INTERNATIONAL STANDARD

IEC 61779-1

First edition
1998-04

Electrical apparatus for the detection and measurement of flammable gases –

Part 1: General requirements and test methods

Appareils électriques de détection et de mesure des gaz combustibles –

Partie 1:
Règles générales et méthodes d'essai

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Terminology, graphical and letter symbols

For general terminology, readers are referred to IEC 60050: *International Electrotechnical Vocabulary* (IEV).

For graphical symbols, and letter symbols and signs approved by the IEC for general use, readers are referred to publications IEC 60027: *Letter symbols to be used in electrical technology*, IEC 60417: *Graphical symbols for use on equipment. Index, survey and compilation of the single sheets* and IEC 60617: *Graphical symbols for diagrams.*

* See web site address on title page.

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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ELECTRICAL APPARATUS FOR THE DETECTION AND MEASUREMENT OF FLAMMABLE GASES –

Part 1: General requirements and test methods

FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the 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, the IEC publishes International Standards. 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. The 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 the 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 National Committees.
3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical reports or guides and they are accepted by the National Committees in that sense.
4) In order to promote international unification, IEC National Committees undertake to apply IEC International Standards transparently to the maximum extent possible in their national and regional standards. Any divergence between the IEC Standard and the corresponding national or regional standard shall be clearly indicated in the latter.
5) The IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with one of its standards.
6) Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. The IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 61779-1 has been prepared by subcommittee 31L: Electrical apparatus for the detection of flammable gases, of IEC technical committee 31: Electrical apparatus for explosive atmospheres.

The text of this standard is based on the following documents:

FDIS	Report on voting
31L/47/FDIS	31L/52/RVD

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

Annex A forms an integral part of this standard.

Annexes B and C are for information only.

A bilingual version of this standard may be issued at a later date.

INTRODUCTION

Guidance for the selection, installation, use and maintenance of gas detecting apparatus are set out in IEC 61779-6: Electrical apparatus for the detection and measurement of flammable gases – Part 6: Guidelines for the selection, installation, use and maintenance[1)].

1) To be published.

ELECTRICAL APPARATUS FOR THE DETECTION AND MEASUREMENT OF FLAMMABLE GASES –

Part 1: General requirements and test methods

1 General

1.1 Scope

1.1.1 This part of IEC 61779 specifies general requirements for construction and testing and describes the test methods that apply to portable, transportable and fixed apparatus for the detection and measurement of flammable gas or vapour concentrations with air. The apparatus, or parts thereof, are intended for use in potentially explosive atmospheres (see 2.1.8) and in mines susceptible to firedamp. This standard is supplemented by the following standards, concerning the specific requirements for the performance of the various types of apparatus:

IEC 61779-2: *Performance requirements for group I apparatus indicating up to a volume fraction of 5 % methane in air*

IEC 61779-3: *Performance requirements for group I apparatus indicating up to a volume fraction of 100 % methane in air*

IEC 61779-4: *Performance requirements for group II apparatus indicating up to a volume fraction of 100 % lower explosive limit*

IEC 61779-5: *Performance requirements for group II apparatus indicating up to a volume fraction of 100 % gas*

NOTE 1 – IEC 61779-1, in association with the standards referred to above, is intended to provide for the supply of apparatus giving a level of safety and performance suitable for general purpose applications. However, for specific applications, a prospective purchaser (or an appropriate authority) may additionally require the apparatus to be submitted to particular tests or approval. For example, group I apparatus (i.e. apparatus to be used in mines susceptible to firedamp) may not be permitted to be used without the additional, prior approval of the relevant authority in mines under its jurisdiction. Such particular tests/approval are to be regarded as additional to and separate from the provisions of the standards referred to above and do not preclude certification to or compliance with these standards.

NOTE 2 – Group I and group II apparatus indicating up to a volume fraction of 100 % methane and group II apparatus indicating up to a volume fraction of 100 % gas are suitable for use only with the specific gases for which they have been calibrated.

NOTE 3 – For the purpose of this standard, the terms "lower flammable limit (LFL)" and "lower explosive limit (LEL)" are deemed to be synonymous, and likewise the terms "upper flammable limit (UFL)" and "upper explosive limit (UEL)" are deemed to be synonymous. For ease of reference, the two abbreviations LFL and UFL may be used hereinafter to denote these two sets of terms. It should be recognized that particular authorities having jurisdiction may have overriding requirements that dictate the use of one of these sets of terms and not the other.

1.1.2 This standard is applicable when an apparatus manufacturer makes any claims regarding any special features of construction or superior performance that exceed these minimum requirements. All such claims shall be verified and the test procedures shall be extended or supplemented, where necessary, to verify the claimed performance. The additional tests shall be agreed between the manufacturer and test laboratory.

1.1.3 This standard is applicable to flammable gas detection apparatus intended to provide an indication, alarm or other output function, the purpose of which is to give a warning of a potential explosion hazard and, in some cases, to initiate automatic or manual protective action(s).

1.1.4 This standard is applicable to apparatus, including the integral sampling systems of aspirated apparatus, intended to be used for commercial and industrial safety applications.

1.1.5 This standard does not apply to external sampling systems, or to apparatus of laboratory or scientific type, or to apparatus used only for process control purposes.

1.2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 61779. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this part of IEC 61779 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60050(351):1975, *International Electrotechnical Vocabulary (IEV) – Chapter 351: Automatic control*

IEC 60079-0:1983, *Electrical apparatus for explosive gas atmospheres – Part 0: General requirements*

IEC 60079-1:1990, *Electrical apparatus for explosive gas atmospheres – Part 1: Construction and verification test of flameproof enclosures of electrical apparatus*

IEC 60079-2:1983, *Electrical apparatus for explosive gas atmospheres – Part 2: Electrical apparatus – type of protection "p"*

IEC 60079-5:1967, *Electrical apparatus for explosive gas atmospheres – Part 5: Sand-filled apparatus*

IEC 60079-6:1995, *Electrical apparatus for explosive gas atmospheres – Part 6: Oil immersion "o"*

IEC 60079-7:1990, *Electrical apparatus for explosive gas atmospheres – Part 7: Increased safety "e"*

IEC 60079-10:1986, *Electrical apparatus for explosive gas atmospheres – Part 10: Classification of hazardous areas*

IEC 60079-11:1991, *Electrical apparatus for explosive gas atmospheres – Part 11: Intrinsic safety "i"*

IEC 60079-13:1982, *Electrical apparatus for explosive gas atmospheres – Part 13: Construction and use of rooms or buildings protected by pressurization*

IEC 60079-14:1984, *Electrical apparatus for explosive gas atmospheres – Part 14: Electrical installations in explosive gas atmospheres (other than mines)*

IEC 60079-15:1987, *Electrical apparatus for explosive gas atmospheres – Part 15: Electrical apparatus, with type of protection "n"*

IEC 60079-18:1992, *Electrical apparatus for explosive gas atmospheres – Part 18: Encapsulation "m"*

IEC 60079-19:1993, *Electrical apparatus for explosive gas atmospheres – Part 19: Repair and overhaul for apparatus used in explosive atmospheres (other than mines or explosives)*

IEC 60079-20:1996, *Electrical apparatus for explosive gas atmospheres – Part 20: Data for flammable gases and vapours, relating to the use of electrical apparatus*

