilities shall be externally accessible and shall not degrade the explosion protection of the equipment.

The adjustments of the zero and sensitivity shall be designed so that:

a) adjustment of one will not affect the other;

or

b) it shall not be possible to adjust only one and the sequence of adjustments shall ensure that the affected one is adjusted second.

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, equipment shall continue to start-up without zero adjustment, after a delay of no more than 15 seconds.

4.2.6 Battery-powered equipment

Equipment powered with integral batteries shall be provided with an indication of low battery condition, and the purpose of this indication shall be explained in the instruction manual.

4.2.7 Gas detection transmitter for use with separate gas detection control units

A specification shall be supplied with the equipment that describes the relationship the gas concentration (detected by the equipment) has with the corresponding indication (transfer function). Such specification shall be detailed to the extent that the accuracy of this transfer function can be verified. As a minimum, the manufacturer shall provide data showing the relationship between the output signal and the gas concentrations corresponding to 0 %, 10 %, 30 %, 50 %, 70 %, 90 % and 100 % of upper limit of indication. The upper limit of indication and status signals (e.g. fault, calibration mode) shall also be specified by the manufacturer.

The manufacturer shall provide a means to interpret the indication, which will enable the accuracy of the transfer function to be verified.

4.2.8 Separate gas detection control units for use with gas detection transmitter(s)

A specification shall be supplied with the equipment 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 manufacturer shall provide data showing the relationship between the input signal and the gas concentrations corresponding to 0 %, 10 %, 30 %, 50 %, 70 %, 90 % and 100 % of upper limit of indication. Required inputs for upper limit of indication and status signals (e.g. fault, calibration mode) shall also be specified by the manufacturer.

The manufacturer shall provide the details of the input signals, which will enable the accuracy of the transfer function to be verified.

4.2.9 Software-controlled equipment

4.2.9.1 General

In the design of software-controlled equipment, the risks arising from faults in the program shall be taken into account by applying [4.2.9.2](#) to [4.2.9.7](#). In addition, where accessories are software-controlled, the risks arising from faults in the programme shall be taken into account where related to safety.

4.2.9.2 Conversion errors

The relationship between corresponding analogue and digital values shall be unambiguous. The output range shall be capable of coping with the full range of input values within the equipment specification. A clear indication shall result if the conversion range has been exceeded.

The design shall take into account the maximum possible analogue-to-digital, computational and digital-to-analogue converter errors. The combined effect of digitization errors shall not be greater than the smallest deviation of indication required by this document.

4.2.9.3 Special state indication

If a special state is entered by equipment this shall be indicated by a signal. For fixed equipment, this shall include a contact or other transmittable output signal.

4.2.9.4 Software

The manufacturer shall have suitable documented procedures for the development, verification, validation and change management (the life cycle) of the software.

Software shall conform to the following:

a) It shall be possible for the user to identify the installed version(s) of software by:

- 1) Indication on the display for at least three seconds during power up and on user command; or
- 2) For equipment without display function or other interrogation function, marking(s) on the equipment visible without disassembly of the equipment.

b) It shall not be possible for the user to modify the program code.

c) Parameter settings shall be checked for validity. Invalid inputs shall be rejected.

d) All user changeable parameters and their valid ranges shall be listed in the manual.

e) An access barrier shall be provided against parameter changing by unauthorized persons, e.g. it may be integrated by an authorization code in the software or may be realized by a mechanical lock.

4.2.9.4DV DE Modification of Clause 4.2.9.4 item (e) as follows:

Add “or by special tool” at the end of the sentence.

f) Parameter settings shall be preserved after removal of power, and while passing a special state.

4.2.9.5 Data transmission

Digital data transmission between spatially separated components of equipment shall be reliable. If transmission errors cause delays that are longer than one third of the time of response $t(90)$ or time to alarm for alarm-only equipment, the equipment shall enter a defined special state. The defined special state shall be documented in the instruction manual.

4.2.9.6 Self-test routines

Programmed equipment shall incorporate self-test methods. Upon failure detection, the equipment shall enter a defined special state. The defined special state shall be documented in the instruction manual.

The following minimum tests shall be performed by the equipment:

a) Power supply of digital units shall be monitored within time intervals of maximum ten times time of response $t(90)$ or time to alarm for alarm-only equipment.

b) All output functions relating to safety shall be testable. The test shall be carried out automatically during the start-up sequence operation, and on user request.

4.2.9.6DV DE Modification of Clause 4.2.9.6 item (b) as follows:

Replace “testable” with “verified”

c) Asynchronous monitoring circuitry (e.g. watchdog timers) shall work independently and separately from the parts of the digital unit, which perform the data processing. The period of the monitoring function shall not exceed 10 % of the maximum time of response $t(90)$ of the equipment in accordance with [Table A.1](#).

d) Program and parameter memory shall be monitored by procedures, which allow the detection of a single bit error.

e) Volatile memory used for functions relating to safety shall be monitored by procedures that test the readability and writeability of the memory cells.

All tests, except for test b), shall be done automatically and be repeated at least daily and after switching on.

4.2.9.7 Functional concept

The manufacturer shall prepare documentation describing:

- data flow (including all possible variations);
- all special states, how they can be identified, and how they are exited;
- user adjustable parameters and their permitted range of adjustment;
- representation of measuring values and indications;
- criteria for generation of alarms and signals;
- extent and realisation of manual and automatic self-test routines;
- extent and realisation of signalling to and from the equipment.

4.3 Labelling and marking

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

4.3DV.1 DE Modification of Clause 4.3 in accordance with the following:

Replace first sentence with the following: “Each equipment type as specified in [3.2](#) 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) “62990-1” followed by “SM” and/or “HM” (to represent conformity with this document);
- f) if applicable, the marking shall conform to the additional marking requirements of IEC 60079-0.

4.3DV.2 DE Modification of Clause 4.3 item (f) as follows:

Replace “IEC 60079- 0” with “UL 60079-0”

Portable and transportable equipment, equipment with integral sensors, gas detection transmitters and remote sensors shall be labelled with the gas(es) and range(s) to be detected or the gas(es) and range(s) shall be indicated on a display upon user request.

For portable equipment requiring the use of a protective case in normal operation, the required markings of a), b), e) and f) shall not be obscured or shall be reproduced on the protective case.

For small gas detection equipment, the marking of e) above may be placed within the instruction manual.

4.4 Instruction manual

4.4DV DR Modification of Clause 4.4 as follows:

Replace clause title “Instruction manual” with “Environmental ratings”

Each equipment shall be prepared with an instruction manual that includes the following information as relevant:

a) complete instructions, drawings and diagrams for safe and proper installation, commissioning, operation, maintenance and decommissioning of the equipment including any information for use of equipment as a Health Monitor (HM) and/or Safety Monitor (SM);

b) details for calibration and/or maintenance which shall include the following:

1) calibration/adjustment procedures including ranges of concentration of gas to be measured, type of balance gas (e.g. air or nitrogen) and humidity of the calibration gases and warning notes concerning the hazards associated with the calibration gases;

2) calibration gas application time;

3) instructions for the use of the field calibration kit including the flow rate where applicable and the maximum velocity of the ambient air;

4) recommendations and requirements for initial checking and calibration of the equipment on a routine basis including the calibration period. The maximum recommended period between two calibrations shall be no longer than 6 months;

NOTE Test methods and requirements of this document are designed for a maximum calibration period of 6 months (see [5.4.8](#)).