IEC 61000-4-1:1992, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 1: Overview of immunity tests – Basic EMC publication*

IEC 61000-4-3:1995, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 3: Radiated, radio-frequency, electromagnetic field immunity test*

IEC 61000-4-4:1995, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 4: Electrical fast transient/burst immunity test – Basic EMC publication*

ISO 2738:1987, *Permeable sintered metal materials – Determination of density, oil content, and open porosity*

ISO 4003:1977, *Permeable sintered metal materials – Determination of bubble test pore size*

ISO 4022:1987, *Permeable sintered metal materials – Determination of fluid permeability*

ISO 6142:1981, *Gas analysis – Preparation of calibration gas mixtures – Weighing methods*

ISO 6145-1:1986, *Gas analysis – Preparation of calibration gas mixtures – Dynamic volumetric methods – Part 1: Methods of calibration*

ISO 6145-3:1986, *Gas analysis – Preparation of calibration gas mixtures – Dynamic volumetric methods – Part 3: Periodic injections into a flowing gas stream*

ISO 6145-4:1986, *Gas analysis – Preparation of calibration gas mixtures – Dynamic volumetric methods – Part 4: Continuous injection method*

ISO 6145-6:1986, *Gas analysis – Preparation of calibration gas mixtures – Dynamic volumetric methods – Part 6: Sonic orifices*

ISO 6147:1979, *Gas analysis – Preparation of calibration gas mixtures – Saturation method*

2 Definitions

For the purpose of this part of IEC 61779, and of the standards listed in 1.1.1, the following definitions apply:

2.1 Gas properties

2.1.1
ambient air
normal atmosphere surrounding the apparatus

2.1.2
clean air
air that is free of flammable gases and interfering or contaminating substances

2.1.3
explosive gas atmosphere
mixture with air, under normal atmospheric conditions, of flammable material in the form of gas or vapour, in which, after ignition, combustion spreads throughout the unconsumed mixture

NOTE 1 – This definition specifically excludes dusts and fibres in suspension in air. Mists are not covered by this standard.

NOTE 2 – Although a mixture that has a concentration above the upper flammable limit (see 2.1.9) is not an explosive atmosphere, in certain cases for area classification purposes, it is advisable to consider it as an explosive gas atmosphere.

NOTE 3 – Normal atmospheric conditions include variations above and below the reference levels of 101,3 kPa and 20 °C provided the variations have a negligible effect on the explosive properties of the flammable materials.

2.1.4
firedamp
flammable gas, consisting mainly of methane, found naturally in mines

2.1.5
flammable gas
gas or vapour which, when mixed with air in a certain proportion, will form an explosive atmosphere

NOTE – For the purpose of this standard the term "flammable gas" includes flammable vapours.

2.1.6
lower flammable limit (LFL)
volume ratio of flammable gas or vapour in air below which an explosive gas atmosphere will not be formed

2.1.7
poisons (of sensors)
substances which lead to temporary or permanent loss of sensitivity of the sensors

2.1.8
potentially explosive atmosphere
atmosphere that could become explosive (The danger is a potential one.)

2.1.9
upper flammable limit (UFL)
volume ratio of flammable gas or vapour in air above which an explosive gas atmosphere will not be formed (see also note 2 to 2.1.3)

2.1.10
volume ratio (v/v)
ratio of the volume of a component gas to the volume of the gas mixture under specified conditions of temperature and pressure

2.1.11
zero gas
gas which is free of flammable gases, and interfering and contaminating substances, the purpose of which is calibration/adjustment of the apparatus zero

2.2 Types of instruments

2.2.1
alarm-only apparatus
apparatus having an alarm but not having a meter or other indicating device that would allow measurement of the deviations permitted by the requirements of the appropriate standards listed in 1.1.1

2.2.2
aspirated apparatus
combustible gas detecting apparatus that obtains the gas by drawing it to the gas sensor – for example, by means of a hand-operated or electric pump

2.2.3
continuous duty apparatus
combustible gas detecting apparatus that is powered for long periods of time, but may have either continuous or intermittent sensing

2.2.4
diffusion apparatus
apparatus in which the transfer of gas from the atmosphere to the gas sensor takes place by random molecular movement, i.e. under conditions in which there is no aspirated flow

2.2.5
fixed apparatus
apparatus that is intended to have all parts permanently installed at a given location

2.2.6
group I apparatus
electrical apparatus for mines susceptible to firedamp

2.2.7
group II apparatus
electrical apparatus for places with a potentially explosive atmosphere, other than mines susceptible to firedamp

2.2.8
portable apparatus
spot-reading or continuous duty apparatus that has been designed to be carried readily from place to place and to be used while it is being carried. A portable apparatus is battery powered and includes, but is not limited to

a) a hand-held apparatus, typically less than 1 kg, suitable for one-handed operation without accessories (such as sampling probes, sample lines), fitted,

b) personal monitors, similar in size and mass to the hand-held apparatus, that are continuously operating (but not necessarily continuously sensing) while they are attached to the user, and

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

2.2.9
spot-reading apparatus
apparatus intended to operate for periods of only a few minutes for irregular intervals

2.2.10
transportable apparatus
apparatus not intended to be portable, but which can be moved readily from one place to another

2.3 Sensors

2.3.1
remote sensor
sensor that is not integral to the main body of the apparatus

2.3.2
sensor
assembly in which the sensing element is housed and which may also contain associated circuit components

2.4 Supply of gas to instrument

2.4.1
sample line
pipeline by means of which the gas being sampled is conveyed to the sensor

2.4.2
sampling probe
separate sample line which is attached to the apparatus as required, that may or may not be supplied with the apparatus. It is usually short (e.g. in the order of 1 m) and rigid (although it may be telescopic), but it may be connected by a flexible tube to the apparatus

2.5 Signals and alarms

2.5.1
alarm set point
fixed or adjustable setting of the apparatus that is intended to preset the level of concentration at which the apparatus will automatically initiate an indication, alarm or other output function

2.5.2
fault signal
audible, visible or other type of output different from the alarm signal, permitting, directly or indirectly, a warning or indication that the apparatus is not working satisfactorily

2.5.3
latching alarm
alarm that, once activated, requires deliberate action to be deactivated

2.6 Times

2.6.1
drift
variation in the apparatus indication with time, at any fixed gas concentration level (including clean air)

2.6.2
final indication
indication given by the apparatus after stabilization

2.6.3
minimum time of operation (spot-reading apparatus)
time interval between the initiation of a measurement procedure and the time when the apparatus indication reaches a stated percentage of the final indication

2.6.4
measuring span
algebraic difference between the upper and lower limits of the measuring range [IEV 351-05-39 modified]

2.6.5
stabilization
state when three successive readings of an apparatus, taken at two minute intervals, indicates no changes greater than ±1 % of the measuring range

2.6.6
time of response *t*(*x*) (not applicable to spot-reading apparatus)
time interval, with the apparatus in a warmed-up condition, between the time when an instantaneous variation in volume ratio is produced at the apparatus inlet and the time when the response reaches a stated percentage (*x*) of the final indication

2.6.7
warm-up time (not applicable to spot-reading apparatus)
time interval, with the apparatus in a stated atmosphere, between the time when the apparatus is switched on and the time when the indication reaches and remains within the stated tolerances (see figures 1 and 2)