5) for portable equipment, the requirement and method for performing a functional check with gas before each day of use and an instruction for calibration and adjustment when a functional check has failed;

4.4DV.1 DR Modification of Clause 4.4 items (b)(4) and (b)(5) to replace with the following and delete the NOTE following item (b)(4):

4) recommendations and requirements for initial checking and calibration of the equipment on a routine basis including the calibration period.

5) for portable equipment, the requirement and method for performing a functional check with gas before use if the reliability of the detector is unknown and an instruction for calibration and adjustment when a functional check has failed;

6) recommendations for maintenance to be taken, and the effect on sensor properties such as sensitivity and time of response, after the measuring range has been exceeded;

7) procedure to check the time taken to reach stable indication when the calibration gas is applied;

8) a recommendation to users to read the procedures described in the recommended code(s) of practice for reference;

9) if applicable, instructions for the replacement of the sensor.

c) details of operational limitations, performance claimed by the manufacturer and special features including, where applicable, the following:

1) gases for which the equipment is suitable, and its specified indication and measuring range(s);

2) information that describes the sensitivities and variation of sensitivity to other gases to which the equipment is responsive;

NOTE Physical or chemical properties of the atmosphere being measured can alter the degree of sensitivity with interaction to other substances known to affect performance.

3) times of response $t(50)$ and $t(90)$ and times of recovery $t(50)$ and $t(10)$ in recommended operating modes (diffusion or aspiration), and the test method(s) (calibration mask, diffusion or flow) used to determine these claims;

4) information on how times of response and times of recovery vary with temperature, humidity, and ambient air velocity or flow rate of the aspirated gas;

4.4DV.2 DR Modification of Clause 4.4 item (c)(4) to delete.

Item (c)(4) does not apply.

5) temperature limits (performance and if applicable, explosion protection);

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

7) pressure limits (performance and if applicable, explosion protection) and, if appropriate, correction factors for pressure dependence;

8) air velocity limits for normal operation and for calibration;

- 9) supply voltage limits;
 - 10) maximum power consumption;
 - 11) relevant characteristics and construction details of required interconnecting cables;
 - 12) for battery operated equipment, battery type(s) and operating time(s) until low battery condition under normal operating conditions, and purpose of the signal of low battery condition;
 - 13) warm-up time;
 - 14) nominal orientation and orientation limits (for fixed and transportable equipment);
 - 15) electromagnetic compatibility (e.g. shielded cable, transient suppression, special enclosure);
 - 16) description of any suppression of indication(s) including default setting(s) and the method for its enablement/disablement;
 - 17) the averaging period for instruments measuring TWA concentration;
 - 18) measuring principle;
 - 19) equipment drift;
 - 20) information on use in potentially explosive atmospheres, if applicable;
 - 21) performance under operating conditions beyond the specification of this document, if applicable (see [5.1](#));
 - 22) the interface specification, cabling characteristics and maximum polling rate for each communication port;
 - 23) the largest and most complex system configuration.
- d) details of storage life and limitations for the equipment, replacement parts and accessories, including, where applicable, the following:
- 1) temperature;
 - 2) humidity;
 - 3) pressure;
 - 4) time.
- e) 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 equipment. 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;
- f) for aspirated equipment, indication of the minimum and maximum flow rates and pressure, tubing type, maximum length and size for proper operation;
- g) for aspirated equipment, instructions for ensuring that the sample lines are intact and that proper flow is established;
- h) specification and significance of each alarm (including over-range indication) and fault signal, the default setting of alarms, the duration and sound pressure level (and associated distance) of such alarms

and signals (if time-limited or non-latching), any provisions that may be made for silencing or resetting such alarms and signals, as applicable, and any special states;

i) specification of the functions not related to safety;

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

k) a statement that alarm devices, outputs or contacts are of the non-latching types, where applicable, and the requirement that the alarm with the highest set point shall be configured latching, if applicable (see [4.2.3.2](#));

l) for battery-operated equipment, installation and maintenance instructions for the batteries;

m) a recommended replacement parts list;

n) where optional accessories (e.g. collecting cones, weather-protecting devices, field calibration kit) are supplied, a list of such accessories and their effects on the instrument characteristics (including time of response, time of recovery and sensitivity), and means for their identification (e.g. part numbers). In addition, it shall be clearly described for each accessory whether it is included in the performance certificate;

o) details of performance certification, if any (e.g. issuing organisation, date, ranges, gases, accessories, etc.), and marking, and any special conditions of use;

p) if an ingress protection (IP) is claimed, such as IEC 60529, the following statement shall be included:

1) IP ratings do not imply that the equipment will detect gas during and after exposure to those conditions;

2) Recommendations for determining appropriate calibration interval and maintenance requirements if exposed to those conditions representative of the IP rating;

3) Recommended accessories to those conditions representative of the IP rating;

4.4DV.3 DR Modification of Clause 4.4 to replace item (p) and it's subitems (1) – (3) with the following:

p) if an ingress protection rating is claimed, the following statement (1) and recommendations (2 and 3) shall be included:

1) Environment ratings do not imply that the equipment will detect gas during and after exposure to those conditions;

2) Recommendations for determining appropriate calibration interval and maintenance requirements if exposed to those conditions representative of the rating;

3) Recommended accessories to those conditions representative of the rating;

q) if equipment with an internal sensor or a remote sensor is intended only for use in dry environments, the statement of “dry environment use only” shall be included;

r) for gas detection transmitter or separate gas detection control units (see [4.2.7](#) and [4.2.8](#)), specification of the transfer function, upper limit of indication and all status signals (e.g. fault, calibration mode);

s) for gas detection transmitter or separate gas detection control unit, information that the time of response / time of recovery of the entire system is determined by summing the times of response / times of recovery, respectively, of all parts of equipment within the gas detection system;

t) for gas detection control unit or separate gas detection control unit, the maximum delay time until special state is entered in case of transmission errors;

u) any necessary instructions or information, where the special nature of the equipment (such as non-linear responses) requires additional instructions or special information that are alternative to, or in addition to, the requirements of [4.3](#) and [4.4](#) a) to t).

5 Test methods

5.1 General

Equipment shall be tested for all the gases for which compliance with this document is claimed. The requirements of this document shall be met. When deviations from stated test condition values are necessary, the deviations and their justifications shall be documented in the test report and instruction manual.

Where a manufacturer makes any claims in the instruction manual regarding any special features of construction or extended performance that exceed the requirements of this document, all such claims shall be verified and the test procedures shall be carried out as stated in each clause and shall be extended or supplemented, where necessary, to verify the claimed special features of construction or extended performance. Any extended or supplemented tests shall be agreed between the manufacturer and test laboratory and described in the test report. When verifying a manufacturer's claimed performance or special feature the minimum requirements of this document shall be met and the manufacturer's claimed extended performance shall be verified.

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

5.2 General requirements for tests

5.2.1 Samples and sequence of tests

5.2.1.1 Test samples

The EMC test ([5.4.7.3](#)), the Fault signal tests ([5.4.9](#)), the Software controlled equipment tests ([5.4.10](#)), and the Protection against water test ([5.4.11](#)) may be performed on a separate equipment sample or a separate equipment sample for each test.