2.7 Miscellaneous

2.7.1
nominal supply voltage
voltage that is given by manufacturers as the recommended operating voltage of their gas detection apparatus

2.7.2
special tool
tool required to gain access to, or to adjust, controls. The design of the tool is intended to discourage unauthorized interference with the apparatus

2.7.3
type of protection
measures applied in the construction of electrical apparatus to prevent ignition of the surrounding explosive atmosphere by such apparatus (see 3.1.2)

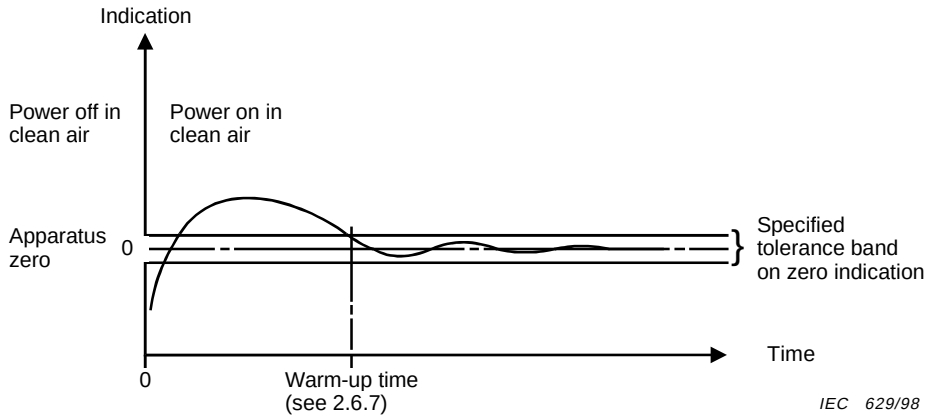

Figure 1 – Warm-up time in clean air (typical)

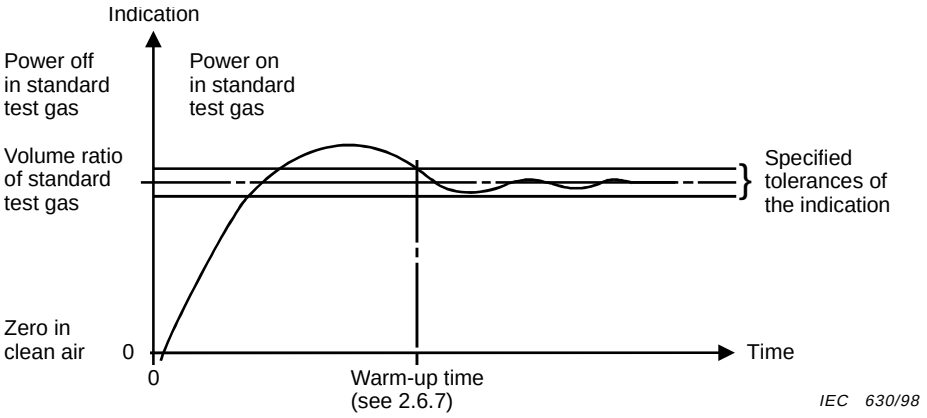

Figure 2 – Warm-up time in standard test gas (typical)

3 General requirements

3.1 Introduction

3.1.1 The apparatus shall comply with both the requirements of this standard and the appropriate standard(s) listed in 1.1.1.

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

3.1.2 Electrical assemblies and components shall comply with the construction and test requirements of 3.2, 3.5 and clause 4, where applicable. In addition, parts of the flammable gas detection apparatus intended for use in hazardous areas shall employ materials, and comply with the construction and explosion protection as specified in the appropriate standards listed in 1.1.1 and in the appropriate standards of IEC 60079. The appropriate standards are the following:

IEC 60079-0
IEC 60079-1
IEC 60079-2
IEC 60079-5
IEC 60079-6
IEC 60079-7
IEC 60079-11
IEC 60079-13
IEC 60079-15
IEC 60079-18

3.1.3 For group I apparatus any electrical circuits to be installed in the same area as the sensor, including those within the sensor, shall be intrinsically safe ("ia"); the sensing elements shall be intrinsically safe, or their enclosures shall comply with the safety requirements specified in 1.1.1.

3.1.4 In the design of software-controlled apparatus, the risks arising from faults in the programme shall be taken into account.

NOTE – No specific test requirements have been developed but they are under consideration.

3.2 Construction

3.2.1 General

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

All apparatus shall be constructed to facilitate regular accuracy checks.

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

3.2.2 Indicating devices

3.2.2.1 An indication shall be provided to show that the apparatus is energized.

NOTE – The indication can be shown at the central unit.

3.2.2.2 For alarm-only apparatus or apparatus where the resolution of the read-out device is inadequate to demonstrate compliance with this standard, the manufacturer shall identify suitable points for connecting indicating or recording devices for the purpose of testing the compliance of the apparatus with this standard.

3.2.2.3 Where a read-out device is inadequate in this way, it shall be of sufficient quality as not to contradict the results obtained by additional indicating or recording devices.

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

3.2.2.5 If individual coloured indicating lights are provided, they shall be coloured as follows:

a) alarms indicating the presence of a gas concentration above an alarm set point shall be coloured RED;

b) equipment fault indicators shall be coloured YELLOW;

c) power supply indicators shall be coloured GREEN.

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

3.2.3 Alarm or output functions

3.2.3.1 Continuous duty apparatus

If alarm devices, output contacts or alarm signal outputs are provided as part of fixed or continuous duty portable apparatus and are intended to operate when a potentially hazardous gas concentration is detected, they shall be of a latching type requiring a deliberate manual action to reset. Where the outputs are connected to an integrated or auxiliary system the means of latching and resetting may be incorporated into these systems. If two or more set or alarm positions are provided, the lower may be non-latching - based on user preference.

NOTE — The integral or latching device may reside in software.

3.2.3.2 Group II portable apparatus indicating up to 100 % LFL

Alarm devices provided as part of a gas detection apparatus shall not be set to operate above 60 % LFL.

NOTE 1 – For other group II apparatus, it is recommended that alarm devices should be set to operate at a gas volume ratio not higher than 60 % LFL.

NOTE 2 – In addition, it is also permissible to fit group II apparatus with an alarm which is designed to indicate when full scale has been exceeded and which is, therefore, set to operate at 100 % LFL.

3.2.4 Fault signals

Fixed and transportable apparatus shall provide a fault signal in the event of failure of power to the apparatus, of loss of continuity in one or more of the wires to any sensor, or of loss of electrical continuity of any gas sensing system. A short circuit or open circuit in connections to any sensor shall be indicated by a fault signal.

Automatically aspirated apparatus shall be provided:

a) in the case of fixed and transportable apparatus: with an integral flow-indicating device that produces a fault signal in the event of flow failure,

b) in the case of portable apparatus: with a means of verifying the air flow.

3.2.5 Adjustments

All adjustment devices shall be designed so as to discourage unauthorized or inadvertent interference with the apparatus. Examples would include procedural devices, in the case of a keyboard instrument, or mechanical devices such as a cover requiring the use of a tool.

Fixed explosion-protected apparatus 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. The means for making adjustments shall not degrade the explosion protection of the apparatus.

The adjustments of the zero and signal amplification shall be so designed that adjustment of one will not affect the other.