5.2.1.1DV.1 DE Modification of Clause 5.2.1.1, first paragraph to replace with the following:

The EMC test ([5.4.7.3](#)), the Fault signal tests ([5.4.9](#)), the Software controlled equipment tests ([5.4.10](#)), and the Environmental exposure test ([5.4.11](#)) may be performed on a single equipment sample or separate equipment samples for each test.

The remaining tests shall be performed on one sample of Type SM equipment as a minimum and three samples of the Type HM equipment.

An additional set of samples of the equipment may be used for the stability test of [5.4.8](#).

For gas detection control unit and separate gas detection control unit with at least three inputs for Type HM, the tests may be performed using one unit only.

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

5.2.1.2 Sequence

The unpowered storage test [5.4.2](#) shall be conducted prior to all remaining tests. The vibration test [5.4.4.1](#) shall be performed after unpowered storage testing for pre-conditioning purposes for those test samples which are used for the tests [5.4.3](#), [5.4.4.2](#), [5.4.5](#), [5.4.6](#) and [5.4.7](#) ([5.4.7.3](#) excluded, if a separate sample is used).

All remaining tests shall be performed to a schedule agreed upon between the manufacturer and the test laboratory. However, the test [5.4.3](#) shall be conducted prior to the tests of [5.4.5](#), [5.4.6.9](#) and [5.4.6.10](#).

If the design of equipment, which has been tested previously to this document, is modified then the test laboratory shall agree with the manufacturer which tests have to be repeated with the modified equipment. The decision and its justification shall be described in the test report.

In the case of modifications to the software or of electronic components which are part of the basic gas detection functionality (signal chain from sensor to output(s)) the following tests shall be repeated as a minimum: measurement of deviations, alarm set point(s), time-weighted (TWA) function, time of response.

5.2.1.3 Gas detection transmitter

For gas detection transmitter the following tests shall be performed: [5.4.2](#) to [5.4.4.1](#), [5.4.5](#), [5.4.6.2](#) to [5.4.6.6](#), [5.4.6.8](#) to [5.4.6.11](#), [5.4.7](#) to [5.4.11](#) (if applicable) using the parameters of the transfer function.

5.2.1.4 Separate gas detection control unit

For separate gas detection 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](#), [5.4.6.5](#), [5.4.6.6](#), [5.4.6.9](#), [5.4.7](#), [5.4.9](#) and [5.4.10](#) using the parameters of the transfer function(s).

5.2.2 Preparation of equipment before each test

The resolution of the indicating device used for the purpose of type testing shall be at least one order of magnitude better than 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. Suppression of indications of the equipment under test shall be disabled.

5.2.2DV.1 DE Modification of Clause 5.2.2, first paragraph to add “(e.g. deadband)” after “Suppression”.

NOTE The resolution of indicating devices which fulfil the requirements of [4.2.2.2](#) might 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 for the purpose of testing the compliance of the equipment with this document. The indication on the display and other output devices of the equipment shall not contradict the results obtained by the indicating or recording devices.

The equipment shall be prepared and mounted for typical use, in accordance with the instruction manual, including all necessary interconnections, initial adjustments and initial calibrations.

Adjustments may be made 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) Equipment 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 Type HM equipment having connection facilities for more than three remote sensors, only three remote sensors need to be subjected to the tests. For Type SM equipment having connection facilities for more than one remote sensors, only one remote sensor needs to be subjected to the tests. The replacement of the remaining sensors by "dummy" impedances 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 equipment 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 equipment manufacturer, except where minimum line resistance offers a more stringent test in the judgement of the test laboratory.

b) Separate gas detection control units.

The replacement of all transmitters by appropriate signal sources and worst-case loads for the test in question shall be permitted. The worst-case loads shall be determined by the test laboratory within the limits specified in the instruction manual. The chosen loads shall be documented in the test report.

c) Equipment having integral sensors.

The entire equipment 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 [5.4.3](#), [5.4.6.5](#), and [5.4.6.6](#) shall be performed without and with any sampling probe.

d) Alarm-only equipment.

Readings shall be taken using an external indicating or recording device connected to test points as specified in 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 unless otherwise specified. The exact configuration of the equipment, including use of or removal of optional accessories, shall be included in the test report.

5.2.3 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 equipment or the results obtained.

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

If a suitable calibration mask is provided with the equipment, 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 equipment is intended to be used.

If clean air cannot be used because of instability of the 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 $\pm 10\%$. The volume fractions of all test gases shall be known to a relative expanded uncertainty of $\pm 5\%$.

For the purpose of this document, where it is appropriate to use zero gas rather than clean air, references to clean air may be regarded as references to zero gas.

For Type HM equipment, the standard test gas shall have a volume fraction equal to the reference value specified in [Table A.1](#). For gases not included in [Table A.1](#), a value agreed between the manufacturer and the test laboratory considering the occupational exposure limit value shall be used and specified in the test report.

For Type SM equipment, the standard test gas shall have a volume fraction equal to 50 % of the upper limit of measurement.

5.3.3 Flow rate for test gases

When the equipment is exposed to the test gases, the flow rate of the gases shall be in accordance with the instruction manual.

5.3.4 Power supply

a) fixed AC or DC powered equipment shall be operated within $\pm 2\%$ of the manufacturer's recommended supply voltage and frequency.

b) battery-powered equipment shall, for short-term tests, be equipped with new or fully charged batteries at the commencement of each series of tests. 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 carried out with all batteries specified in the instruction manual.

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 gases shall be held at a temperature constant to ± 2 K within the range of 15 °C to 25 °C, throughout the duration of each test, unless otherwise specified for the particular test. This requirement is not applicable to tests [5.4.4.1](#) and [5.4.7.3](#); the temperature conditions shall not result in damage to the sensor.

5.3.6 Pressure

The tests shall be performed at the prevailing ambient pressure provided that it lies between 86 kPa and 108 kPa. If a deviation greater than ± 1 kPa occurs during a test, the pressure changes shall be recorded and taken into account, using the results of the pressure test [5.4.5.2](#).

5.3.7 Humidity

The relative humidity (RH) of the ambient air, clean air and test gases shall be within the range stated in the instruction manual throughout each test.

The relative humidity (RH) of the clean air and test gases shall be controlled to be within ± 10 % RH of initial condition throughout each test. The pressure test [5.4.5.2](#) shall be performed with clean air and test gases having the same volume fraction of water vapour.

The use of dry gases is permitted when the application and maximum duration are 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.

The requirements of this clause need not be fulfilled for tests [5.4.4.1](#) and [5.4.7.3](#); the humidity conditions shall not result in damage to the sensor.

5.3.8 Acclimation time

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

5.3.9 Orientation

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

5.3.10 Communications options

For equipment having communications options used during normal gas detection operation, tests in [5.4.3](#), [5.4.5.1](#), [5.4.6.5](#) and [5.4.6.6](#) shall be performed with all communication ports connected. The maximum transaction rate, communication channel characteristics and activity level specified in the instruction manual shall be employed.

5.3.11 Gas detection equipment as part of systems

For gas detection equipment, which are part of systems, tests in [5.4.3](#), [5.4.5.1](#), [5.4.6.5](#), [5.4.6.6](#), [5.4.6.8](#) and [5.4.6.9](#) shall be performed with the maximum system communications transaction rate and activity level.

5.4 Tests

5.4.1 General

Tests shall be carried out, where applicable, to ensure that the equipment satisfies the design requirements of Clause [4](#).

The equipment shall meet the performance requirements of Annex [A](#). To determine the performance requirements for gases not listed within [Table A.1](#), the general limit value guidelines of [Table A.1](#) along with agreement on performance requirements between the manufacturer and test laboratory shall be followed.

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 [3.6.3](#)), unless otherwise stated.

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

5.4.1DV.1 DE Modification of Clause 5.4.1, fifth paragraph to delete “not exceed 7,5 min and shall”.

For equipment having more than one selectable indication or measuring range for a gas, each associated measuring 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.

If different sensors are used for achieving different measuring ranges of the equipment, all tests of [5.4](#) shall be applied for each sensor.

For Type HM equipment, the most sensitive measuring range which is in accordance with [4.2.1](#) 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 [5.4.3.1](#), as a minimum. The least sensitive range shall also be tested in accordance with [5.4.6.9](#).

For Type SM equipment, the most sensitive measuring 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](#).

The acceptance criteria in the following sub-clauses except for [5.4.3](#) are the maximum permitted deviations of the indications of the equipment from the reference indications obtained at the start of the test or at reference conditions (e.g. at reference temperature 20 °C).

5.4.2 Unpowered storage

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

- a) a temperature of $(-20 \pm 3) ^\circ\text{C}$ for $(24 \pm 1/0) \text{ h}$;
- b) ambient temperature for at least 24 h;
- c) a temperature of $(40 \pm 2) ^\circ\text{C}$ for $(24 \pm 1/0) \text{ h}$;
- d) ambient temperature for at least 24 h;

The humidity requirement of [5.3.7](#) does not apply at the temperature of $-20 ^\circ\text{C}$. The humidity of the ambient air shall be such that condensation does not occur.

5.4.3 Measurement of deviations

5.4.3.1 Zero uncertainty, relative expanded uncertainty and calibration curve for Type HM

Each indication 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 equipment to test gases with the following volume fractions of the standard test gas: 0,1 (except if not practicable as stated below); 0,5; 1; 2; 5 (or 90 % of the upper limit of measurement if 5 times is outside the measuring range). For each test gas volume fraction, expose the equipment 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 instead of 0,1. The lowest test gas volume fraction shall not exceed 0,2 times the standard test gas volume fraction.

NOTE Concentrations greater than 5 times the reference value are not considered relevant to the calculation of relative expanded uncertainty of Type HM equipment.

Calculate the lower limit of measurement as specified in [6.3](#) using the indications in clean air taken in conjunction with the test gas volume fractions up to and including two times the standard test gas volume fraction. Calculate for each test gas volume fraction, the relative expanded uncertainty as specified in [6.2](#).

Acceptance criteria of the equipment is based upon [6.4](#).

5.4.3.2 Calibration curve for Type SM

Each indication shall be taken after a time interval equal to 10 times the time of response $t(50)$ for test gas application and equal to 5 times the time of recovery $t(10)$ for clean air application, as specified in the instruction manual.

Expose the equipment 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.

Acceptance Criteria: Each indication shall not differ from the volume fraction of the test gas by more than ± 20 % of the test gas volume fraction or ± 10 % of the upper limit of measurement, whichever is the greater.

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, as required by IEC 60068-2-6 and the following test procedures.

The temperature, pressure and humidity conditions shall not result in damage to the sensor; however, the requirements for ambient temperature [5.3.5](#), pressure [5.3.6](#) and humidity [5.3.7](#) need not be fulfilled.

5.4.4.1.2 Procedures

5.4.4.1.2.1 General

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

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

The alarm set point shall be set:

- for Type HM equipment, at 80 % of the standard test gas volume fraction;
- for Type SM equipment, at 10 % of the upper limit of measurement.

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

The equipment shall be energized and vibrated successively in each of three planes respectively parallel to each of the three major axes of the equipment. Before and after the test, measurements shall be taken in clean air and then with standard test gas. During vibration, the equipment shall be operated in ambient air. If necessary, clean air may be applied to the sensor in order to obtain a stable indication.

The equipment 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 equipment, remote sensors, gas detection transmitters and equipment 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/s² acceleration amplitude.

5.4.4.1.2.3 Procedure 2

For gas detection control units and separate gas detection 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/s² acceleration amplitude.

5.4.4.1.3 Acceptance criteria

During the vibration test, the equipment shall not suffer any loss of function nor give any false alarm or fault signal. The equipment shall not suffer damage resulting in hazard or loss of function.

Type HM equipment: The deviation of the indications in clean air shall be less than or equal to the lower limit of measurement in [Table A.1](#) or the value specified in the instruction manual, whichever is lower. The deviation of the indications in standard test gas shall be within ± 20 % of the indication.

Type SM equipment: The deviation of the indications in clean air shall be less than or equal to 10 % of the upper limit of measurement. The deviation of the indications in standard test gas shall be within ± 20 % of the indication.

5.4.4.2 Drop test

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

Portable equipment shall be released, while operating, from a height of $(1 \text{ }_0^{+0,05})$ m above a concrete surface and allowed to free fall.

Transportable equipment with a mass less than 5 kg shall be released, while not operating, from a height of $(0,3 \text{ }_0^{+0,03})$ m above a concrete surface and allowed to free fall.

Other transportable equipment shall be released, while not operating, from a height of $(0,1 \text{ }_0^{+0,02})$ m above a concrete surface and allowed to free fall.

All heights are measured from the lowest point of the equipment.

The test required above shall be performed three separate times, the portable equipment being released each time with a different side (surface) facing down at the time of release and the transportable equipment 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.

The equipment shall be considered to have failed this test if there is a loss of function (e.g. alarm, pump function, controls, display) after the test.

Automatic re-starting or shut-down of the equipment shall not occur during the test.

Acceptance criteria for Type HM equipment: The deviation of the indications in clean air shall be less than or equal to the lower limit of measurement in [Table A.1](#) or the value specified in the instruction manual,

whichever is lower. The deviation of the indications in standard test gas shall be within ± 20 % of the indication.

Acceptance criteria for Type SM equipment: The deviation of the indications in clean air shall be less than or equal to 10 % of the upper limit of measurement. The deviation of the indications in standard test gas shall be within ± 20 % of the indication.

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 equipment 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 equipment to acclimate at the new temperature, the sensor shall be exposed to the ambient or clean air inside the temperature chamber. The ambient air or clean air shall have a minimum humidity where necessary to avoid drying out the sensor.

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 gas detection control units and separate gas detection control units: at temperatures of 5 °C, 20 °C and 55 °C;
- for portable equipment: at temperatures of –20 °C, 5 °C, 20 °C and 40 °C;
- for portable equipment with restricted temperature range: at temperatures of 5 °C, 20 °C and 40 °C;
- for all other types of equipment: at temperatures of –20 °C, 5 °C, 20 °C and 55 °C;
- for all other types of equipment with restricted temperature range: at temperatures of 5 °C, 20 °C and 40 °C.

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.