3.2.6 Battery-powered apparatus

Apparatus powered with integral batteries shall be provided with an indication of low battery condition, and the nature and purpose of this indication shall be explained in the manual (see 3.4 j)). All battery-powered apparatus shall be so constructed that, when the apparatus is tested according to 4.4.19, it shall comply with the requirements of the appropriate standards listed in 1.1.1.

3.3 Labelling and marking

The apparatus shall comply with the marking requirements contained in the relevant IEC 60079 standards covering electrical apparatus for explosive atmospheres referred to in 3.1.2, as applicable.

The apparatus shall be marked with the number of the IEC 60079 standard (i.e. part 1, part 2, part 3, part 4 or part 5) with which the performance is claimed to comply. The marking shall be adjacent to that required by the standards referred to in 3.1.2. Where the apparatus incorporates flame arresting devices complying with 3.5 of this standard, the marking shall include the symbol "s" in accordance with 25.6 of IEC 60079-0.

All equipment and protective systems shall be marked legibly and indelibly with the following minimum requirements:

a) name and address of the manufacturer;

b) certification marking;

c) designation of series or type;

d) serial number, if any;

e) specific marking describing the type of explosive protection.

Fixed group II apparatus with remote sensors shall carry a label, on each sensor, indicating the calibration gas.

3.4 Instruction manual

Each apparatus shall be provided with an instruction manual that includes the following information:

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

b) operating instructions and adjustment procedures;

c) recommendations for initial checking and calibration of the apparatus on a routine basis, including instructions for the use of the field calibration kit, if provided (see also clause 5);

NOTE – Users are referred to IEC 61779-6.

d) details of operational limitations including, where applicable, the following:

   1) gases for which the apparatus is suitable and the relative sensitivities of the instrument to these gases,

   2) information that describes the sensitivities to other gases to which the apparatus is responsive,

   3) temperature limits,

   4) humidity ranges,

   5) supply voltage limits,

   6) relevant characteristics and construction details of required interconnecting cables,

   7) battery data,

   8) pressure limits,

   9) sample flow rate,

   10) warm-up time,

   11) stabilization time;

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

   1) temperature,

   2) humidity,

   3) time,

   4) pressure;

f) bases used for converting test and calibration gas concentrations from % LFL to % volume fraction;

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

h) for aspirated apparatus, indication of the minimum and maximum flow rates and pressure; also, tubing type, maximum length and size for proper operation;

i) for aspirated apparatus, instructions for ensuring that the sample lines are intact and that proper flow is established (see 3.2.4);

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

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

l) a statement that alarm devices, outputs or contacts are of the non-latching types, where applicable (see 3.2.3.1);

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

n) a recommended replacement parts list;

o) where optional accessories (e.g. collecting cones, weather-protecting devices) are supplied, the manufacturer shall list such accessories and state their effects on the instrument characteristics (including response time and sensitivity), and provide means for their identification (e.g. part numbers included in manual);

p) details of certification and marking, and any special conditions of service;

q) storage life and recommended storage conditions for replacement parts and accessories, where critical;

r) where the special nature of the apparatus (such as non-linear responses) requires additional instructions or special information that are alternative to, or in addition to, the requirements of 3.3 and 3.4 a) to q), the instructions or information shall be provided.

3.5 Diffusion sensors

NOTE – Requirements for diffusion sensors are being prepared. [1)]

4 Test methods

4.1 Introduction

The test methods and procedures described in 4.2 to 4.4 are intended as a basis for establishing whether the apparatus conforms with the supplementary requirements for performance given in the appropriate standards listed in 1.1.1.

4.2 General requirements for tests

4.2.1 Samples and sequence of tests

4.2.1.1 For the purpose of type testing, the tests shall be carried out on one apparatus. Another apparatus may be used for tests according to 4.2.1.2.

4.2.1.2 The apparatus shall be subjected to all of the tests applicable to that type of apparatus, as described in 4.4. The test sequence detailed below shall be followed. However, test items 4) and 5) may be carried out to a schedule agreed upon between the manufacturer and the test laboratory.

One apparatus shall successfully complete all the tests, 1) to 7) inclusive. Another apparatus may be used for tests 8) and 9).

1) Unpowered storage (4.4.2)

2) Preparation and verification

   Calibration and adjustment (4.4.3)

   Alarm set point(s) (4.4.6)

   Flow rate (4.4.11)

   Warm-up time (4.4.15)

   Time of response (4.4.16)

   Minimum time of operation (4.4.17)

   Addition of sampling probe (4.4.22)

   Field calibration kit (clause 5)

3) Short-term stability (4.4.4.1)

   Test on spot-reading apparatus (4.4.5)

4) Mechanical

   Vibration (4.4.13)

   Drop test (4.4.14)

5) Electrical battery capacity (4.4.19)

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1) The review is conducted by a working group.

Power supply variations (4.4.20)

Power supply interruptions, voltage transients and step changes of voltage (4.4.21)

Electromagnetic interference (4.4.25)

6) Orientation (4.4.12)

7) Climatic

Temperature (4.4.7)

Pressure (4.4.8)

Humidity (4.4.9)

Air velocity (4.4.10)

8) Stability

Long-term tests for continuous duty apparatus (4.4.4.2 to 4.4.4.5)

9) Environmental

High gas concentration (4.4.18)

Dust (4.4.23)

Poisons (4.4.24)

4.2.1.3 Tests shall also be carried out, where applicable, to ensure that the apparatus satisfies the construction requirements of 3.2. The requirements for these tests are generally self-evident, except that for short-circuit requirements in 3.2.4, ballast resistors shall be substituted for each wire connecting the instrument to any remote sensor. The values of these resistors shall be those declared, in the instruction manual (see 3.4 d)), to be the maximum lead resistances allowing satisfactory compliance with the standard. The device used for the short circuit shall be of negligible resistance and shall be applied to convenient points in the circuit, at the sensor ends of the ballast resistors.

4.2.1.4 For apparatus having more than one selectable range or scale for the same or different gases or vapours, each range shall be tested. For the second and subsequent ranges the necessary amount of testing shall be agreed upon between the manufacturer and the test laboratory.

4.2.2 Preparation of apparatus before testing

The apparatus shall be prepared and mounted as near to typical service as possible, in accordance with the instruction manual – including all necessary interconnections, initial adjustments and initial calibrations. Adjustments may be made, where appropriate, at the beginning of each test.

In particular, the following points shall be noted:

a) Apparatus having remote sensors

For the purpose of the tests in 4.4, 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.

For apparatus having connection facilities for more than one remote sensor, only one remote sensor needs to be subjected to the tests. The replacement of all but one sensor by "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 (see 3.4 d)).

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

b) Apparatus having self-contained sensors

The entire apparatus shall be exposed to the test conditions without removal of any normally attached parts, including any sampling probe for tests 4.4.11, 4.4.15, 4.4.16 and 4.4.17.

c) Alarm-only apparatus

For alarm-only apparatus, readings shall be taken using an external meter connected to the test points described in 3.2.2.2.

In all cases, optional parts shall be either attached or removed according to which condition will give the most unfavourable result (at the discretion of the testing laboratory) for the test being conducted.

4.2.3 Mask for calibration and tests

When a mask is used for calibration or for the injection of test gas into the sensor, the design and operation of the mask used by the testing laboratory – in particular the pressure and velocity inside the mask – shall not inadmissibly influence the response of the apparatus or the results obtained.