For battery powered equipment, the test shall be carried out with all batteries specified in the instruction manual.

Acceptance Criteria for Type HM equipment: The deviation of the indications in clean air shall be less than or equal to the lower limit of measurement in [Table A.1](#) or the value specified in the instruction manual, whichever is lower. The deviation of the indications in standard test gas shall be within ± 20 % of the indication.

Acceptance Criteria for Type SM equipment: The deviation of the indications in clean air shall be less than or equal to 10 % of the upper limit of measurement. The deviation of the indications in standard test gas shall be within ± 20 % of the indication.

5.4.5.2 Pressure

The effects of pressure variation shall be observed by placing the equipment (including the aspirator for aspirated equipment) in a test chamber that permits the pressure of the test gases to be varied. The pressure shall be maintained at the specified levels within $\pm 0,5$ kPa 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 120 kPa pressure level may be omitted if the instruction manual specifies that the equipment is not intended for use for above 110 kPa pressure levels.

NOTE For below ground applications the pressure levels can exceed 110 kPa.

The pressure shall be changed with a rate less than 20 kPa/h or at a greater rate if agreed between the test laboratory and the manufacturer.

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

For Type HM equipment, calculate the differences between the measured values in standard test gas for each 10 kPa step, i.e. 80 to 90 kPa, 90 to 100 kPa, 100 to 110 kPa, 110 to 120 kPa (if tested) for the calculation of the uncertainty according to [6.2.2.4](#).

Acceptance Criteria for Type HM equipment: The deviation of the indications in clean air at all pressures from that at 100 kPa shall be less than or equal to the lower limit of measurement in [Table A.1](#) or the value specified in the instruction manual, whichever is lower. The deviation of the indications in standard test gas at all pressures from that at 100 kPa shall be within ± 35 % of the indication.

Acceptance Criteria for Type SM equipment: The deviation of the indications in clean air shall be less than or equal to 10 % of the upper limit of measurement. The deviation of the indications in standard test gas shall be within ± 35 % of the indication.

5.4.5.3 Humidity of test gas

The test shall be conducted at a temperature of (40 ± 2) °C. After an acclimation time of at least 2 h, the equipment shall be calibrated and adjusted as specified in the instruction manual.

The test shall then be performed at relative humidities of 20 %, 50 % and 90 %. At each relative humidity, the equipment or sensor shall be acclimated in clean air for (60 ± 5) minutes and then exposed to the standard test gas. The relative humidity levels shall be known to within ± 5 % (RH).

The volume fraction of the test gas shall be held constant, or due allowance of changes in its concentration by dilution in water shall be made.

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.

Acceptance Criteria for Type HM equipment: The deviation of the indications in clean air shall be less than or equal to the lower limit of measurement in [Table A.1](#) or the value specified in the instruction manual, whichever is lower. The deviation of the indications in standard test gas shall be within ± 20 % of the indication.

Acceptance Criteria for Type SM equipment: The deviation of the indications in clean air shall be less than or equal to 10 % of the upper limit of measurement. The deviation of the indications in standard test gas shall be within ± 20 % of the indication.

5.4.5.4 Air velocity

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

The equipment with integral sensor or the remote sensor shall be tested in a flow chamber in both ambient air and standard test gas.

Clean air shall be used instead of ambient air for low measuring ranges of toxic gases which are commonly present in ambient air.

For equipment with 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 sensor shall be operated in the orientation recommended by the manufacturer. If there is no such recommendation e.g. for portable equipment, 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 inlet;
- 2) flow directed 180° to item 1 above);
- 3) flow directed 90° to item 1 above).

Each orientation is given with a tolerance of $\pm 5^\circ$.

Measurements shall be made under non-forced ventilation conditions, at $(3 \pm 0,3)$ m/s and at $(6 \pm 0,6)$ m/s.

Directions of flow which are prohibited within the instruction manual shall not be tested.

Acceptance Criteria for Type HM equipment: The deviation of the indications in clean air shall be less than or equal to the lower limit of measurement in [Table A.1](#) or the value specified in the instruction manual, whichever is lower. The deviation of the indications in standard test gas shall be within ± 20 % of the indication.

Acceptance Criteria for Type SM equipment: The deviation of the indications in clean air shall be less than or equal to 10 % of the upper limit of measurement. The deviation of the indications in standard test gas shall be within ± 20 % of the indication.

5.4.6 Performance tests

5.4.6.1 Alarm set-point(s)

When equipment 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 in the following manner:

For equipment 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 equipment 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 equipment of type a) above with alarms which have been set to 80 % of the volume fraction of standard test gas, and for equipment of type b) above where the pre-set alarm set-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 equipment 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 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.

The alarm shall be activated by the test gas at each set-point within $t(90)$.

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 equipment 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 is pre-set by the manufacturer and cannot be changed, a test gas equivalent to five times the preset level 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.

Acceptance Criteria: The time to alarm or alarm reading shall not be greater than 20 s for temperatures at and above 5 °C and 30 s for temperatures below 5 °C.

5.4.6.3 Flow rate

This test shall only be performed for aspirated equipment.

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

To test the low flow fault signal decrease the flow rate of clean air until the low flow fault signal operates. The equipment 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 fault signal is set.

All other aspirated equipment 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.

Acceptance Criteria: The deviation of the indications in standard test gas shall be within ± 20 % of the indication. The low flow fault signal shall be activated for automatically aspirated equipment.

5.4.6.4 Warm-up time

An adjustable alarm set point shall be set to 20 % of the upper limit of measurement or the lowest available set point, whichever is higher.

Expose the equipment to clean air and standard test gas until stabilized and record the indication.

Wait until the indication of equipment is stabilised in ambient or clean air, then switch off the equipment and place in ambient air for a minimum period of 24 h. Then expose the equipment to clean air for a minimum of 1 h. Switch on the equipment and record the indication at the end of the warm-up time specified in the instruction manual. Immediately expose the equipment to standard test gas until stabilized and record the indication.

Acceptance Criteria for Type HM equipment: The deviation of the indications in clean air shall be less than or equal to the lower limit of measurement in [Table A.1](#) or the value specified in the instruction manual, whichever is lower. The deviation of the indications in standard test gas shall be within ± 20 % of the indication. There shall be no false indication or false alarm.

Acceptance Criteria for Type SM equipment: The deviation of the indications in clean air shall be less than or equal to 10 % of the upper limit of measurement. The deviation of the indications in standard test gas shall be within ± 20 % of the indication. There shall be no false indication or false alarm.

5.4.6.5 Time of response

Expose the equipment 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 % (RH).

Perform this test for diffusion equipment using a diffusion test method (e.g. see [B.2.2](#)), which allows the equipment to be exposed to the step change. If such a method cannot be used due to the properties of the test gas then a calibration mask method (e.g. see [B.2.1](#)) may be used.

EXAMPLE: Examples of such properties are absorption and stability.

5.4.6.5DV.1 DR Modification of Clause 5.4.6.5, second paragraph to add “at less than 0.3 m/s flow after “(e.g. [B.2.2](#))”.

For aspirated equipment, 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 (see Annex B).

Acceptance Criteria: The times of response $t(50)$ and $t(90)$ shall not exceed the requirements in Table A.1. For a gas which is not in the table, the time of response $t(90)$ shall not exceed 150 s; the time of response $t(50)$ shall not exceed 60 s.

For an optional sampling probe, an extra test is required to measure the additional delay. This shall be less than 3 s/m of the total length of the probe plus tubing or any greater value, which is stated in the instruction manual.

5.4.6.6 Time of recovery

Expose the equipment to standard test gas for (450 ± 10) s and then to a step change to ambient air. The relative humidity of 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 standard test gas and ambient air shall not be greater than 5 % (RH).

Perform this test for diffusion equipment by applying standard test gas using the mask then suddenly removing the mask and exposing the sensor to ambient air. The air velocity at the sensor inlet shall not exceed 0,5 m/s.

For aspirated equipment, the step change shall be applied 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.

Acceptance Criteria: The times of recovery $t(50)$ and $t(10)$ shall not exceed the requirements in Table A.1, for a gas which is not in the table, the time of recovery $t(10)$ shall not exceed 300 s; the time of recovery $t(50)$ shall not exceed 60 s.

For an optional sampling probe, an extra test is required to measure the additional delay. This shall be less than 3 s/m of the total length of the probe plus tubing or any greater value, which is stated in the instruction manual.

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

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

Acceptance Criteria for Type HM equipment: The deviation of the indications in clean air shall be less than or equal to the lower limit of measurement in Table A.1 or the value specified in the instruction manual, whichever is lower. The deviation of the indications in standard test gas shall be within ± 20 % of the indication.

Acceptance Criteria for Type SM equipment: The deviation of the indications in clean air shall be less than or equal to 10 % of the upper limit of measurement. The deviation of the indications in standard test gas shall be within ± 20 % of the indication.

5.4.6.8 Field calibration kit

Calibrate the equipment with clean air and standard test gas using the field calibration kit according to the instruction manual with no forced ambient ventilation and record the indication.

Apply clean air and standard test gas to the equipment as in normal operation with no forced ambient ventilation and record the indication.

Afterwards, apply standard test gas to the equipment using the field calibration kit and increase the ambient air speed to 6 m/s perpendicular to that part of the field calibration kit directly connected to the sensor and record the indication.

Acceptance Criteria for Type HM equipment: The deviation of the indications in clean air shall be less than or equal to the lower limit of measurement in [Table A.1](#) or the value specified in the instruction manual, whichever is lower. The deviations of the indications in standard test gas shall be within ± 10 % of the indication.

Acceptance Criteria for Type SM equipment: The deviation of the indications in clean air shall be less than or equal to 5 % of the upper limit of measurement. The deviations of the indications in standard test gas shall be within ± 10 % of the indication.

5.4.6.9 Gas concentrations above the upper limit of indication

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

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

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

Acceptance Criteria for Type HM equipment: The deviation of the indications in clean air shall be less than or equal to the lower limit of measurement in [Table A.1](#) or the value specified in the instruction manual, whichever is lower. The deviation of the indications in standard test gas shall be within ± 20 % of the indication. An over-range condition shall be clearly indicated and, where fitted, an alarm shall be activated.

5.4.6.9DV.1 DE Modification of Clause 5.4.6.9 in accordance with the following:

Add “or shall latch when over-range is reached thus requiring recovery and re-calibration” at the end of the second sentence of the fourth paragraph.

Acceptance Criteria for Type SM equipment: The deviation of the indications in clean air shall be less than or equal to 10 % of the upper limit of measurement. The deviation of the indications in standard test gas shall be within ± 20 % of the indication. An over-range condition shall be clearly indicated and, where fitted, an alarm shall be activated.

5.4.6.9DV.2 DE Modification of Clause 5.4.6.9 in accordance with the following:

Add “or shall remain in a latched state” at the end of the first sentence” and “or shall latch when over-range is reached thus requiring recovery and recalibration” at the end of the second sentence of the fifth paragraph.

5.4.6.10 Extended operation in test gas

5.4.6.10.1 Portable equipment

Measurements shall be taken in clean air.

Operate the equipment for 8 h per day in a test gas of a volume fraction in accordance with the reference value of [Table A.1](#) over 3 days or for equipment with a calibration period less than 3 days until the end of the calibration period. For the rest of each day, the equipment 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 equipment to ambient air for 60 min and then record the indication in clean air.

Acceptance Criteria for Type HM equipment: The deviation of the indications in clean air shall be less than or equal to the lower limit of measurement in [Table A.1](#) or the value specified in the instruction manual, whichever is lower. The deviation of the indications in standard test gas shall be within ± 20 % of the indication.

Acceptance Criteria for Type SM equipment: The deviation of the indications in clean air shall be less than or equal to 10 % of the upper limit of measurement. The deviation of the indications in standard test gas shall be within ± 20 % of the indication.

5.4.6.10.2 Fixed and transportable equipment

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

Operate the equipment continuously for 7 days in test gas or for equipment with a calibration period less than 7 days until the end of the calibration period. The test gas volume fraction shall be the reference value of [Table A.1](#).

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

Acceptance Criteria for Type HM equipment: The deviation of the indications in clean air shall be less than or equal to the lower limit of measurement in [Table A.1](#) or the value specified in the instruction manual, whichever is lower. The deviation of the indications in standard test gas shall be within ± 20 % of the indication.

Acceptance Criteria for Type SM equipment: The deviation of the indications in clean air shall be less than or equal to 10 % of the upper limit of measurement. The deviation of the indications in standard test gas shall be within ± 20 % of the indication.

5.4.6.11 Orientation tests

5.4.6.11.1 Portable equipment

Rotate the equipment while applying clean air and then standard test gas, through 360° in steps of 90° around each of its three mutually perpendicular axes. Record the stabilized indication in each position for application of both clean air and standard test gas.

Acceptance Criteria for Type HM equipment: The deviation of the indications in clean air shall be less than or equal to the lower limit of measurement in [Table A.1](#) or the value specified in the instruction manual, whichever is lower. The deviation of the indications in standard test gas shall be within $\pm 20\%$ of the indication.

Acceptance Criteria for Type SM equipment: The deviation of the indications in clean air shall be less than or equal to 10 % of the upper limit of measurement. The deviation of the indications in standard test gas shall be within $\pm 20\%$ of the indication.

5.4.6.11.2 Fixed and transportable equipment

Test the equipment with integral sensor or remote sensor with clean air and standard test gas at the nominal orientation and at the orientation limits stated in the instruction manual or $\pm 15^\circ$ from the nominal orientation, whichever is greater. Perform the test for each of two mutually perpendicular axes excluding the vertical axis.

Acceptance Criteria for Type HM equipment: The deviation of the indications in clean air shall be less than or equal to the lower limit of measurement in [Table A.1](#) or the value specified in the instruction manual, whichever is lower. The deviation of the indications in standard test gas shall be within $\pm 20\%$ of the indication.

Acceptance Criteria for Type SM equipment: The deviation of the indications in clean air shall be less than or equal to 10 % of the upper limit of measurement. The deviation of the indications in standard test gas shall be within $\pm 20\%$ of the indication.

5.4.7 Electrical tests

5.4.7.1 Battery capacity for battery-powered equipment

This test shall be carried out with all batteries specified in the instruction manual.

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

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

The equipment 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. Where it is impractical to discharge the equipment continuously, the equipment may be switched off (e.g. overnight) to ensure the low battery condition is observed in the required time.