NOTE – It is recommended that the testing laboratory should consult with the manufacturer in determining the design of the calibration mask. The manufacturer may provide a suitable calibration mask together with details of suggested pressure or flow for application of calibration gases with the apparatus.

4.3 Normal conditions for test

4.3.1 General

The test conditions specified in 4.3.2 to 4.3.10 shall be used for all tests, unless otherwise stated.

4.3.2 Test gas(es)

The flammable gas(es) to be used in a mixture with clean air for initial and all subsequent tests shall be selected in accordance with a) or b) below.

a) Methane for apparatus intended for sensing methane or firedamp, or intended for general purpose flammable gas detection that includes the detection of methane.

b) The actual specific gas or a representative gas for apparatus intended for sensing a specific flammable gas or a specific family of chemically similar flammable gases.

NOTE – This gas or vapour will normally be the test gas recommended by the manufacturer.

For all the other gases for which the apparatus is deemed to be suitable, the calibration curves and response times shall be supplied by the manufacturer and a representative sample verified by the testing laboratory.

NOTE 1 – For the purpose of this standard, where it is appropriate to use zero gas rather than clean air, references to clean air may be regarded as references to zero gas.

NOTE 2 – The gas mixture may be prepared by any suitable method, for example in accordance with the methods outlined in ISO 6142, ISO 6145 or ISO 6147.

NOTE 3 – Where vapours are used, the volume ratio of the standard test gas should be known to an uncertainty of ±2 %.

4.3.3 Standard test gas

The volume ratios of the standard test gas shall be as follows:

a) for group I apparatus indicating up to a volume fraction of 5 % methane: equivalent range of either a volume fraction of (1,5 ± 0,15) % or a volume fraction of (2,0 ± 0,2) %, as agreed between the manufacturer and the testing laboratory;

b) for other group I and all group II apparatus: 45 % to 55 % of the measuring range, wherever possible, not within the explosive range;

c) the volume ratios shall be known to an accuracy of ±2 % of the gas concentration.

4.3.4 Flow rate for test gases

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

NOTE – For apparatus that samples by diffusion, either a calibration mask in accordance with 4.2.3 or a test chamber may be used (see also annex B).

4.3.5 Voltage

a) Mains-powered apparatus shall be operated within 2 % of the manufacturer's recommended supply voltage and frequency.

b) Battery-powered apparatus 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.

4.3.6 Ambient temperature

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

4.3.7 Pressure

Generally, tests shall be performed at ambient atmospheric pressures ±1 kPa. However, for instruments susceptible to pressure variations, the influence of pressure changes shall be taken into account, using the results of the pressure test (4.4.8).

4.3.8 Humidity

The tests shall be performed in ambient air having a relative humidity (RH) controlled to within ±10 % RH over the range 30 % to 70 % throughout each test, except for tests 4.4.2, 4.4.7 and 4.4.9.

4.3.9 Stabilization time

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

4.3.10 Orientation

The apparatus shall be tested in the orientation recommended by the manufacturer.

4.4 Test methods

4.4.1 General

The following tests shall be performed in accordance with 4.3, unless otherwise stated. All tests shall be performed. At the end of each test, indications shall be taken in both clean air and the standard test gas, unless otherwise stated. The values of the indications used for verification of compliance with the performance standards listed in 1.1.1 shall be the final indications (see 2.6.2) of both the clean air and standard test gas readings, unless otherwise stated.

4.4.2 Unpowered storage

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

a) a temperature of –25 °C ± 3 °C for 24 h;

b) ambient temperature for at least 24 h;

c) a temperature of 60 °C ± 2 °C for 24 h;

d) ambient temperature for at least 24 h.

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

4.4.3 Calibration and adjustment

4.4.3.1 Initial preparation of the apparatus

The apparatus shall be calibrated and adjustments shall be carried out, if needed, to obtain correct indications in accordance with the manufacturer's instruction manual.

For apparatus having more than one selectable range or scale for the same or different gases or vapours, the necessary amount of testing shall be agreed upon between the manufacturer and the test laboratory.

4.4.3.2 Calibration curve (not applicable to alarm-only apparatus)

The apparatus shall be exposed to the gas selected in accordance with 4.3.2, at four volume ratios evenly distributed over the measuring range, starting with the lowest and finishing with the highest of the selected volume ratios. This operation shall be carried out three times consecutively.

4.4.3.3 Response to different gases (not applicable to alarm-only apparatus)

For group II apparatus, the accuracies of the response curves or correction charts provided in the manufacturer's manual shall be checked by measuring the response for gases which are representative of each gas family, at a minimum of three different points spread evenly between 20 % and 100 % of the measuring range to verify response characteristics.

4.4.4 Stability (continuous duty apparatus only)

NOTE – For these tests, the apparatus may be powered by an external supply.

4.4.4.1 Short-term stability

The apparatus shall be operated in clean air continuously for a period of 1 h. At approximately 10 min intervals, the apparatus shall be exposed to the standard test gas until stabilized. Indications in air and the standard test gas shall be taken for each exposure.

4.4.4.2 Long-term stability (fixed and transportable apparatus - group I only)

The apparatus shall be operated in clean air continuously for a period of four weeks and shall be exposed to the standard test gas for an 8 h period at weekly intervals over the four-week period. Indications shall be taken prior to the application of, after stabilization and prior to removal of the standard test gas.

4.4.4.3 Long-term stability (portable apparatus - group I only)

The apparatus shall be operated in clean air continuously for a period of 8 h per day over a four-week period. The apparatus shall be exposed to the standard test gas for 1 h during each operating period. Indications shall be taken prior to the application of, after stabilization, and prior to removal of the standard test gas.

4.4.4.4 Long-term stability (fixed and transportable apparatus - group II only)

The apparatus shall be operated continuously in clean air for a period of three months. At the end of every two weeks over the three-month period, the apparatus shall be exposed to the standard test gas until stabilized. Indications shall be taken prior to both the application and removal of the standard test gas.

At the end of the first test cycle, the apparatus shall be exposed to the standard test gas for an 8 h period. Indications shall be taken prior to the application of, after stabilization, and prior to removal of the standard test gas.

4.4.4.5 Long-term stability (portable apparatus - group II only)

The apparatus shall be operated in clean air continuously for a period of 8 h per day over a four-week period. The apparatus shall be exposed to the standard test gas until stabilized, once during each operating period. Indications shall be taken prior to the application of, after stabilization and prior to removal of the standard test gas.

4.4.5 Stability (spot-reading apparatus only)

4.4.5.1 Group I spot-reading apparatus indicating up to a volume fraction of 5 % methane and all group II spot-reading apparatus

The apparatus shall be exposed to clean air for 1 min followed by the standard test gas for 1 min. The operation shall be repeated 200 times. The final indication will be taken in clean air and the standard test gas, after stabilization at the end of the test.

4.4.5.2 Group I spot-reading apparatus indicating up to a volume fraction of 100 % methane

The apparatus shall be exposed to clean air for 1 min, followed by the standard test gas for 1 min. The operation shall be repeated 200 times. The final indication will be taken in clean air and the standard test gas, after stabilization, at the end of the 200 operations.

NOTE — For these tests, the apparatus may be powered by an external supply.