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

Acceptance Criteria for Type HM equipment: The deviation of the indications in clean air shall be less than or equal to the lower limit of measurement in [Table A.1](#) or the value specified in the instruction manual, whichever is lower. The deviation of the indications in standard test gas shall be within $\pm 20\%$ of the indication. The low battery indication shall be activated.

Acceptance Criteria for Type SM equipment: The deviation of the indications in clean air shall be less than or equal to 10 % of the upper limit of measurement. The deviation of the indications in standard test gas shall be within ± 20 % of the indication. The low battery indication shall be activated.

5.4.7.2 Power supply variations (excludes battery-powered equipment)

The equipment shall be set up at nominal supply voltage and, for AC powered equipment, rated frequency. For equipment 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 shall be set as near as possible to that concentration.

The equipment shall be exposed to clean air and standard test gas and the reading recorded at 115 %, 100 % and 80 % of nominal supply voltage and at +2 % above the lower supply voltage fault limit. Where the instruction manual specifies another supply range, the equipment shall be tested at the upper and lower limits of that range.

It shall be verified at +2 % above the lower supply voltage fault limit that all output functions are working properly even at the worst case load conditions.

The analogue outputs shall be tested at the maximum output level. Relays shall be able to energize at +2 % above the lower supply voltage fault limit.

Acceptance Criteria for Type HM equipment: The deviation of the indications in clean air shall be less than or equal to the lower limit of measurement in [Table A.1](#) or the value specified in the instruction manual, whichever is lower. The deviation of the indications in standard test gas shall be within ± 20 % of the indication. No false alarm shall be activated. All output functions shall operate correctly.

Acceptance Criteria for Type SM equipment: The deviation of the indications in clean air shall be less than or equal to 10 % of the upper limit of measurement. The deviation of the indications in standard test gas shall be within ± 20 % of the indication. No false alarm shall be activated. All output functions shall operate correctly.

5.4.7.3 Electromagnetic compatibility

5.4.7.3.1 Test

The equipment, including the sensor and interconnecting wiring, shall be subjected to the tests described in IEC 61326-1:2012, Table 2. The emission tests of IEC 61000-6-3 or of IEC 61000-6-4, as applicable, shall be performed.

The temperature, pressure and humidity conditions shall not result in damage to the sensor; however, the requirements for ambient temperature [5.3.5](#), pressure [5.3.6](#) and humidity [5.3.7](#) need not to be fulfilled.

The tests shall be carried out in ambient air. Equipment with alarms shall be tested in a latched alarm condition and also in a non-alarm condition. The alarm set point shall be set to 20 % of the indication in standard test gas.

For multi-gas portable equipment, this test shall be performed with a full set of typical sensors.

Any special advice in the instruction manual concerning EMC shall be followed.

5.4.7.3.2 Performance criteria

The following performance criteria shall apply to the equipment:

Performance criterion A:

The equipment shall continue to operate as intended both during and after the test. No loss of function is allowed. No spurious alarms or deactivation of alarms is allowed. The deviation of the indications shall be within $\pm 20\%$ of the indication in standard test gas.

Performance criterion B:

During the test

- degradation of performance is allowed but the deviation of the indications shall be within $\pm 40\%$ of the indication in standard test gas, or
- the equipment shall show a specified fault indication and/or output.

After the test any degradation in performance shall be self-recoverable and the equipment shall continue to operate as intended. No permanent change of actual operating state or stored data or continuous deactivation of alarm is allowed.

If the equipment includes latching alarms or status signals it is permitted that these may be triggered during the test. After the test signal has been removed, the latching circuits shall be reset and the correct operation of the alarm circuit verified by applying test gas or simulation of signal depending on the type of equipment.

If performance criterion B is required in IEC 61326-1:2012, the requirements can be presumed to be fulfilled if the equipment complies with performance criterion A.

Performance criterion C:

Temporary loss of function is allowed during the test, provided the loss of function is self-recoverable or can be easily restored by the operation of the controls. The equipment shall operate as intended after the test. No change of stored data is allowed.

If performance criterion C is required in IEC 61326-1:2012, the requirements can be presumed to be fulfilled if the equipment complies with performance criterion A or B.

Acceptance Criteria for Types HM and SM equipment: The requirements of IEC 61326-1:2012, Table 2 shall be fulfilled. The emission requirements of IEC 61000-6-3 or of IEC 61000-6-4, as applicable, shall be fulfilled.

5.4.7.3.3 DC Input Power Ports

IEC 61326-1 does not contain requirements for DC power ports related to voltage dips and short interruptions. Tests shall be carried out following IEC 61000-4-29 with the following severity.

These tests are not applicable to DC connections between components of equipment which are not directly connected to the DC power network.

Acceptance Criteria for Types HM and SM equipment: Performance criterion C in IEC 61326-1 shall be fulfilled for voltage dips with 0 % residual voltage for a duration of 1 000 ms.

Acceptance Criteria for Types HM and SM equipment: Performance criterion C in IEC 61326-1 shall be fulfilled for short interruptions with 0 % residual voltage for a duration of 20 ms.

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 equipment that has a TWA function.

5.4.7.4.2 TWA calculation

Apply the following regime over the TWA measuring period using test gases of the stated volume fractions for both Type HM and Type SM equipment:

- the reference value according to [Table A.1](#) for 25 % of the period;
- 50 % of the reference value according to [Table A.1](#) 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.

Acceptance Criteria: The mean percentage shall be between 45 % and 55 % of the reference value.

5.4.7.4.3 TWA alarm

The equipment 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.

Acceptance Criteria: The TWA alarm shall activate when (50 ± 5) % of the TWA period has elapsed.

5.4.8 Stability

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

The equipment 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.

5.4.8DV.1 D1 Modification of Clause 5.4.8 second paragraph to replace with the following:

The equipment 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 manufacturer recommended calibration period and the last at the end of the manufacturer recommended calibration period. 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.

5.4.8DV.2 D1 Modification of Clause 5.4.8 to add the following after the third paragraph:

Additionally subject the sensor to a continuous toxic gas concentration equivalent to 3 % $\pm$ 1 % of the current NIOSH IDLH value for a period of 7 days or the manufacturer's claimed duration, whichever is lower. For equipment that provides a fault signal upon sensing element failure, the duration may be reduced to the manufacturer's claimed duration.

At termination of the exposure, immediately apply clean air for a period of 5 min $\pm$ 30 sec, or as defined by the manufacturer, whichever is less, and record the reading. Immediately following the clean air exposure, apply the standard test gas for 5 min $\pm$ 30 sec and record the reading.

Acceptance Criteria for Type HM equipment: The deviation of the indications in clean air shall be less than or equal to the lower limit of measurement in [Table A.1](#) or the value specified in the instruction manual, whichever is lower. The deviation of the indications in standard test gas shall be within ± 20 % of the indication.

Acceptance Criteria for Type SM equipment: The deviation of the indications in clean air shall be less than or equal to 10 % of the upper limit of measurement. The deviation of the indications in standard test gas shall be within ± 20 % of the indication.

5.4.9 Fault signal tests

5.4.9.1 General

Fault signals shall be verified against the requirements of [4.2.4](#).

5.4.9.2 Low voltage and power interruption

These tests shall be performed in ambient air. Externally powered equipment shall be powered at the nominal voltage, calibrated and allowed to stabilize, then exposed to the following conditions:

- 1) The voltage shall be decreased to 2 % lower than the specified lower supply voltage fault limit and the fault as specified in the instruction manual shall be indicated.
- 2) The nominal voltage shall be restored, and faults shall automatically clear or shall be manually reset if necessary.
- 3) The power shall be removed to test complete power loss and the fault as specified in the instruction manual shall be indicated.

NOTE The equipment may also indicate alarm(s).

5.4.9.3 Field wiring faults

These tests shall be performed in ambient air. For short-circuit requirements in [4.2.4](#), each wire connecting the equipment to any remote sensor or gas detection transmitter shall be substituted with a load resistor. The values of these resistors shall be equivalent to the maximum wire resistance for the cable specified in the instruction manual (see [4.4 c\)](#)). The device used for the short circuit shall be of negligible resistance and shall be applied at the remote sensor or gas detection transmitter ends of the load resistors.

A fault signal shall be indicated under all conditions shown below.

1) Each wire to the remote sensor or gas detection transmitter shall be opened one at a time. All faults and alarms shall be cleared and the equipment returned to normal operation prior to opening the subsequent wire.

2) All combinations of two wires to the remote sensor or gas detection transmitter shall be shorted one at a time. All faults and alarms shall be cleared and the equipment returned to normal operation prior to shorting the subsequent combination of wire.

NOTE The equipment may also indicate an alarm(s).

5.4.9.4 Digital communication fault

The test shall be performed in ambient air. Disruption or corruption of the communication shall be induced between the remote sensor and control unit, and a fault signal shall be indicated at the control unit in accordance with [4.2.9.5](#). The procedure of the test shall be agreed upon between the test laboratory and the manufacturer.

5.4.9.5 Measured values below zero

5.4.9.5.1 General

The test shall be performed either by using test gas (Procedure 1) or by replacing the sensor with a simulator (Procedure 2) as agreed between the manufacturer and test laboratory.

5.4.9.5.2 Procedure 1

The equipment shall be adjusted according to the instruction manual. Then the following test shall be carried out:

A zero adjustment shall be performed at application of a test gas. The volume fraction of the test gas shall be 1,2 times the absolute value of the fault signal level specified in the instruction manual. Then the volume fraction of the test gas shall be lowered. The fault signal shall be activated at the latest when the volume fraction is zero. Between the volume fraction of the test gas used for zero adjustment and the release of the fault signal, the indication shall be in accordance with [4.2.2.3](#) for type HM equipment or type SM equipment, respectively.

NOTE The indication includes tolerance. Therefore, it should be considered that the zero indication, concentration indication, and fault indication may not changeover at the exact test gas concentration specified as threshold.

5.4.9.5.3 Procedure 2

The equipment shall be adjusted with the simulator and the following test carried out:

For type HM equipment:

Starting at the lower limit of measurement, the simulated signal shall be lowered. The fault signal shall be activated at the fault signal level specified in the instruction manual. At simulator signals between the lower limit of measurement and this fault level, the indication shall be in accordance with [4.2.2.3](#) for type HM equipment.

For type SM equipment:

Starting at 5 % of the upper limit of measurement, the simulated signal shall be lowered. The fault signal shall be activated at the fault signal level specified in the instruction manual. At simulator signals between the signal at start and this fault level, the indication shall be in accordance with [4.2.2.3](#) for type SM equipment.

5.4.9.6 Sensor disconnection

The test shall be performed in ambient air. Equipment where the sensor can be replaced without opening the housing shall be calibrated and allowed to stabilize. The sensor shall be removed. A fault signal shall be indicated within 15 minutes.

5.4.9.7 Automatically Aspirated Equipment

See [5.4.6.3](#).

5.4.10 Software controlled equipment

Software controlled equipment shall be verified against the requirements of [4.2.9](#). Compliance shall be demonstrated by a clause-by-clause report to [4.2.9](#) provided by the manufacturer. The equipment shall be operated during the verification test in such a manner that, starting from the measuring state, the following operation states shall be performed if applicable:

- a) special states if they can be entered without destruction of the hardware or modification of the software;
- b) activation of every message on a display if they can be activated without destruction of the hardware or modification of the software;
- c) test routines if they can be tested without destruction of the hardware or modification of the software; and
- d) change of parameters.

5.4.11 Protection against water

5.4.11DV DR Modification of Clause 5.4.11 to replace title “Protection against water” with “Environmental exposure” and add new subclause as follows:

5.4.11DV.1 General

This clause is applicable to equipment or part of the equipment containing one or more gas sensors. This clause is not applicable for sensors intended for use only in dry environments.

5.4.11DV.1 DR Modification of Clause 5.4.11 first paragraph to revise as follows:

Add “or non-dust contaminant” before “environments” in last sentence.

The alarm set point shall be set:

- for Type HM equipment, at 80 % of the standard test gas volume fraction;

– for Type SM equipment, at 10 % of the upper limit of measurement.

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

For fixed and transportable equipment, the equipment shall be positioned in the worst case orientation in accordance with the instruction manual. For portable equipment, the equipment shall be positioned in the typical orientation of use.

The standard test gas shall be applied. For diffusion equipment, a delivery system shall be used that will simulate the natural aspiration of the sensing element. The final indication and the time to 90 % of the final indication shall be recorded. The calibration mask may be used as the delivery system if the direction of gas flow enters through any weather protection and/or membrane prior to exposure to the sensing element. Alarms shall be reset prior to water exposure.

5.4.11DV.2 DR Modification of Clause 5.4.11 fifth paragraph to revise as follows and add NOTE:

Replace “water” with “environmental” in last sentence.

NOTE: This is not a requirement for ingress protection, but one to assure the performance of the gas detector when subjected to the environmental conditions that apply to an ingress rating.

5.4.11ADV.1 DR Modification of Clause 5.4.11 to add subclause 5.4.11ADV.2 as follows:

5.4.11ADV.2 Dust

The equipment in normal operation shall be exposed to the dust test of the environmental rating as marked.

For equipment marked to indicate an environmental rating for protection against the ingress of dust, this test shall be performed within a dust chamber defined by IEC 60529. The equipment shall be mounted in accordance with the manufacturer's instructions, set to the lowest alarm level or 10 % of the measuring range, whichever is greater, and then calibrated in accordance with [5.3.2](#), and the time to 90 % of the standard test gas application shall be recorded. No preconditioning of the equipment per [5.4.2](#) is required. The equipment shall be exposed to the circulating dust cloud within the chamber for a period of 2 hours, -0/+5 minutes, with no vacuum applied to the sensor.

The equipment shall not give any false alarms during the 2 hour test. Upon completion of the 2 hour test, any trouble or fault conditions indicated may be cleared in accordance with the manufacturer's instructions and the equipment shall be allowed to undergo any stated maintenance conditions in accordance with the manufacturer's recommendations related to environmental exposure. The equipment shall be exposed to the standard test gas in accordance with [5.3.2](#), and the final value and time to 90 % of the standard test gas application shall be recorded.

The equipment in normal operation shall be exposed to the IPX3 water test method of IEC 60529.