4.4.6 Alarm set point(s)

When the apparatus is provided with either

a) externally adjustable means of setting either one or more alarm set points, or

b) internally pre-set alarm point(s)

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

1) for apparatus of type a) with a single alarm set point, the alarm shall be set to a point equivalent to 90 % volume ratio of the standard test gas. For apparatus of type a) with more than one alarm set point, as many as possible of the alarms shall be set separately to 90 % of the volume ratio of the standard test gas and the alarms shall activate following application of the standard test gas;
2) for apparatus of type b) where the pre-set alarm point is in the range 70 % to 90 % of the volume ratio of the standard test gas, the alarm shall activate following application of the standard test gas;
3) for other apparatus of types a) and b), for each alarm that has a set point below 70 % or above 90 % of the volume ratio of the standard test gas, the alarm shall be set as near as possible to 90 % of the volume ratio of the standard test gas and the sensor shall be exposed to a gas/air mixture equivalent to (120 ± 10) % of the volume ratio corresponding to the individual alarm set point. The alarm shall activate following application of this gas.

In all cases, the test gas shall be applied until either activation of the alarm(s) or twice *t*(90), whichever is less.

4.4.7 Temperature

This test shall be performed in a temperature chamber having the capability of holding the sensor or apparatus at the specified temperature within ±2 °C. When the apparatus (or the portion under test) has reached the temperature specified in the standards listed in 1.1.1, as appropriate, the sensor shall be exposed sequentially to air and the standard test gas, which shall be at the same temperature as the atmosphere in the test chamber. The dew point of the air or standard test gas shall be below the lowest temperature of the test chamber and kept constant during the test.

4.4.8 Pressure

The effects of pressure variation shall be observed by placing the sensor or apparatus (including the aspirator for aspirated apparatus) in a test chamber that permits the pressure of clean air and of the standard test gas to be varied.

The pressure shall be maintained at the specified levels for 5 min, before a reading is accepted or a test is made. Readings shall be taken with clean air or the standard test gas respectively.

4.4.9 Humidity

Air with three different humidities evenly distributed over the range specified shall be supplied separately to the sensor using a temperature chamber or test mask. The procedure shall then be repeated with standard test gases with humidities over the ranges specified. The relative humidity levels shall be known to within ±3 % RH.

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

4.4.10 Air velocity

4.4.10.1 General

The effects of air speed over a range of 0 m/s to 6 m/s on apparatus with sensors that operate by diffusion shall be determined using the test conditions given in 4.4.10.2.

4.4.10.2 Test conditions

The separate sensors of apparatus with remote sensors and, when practicable, the entire apparatus if the sensors are integral shall be tested in a flow chamber under no forced ventilation conditions and at a speed of 6 m/s.

NOTE – The flow chamber should be suitable for the application of clean air and the standard test gas to meet the requirements of the standards listed in 1.1.1.

For apparatus having integral sensors which are too large to be tested in a flow chamber, other flow apparatus for carrying out the test shall be permitted.

The orientation of the sensor in relation to the direction of the flow shall be such that the flow reaches the apparatus from each of three mutually perpendicular directions, while the orientation of the apparatus is kept constant.

NOTE 1 – Directions of flow which are not likely to occur in practice, due to the design of the apparatus, or which are expressly prohibited by the manufacturer shall not be tested.

NOTE 2 – If there is one direction of flow for which the effect of air speed depends on whether the flow is incident or emergent with respect to the sensor inlet (e.g. sintered metal plate), both cases shall be tested.

4.4.11 Flow rate

For automatically aspirated apparatus, a flow failure indicator shall be provided.

The flow rate shall be tested by varying the flow rate

– from 130 % of the nominal flow rate or, if this is not possible, from the nominal flow rate,
– to 50 % of the nominal flow rate, or to the flow rate at which the failure alarm is set, if this is higher.

4.4.12 Orientation

4.4.12.1 Portable apparatus

The sensor, or the whole apparatus if relevant, shall be rotated through 360° in steps of 90° around each of its three mutually perpendicular axes.

4.4.12.2 Fixed and transportable apparatus

The sensor, or the apparatus having an integral sensor, shall be tested within the orientation limits stated in the manufacturer's instructions, around each of the three mutually perpendicular axes, but with the inclination of ±15° from the nominal orientation, if the manufacturer has stated orientation limits of ±15° or less.

4.4.13 Vibration

4.4.13.1 Apparatus

The vibration test machine shall consist of a vibrating table capable of producing a vibration of variable frequency and variable constant excursion (or variable constant acceleration peak), with the test apparatus mounted in place, as required by the following test procedures.

4.4.13.2 Procedures

4.4.13.2.1 The apparatus shall be energized and mounted on the vibration test machine and vibrated successively in each of three mutually perpendicular planes parallel to the edges of the apparatus.

The alarm set point shall be no higher than 20 %.

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

The apparatus shall be vibrated over the frequency range specified at the excursion or constant acceleration peak specified, for a period of 1 h in each of the three mutually perpendicular planes. The rate of change of frequency shall not exceed 10 Hz/min.

4.4.13.2.2 Procedure 1

For remote detector heads, the vibration shall be as follows:

10 Hz to 30 Hz, 1,0 mm total excursion;

31 Hz to 150 Hz, 2 *g* acceleration peak.

NOTE – This procedure is also applicable for controllers where the detector head is integral with or directly attached to the controller.

4.4.13.2.3 Procedure 2

For control units intended to be installed remotely from the detector heads, the vibration shall be as follows:

10 Hz to 30 Hz, 1,0 mm total excursion;

31 Hz to 100 Hz, 2 *g* acceleration peak.

4.4.13.2.4 At the conclusion of the test the sensor shall be exposed to clean air followed by the standard test gas.

4.4.14 Drop test for portable apparatus

This test is applicable only to portable apparatus and separate sensors of fixed apparatus. If the manufacturer recommends that the instrument be used in its carrying case, the test shall be carried out with the case.

4.4.14.1 While operating, the apparatus shall be released from a height of 1 m above a concrete surface and allowed to free fall.

4.4.14.2 The test required by 4.4.14.1 shall be performed three separate times, the apparatus being released each time with a different side (surface) facing down at the time of release.

4.4.14.3 The apparatus shall be considered to have failed this test if it is obviously inoperative after the test.

NOTE – Failures resulting from this test may not become apparent until subsequent required tests are conducted.

4.4.14.4 The sensing portion of the apparatus shall first be subjected to clean air and subsequently be subjected to the test gas.

4.4.15 Warm-up time (not applicable to spot-reading apparatus)

The alarm set point should be no higher than 20 %.

The apparatus shall be switched off and left for 24 h in clean air. After the 24 h period, the apparatus shall be switched on in clean air and the warm-up time measured.

Group I apparatus, except spot-reading apparatus, shall be switched off for a further 24 h in clean air. After this period, the apparatus shall be exposed for 5 min to the standard test gas, then switched on in the presence of the test gas and the warm-up time measured.

4.4.16 Time of response (not applicable to spot-reading apparatus)

The apparatus shall be switched on in clean air and, after an interval corresponding to at least two times the warm-up time, as determined in accordance with 4.4.15, without switching off, the apparatus or the sensor(s) shall

a) be subjected to a step change from clean air to the standard test gas, which shall be introduced by means of suitable equipment (see annex B),

b) following stabilization at the standard test gas, be subjected to a step change back to clean air.

Both times of response *t*(50) and *t*(90) shall be measured in each direction (see 2.6.6).

The times of response shall apply to the apparatus in the as supplied condition and without optional accessories, e.g. collecting cones, weather protection, attached to the sensor for special purposes.

4.4.17 Minimum time to operate (spot-reading apparatus)

The standard test gas shall be applied to the apparatus simultaneously with the initiation of the measurement procedure.

4.4.18 High gas concentration operation above the measuring range (applicable only to apparatus indicating up to a volume fraction of 5 % methane or 100 % LFL)

The entire apparatus, or the remote sensors of fixed or transportable apparatus, shall be subjected to the tests given in 4.4.18.1 and 4.4.18.2, using a test apparatus that simulates a sudden exposure to gas concentrations such as those described in annex B.

4.4.18.1 Non-ambiguity test

The apparatus, or remote sensor, shall be subjected to a step change from clean air to a volume fraction of 100 % gas and shall be maintained in such gas for 2 min, or for the minimum time of operation when testing spot-reading apparatus with an integral time cycle.

4.4.18.2 Residual effect

4.4.18.2.1 Spot-reading apparatus

The apparatus shall be subjected to 50 cycles, each cycle being an exposure of a volume fraction of 50 % gas for the minimum time of operation, followed by exposure to clean air for the minimum time of operation. Following the final cycle, five operations in clean air shall be made, each operation equivalent to the minimum time of operation, and the apparatus shall then be subjected to the standard test gas.

4.4.18.2.2 Apparatus other than spot-reading apparatus

The apparatus, or remote sensor, shall be subjected to a step change from clean air to a volume fraction of 50 % gas that shall be maintained for 3 min. The sensor shall then be subjected to clean air for 20 min, followed by the standard test gas.

4.4.19 Battery capacity

4.4.19.1 Battery-powered portable continuous duty apparatus

4.4.19.1.1 With a battery fully charged at the beginning of the test, the apparatus shall be operated in clean air for a total period of

a) 8 h, if fitted with a user-operable on/off switch,

b) 10 h, if not so fitted, or

c) any longer time as specified by the manufacturer.

At the end of the specified period, the apparatus is exposed to the standard test gas.

4.4.19.1.2 The apparatus shall then continue to operate until an indication that the low battery condition has been reached. The apparatus shall continue to operate for an additional 10 min.

4.4.19.2 Battery-powered portable spot-reading apparatus

4.4.19.2.1 With the battery fully charged at the beginning of the test, the apparatus shall be operated in clean air 200 times.

The duration of each operation shall be equal to the minimum time of operation; 1 min shall elapse after each operation.

At the end of the 200 operations, the apparatus shall be exposed to the test gas.

4.4.19.2.2 The cycle of operations shall then be continued until an indication that the low-battery condition has been reached. The apparatus shall be operated for an additional 10 times.

4.4.20 Power supply variations

4.4.20.1 General

The apparatus shall be set up under normal conditions (see 4.3), at nominal supply voltage and, where appropriate, rated frequency. For apparatus with remote sensors, the test shall be performed with both maximum and minimum resistance of the interconnecting cable. The apparatus shall then be subjected to the tests specified in 4.4.20.2 and 4.4.20.3.

4.4.20.2 AC and d.c. powered apparatus

The apparatus calibration shall be checked at both 115 % and 80 % of nominal supply voltage.

4.4.20.3 Other power supply ranges

Where the manufacturer of the apparatus specifies a supply range other than those specified in 4.4.20.2, the apparatus shall be tested at the upper and lower limits of the supply voltage specified by the manufacturer.

4.4.21 Power supply interruptions, voltage transients and step changes of voltage

4.4.21.1 General

The apparatus shall be set up under normal conditions, in accordance with 4.3, and then shall be subjected to the tests specified in 4.4.21.2 to 4.4.21.4 in clean air only.

The alarm set point should be no higher than 20 %.

4.4.21.2 Short interruption of power supply

The power supply shall be interrupted for 10 ms, repeated 10 times at random time intervals having a mean value of 10 s.

4.4.21.3 Voltage transients

The apparatus shall be tested according to IEC 61000-4-4, test severity 2. The test procedure for type tests performed in laboratories shall be used. The test duration shall be 1 min for each line or terminal to be tested.

4.4.21.4 Step changes of voltage without interruption

For a.c. and external d.c. powered apparatus, the power voltage shall be increased by 10 %, maintained at this value until the apparatus is stabilized, and then reduced to 15 % below nominal voltage. Each step change shall take place within 10 ms.

4.4.22 Addition of sampling probe

When it is intended to add a sampling probe, the apparatus shall first be calibrated using the standard test gas without the sampling probe. The sampling probe shall then be added, and the test repeated.

4.4.23 Dust (for apparatus where the air is sampled by natural diffusion only)

The effect of dust shall be simulated by uniformly reducing the gas inlet area of the apparatus by 50 % before subjecting it to clean air or the standard test gas.

4.4.24 Poisons and other gases

4.4.24.1 Poisons (applicable only to group I apparatus with catalytic sensors)

The apparatus shall be exposed to a volume fraction of 1 % methane in air mixture containing a volume fraction of 10 ppm of hexamethydisiloxane and shall perform 40 min continuous operation for continuous duty apparatus, or 100 tests for spot-reading apparatus.

4.4.24.2 Certain materials that may be present in industrial atmospheres can lead to "poisoning" or other undesirable effects which may result in a change of sensitivity of a gas sensor.

NOTE – As improved tolerances to these materials are frequently claimed by manufacturers, evidence of the testing procedure used to substantiate these claims and test results may be open to validation or verification by agreement between a purchaser, a manufacturer, and a testing laboratory. Possible "poisoning" agents and their effects on sensor performance are discussed in draft publication IEC 61779-6.

4.4.24.2 Other gases

The apparatus shall be tested separately with the following gas mixtures:

a) group I apparatus indicating up to a volume fraction of 5 % methane in air:
   1) a volume fraction of 1,5 % methane + a volume fraction of 13 % oxygen in nitrogen;
   2) a volume fraction of 1,5 % methane + a volume fraction of 5 % carbon dioxide in air;
   3) a volume fraction of 1,5 % methane + a volume fraction of 0,075 % ethane in air;
b) group I apparatus indicating up to a volume fraction of 100 % methane:
   1) a volume fraction of 50 % methane + a volume fraction of 6,5 % oxygen in nitrogen;
   2) a volume fraction of 50 % methane + a volume fraction of 5 % carbon dioxide in nitrogen;
   3) a volume fraction of 50 % methane + a volume fraction of 2,5 % ethane in nitrogen.

The gas mixtures may be prepared by any suitable method. The tolerances on the volume ratio or each component gas shall be within ±10 % of the nominal gas concentration.

The actual value of the methane volume ratio shall be known to be within ±2 % relative.

4.4.25 Electromagnetic compatibility

The apparatus, including the sensor and interconnecting wiring, shall be subjected to a test method used in conducting EMC radiated immunity tests according to IEC 61000-4-1 and IEC 61000-4-3.

The test requirements shall be carried out with severity level 2; test field strength 3 V/m.

The alarm set point shall be set no higher than 20 %.

The test shall be carried out in clean air.

In the case of field systems with remote sensing where the control unit is intended for general purpose rack mounting or its equivalent, such a control unit shall be submitted to these tests in an enclosure supplied by the manufacturer.

The instruction manual shall inform the user that such apparatus is to be used with the same enclosure to avoid adverse electromagnetic effects.

NOTE – Electromagnetic emission requirements may be required by other standards.

5 Field calibration kit

If a field calibration kit is provided with the apparatus, carry out the following test:

a) calibrate the apparatus in accordance with 4.4.3.1 using the test conditions given in 4.3 and using the test equipment for the tests described in 4.4;

b) use the field calibration kit in a manner corresponding to the manufacturer's instructions for checking the apparatus response.

Annex A
(normative)

Flammability limits (i.e. LFL and UFL) of some flammable gases and vapours

Flammability limits (LFL and UFL) of some flammable gases and vapours are given for guidance in table A.1 only for performing type testing according to this standard.

The data in the following table are taken directly from IEC 60079-20 (technical report).

Table A.1 – The following headings are used:

Ref.	Reference number for each gas or vapour
Rho, ρ	Density relative to air (normally at standard temperature and pressure, unless otherwise stated)
FP	Flash point
Ign. temp.	Ignition temperature
MESG	Maximum experimental safe gap
T class	Temperature class according to IEC 60079-0
Group	See 3.2.

Table A.1 – Flammability data

Ref.	Gas or vapour	Formula	Rho	FP	Flammability limits				Ign.	MESG	T class	Group
			ρ		Lower	Upper	Lower	Upper	temp.			
				°C	Volume per cent		mg/l		°C	mm		
1	Acetaldehyde	CH_3CHO	1,52	–38	4,00	60,00	74	1108	204	0,92	T3	IIA
2	Acetic acid	CH_3COOH	2,07	40	4,00	17,0	100	428	464	1,78	T1	IIA
3	Acetic anhydride	$(CH_3CO)_2O$	3,52	49	2,00	10,0	85	428	334	1,23	T2	IIA
4	Acetone	$(CH_3)_2CO$	2,00	<–20	2,50	13,0	80	316	535	1,01	T1	IIA
5	Acetonitrile	CH_3CN	1,42	2	3,00	16,0	51	275	523	1,50	t1	IIA
6	Acetyl chloride	CH_3COCl	2,70	–4	5,00	19,0	157	620	390		T2	(IIA)
7	Acetylene (see 4.3)	$CH{=}CH$	0,90		2,30	100,0	24	1092	305	0,37	T2	IIC
8	Acetyl fluoride	CH_3COF	2,14	<–17	5,60	19,9	142	505	434	1,54	T2	IIA
9	Acrylaldehyde	$CH_2{=}CHCHO$	1,93	–18	2,85	31,8	65	728	217	0,72	T3	IIB
10	Acrylic acid	$CH_2{=}CHCOOH$	2,48	56	2,90		85		406	086	T2	IIB
11	Acrylonitrile	$CH_2{=}CHCN$	1,83	–5	2,80	28,0	64	620	480	0,87	T1	IIB
12	Acryloyl chloride	$CH_2CHCOCl$	3,12	–8	2,68	18,0	220	662	463	1,06	T1	IIA
13	Allyl acetate	$CH_2{=}CHCH_2OOCCH_3$	3,45	13	1,70	9,3	69	3 800	348	0,96	T2	IIA
14	Allyl alcohol	$CH_2{=}CHCH_2CH$	2,00	21	2,50	18,0	61	438	378	0,84	T2	IIB
15	Allyl chloride	$CH_2{=}CHCH_2Cl$	2,64	–32	2,90	11,2	92	357	390	1,17	T2	IIA
16	Allyl 2-3-epoxypropyl ether	$CH_2{=}CHCH_2{-}O{-}\overline{CHCH_2CH_2O}$	3,94	45					249	0,70	T3	IIB
17	2-Aminoethanol	$NH_2CH_2CH_2OH$	2,10	86					410		T2	IIA
18	Ammonia	NH_3	0,59		15,0	33,6	107	240	630	3,18	T1	IIA
19	Amphetamine (INN)	$C_6H_5CH_2CH(NH_2)CH_3$	4,67	<100								IIA
20	Aniline	$C_6H_6NH_2$	3,22	75	1,20	11,0	47	425	630		T1	IIA

Table A.1 – Flammability data (continued)

Ref.	Gas or vapour	Formula	Rho	FP	Flammability limits				Ign.	MESG	T class	Group
			ρ		Lower	Upper	Lower	Upper	temp.			
				°C	Volume per cent		mg/l		°C	mm		
21	Azepane	$CH_2(CH_2)_5NH$	3,41	23					279	1,00	T3	IIA
22	Benzaldehyde	C_6H_5CHO	3,66	64	1,40		62		192		T4	IIA
23	Benzene	C_6H_6	2,70	–11	1,20	8,6	39	280	560	0,99	T1	IIA
24	1-Bromobutane	$CH_3(CH_2)_2CH_2Br$	4,72	13	2,50	6,6	143	380	265		T3	IIA
25	2-Bromo-1,1-diethoxyethane	$(CH_3CH_2O)_2CHCH_2Br$	7,34	57					175	1,00	T4	IIA
26	Bromoethane	CH_3CH_2Br	3,75	<–20	6,70	11,3	306	517	511		T1	IIA
27	Buta-1,3-diene	$CH_2=CHCH=CH_2$	1,87	–85 gas	1,40	16,3	31	365	430	0,79	T2	IIB
28	Butane	C_4H_{10}	2,05	–80 gas	1,40	9,3	33	225	372	0,96	T2	IIA
29	Isobutane	$(CH_3)_2CHCH_3$	2,00	gas	1,3	9,8	31	236	460	0,95	T1	IIA
30	Butan-1-ol	$CH_3(CH_2)_2CH_2OH$	2,55	29	1,70	12,0	52	372	359	0,94	T2	IIa
31	Butanone	$CH_3CH_2COCH_3$	2,48	–9	1,80	10,0	50	302	404	0,84	T2	IIB
32	But-1-ene	$CH_2=CHCH_2CH_3$	1,95	–80 gas	1,60	10,0	38	235	440	0,94	T2	IIA
33	But-2-ene (isomer not stated)	$CH_3CH=CHCH_3$	1,94	gas	1,60	10,0	40	228	325	0,89	T2	IIB
34	But-3-en-3-olide	$CH_2=CCHO(O)O$	2,90	33					282	0,84	T3	IIB
35	2-(2-Butoxyethoxy) ethanol	$CH_3(CH_2)_3OCH_2CH_2OCH_2CH_2OH$	5,59	78					225	1,11	T3	IIA
36	Butyl acetate	$CH_3COOCH_2(CH_2)_2CH_3$	4,01	22	1,3	7,5	64	390	370	1,04	T2	IIA
37	n-Butyl acrylate	$CH_2=CHCOOC_4H_9$	4,41	38	1,2	8,0	63	425	268	0,88	T3	IIB
38	Butylamine	$CH_3(CH_2)_3NH_2$	2,52	–12	1,7	9,8	49	286	312	0,92	T2	IIA
39	Isobutylamine	$(CH_3)_2CHCH_2NH_2$	2,52	–20	1,47	10,8	44	330	374	1,15	T2	IIA
40	Butyl 2,3-epoxypropyl ether	$CH_3(CH_2)_3OCH_2CHCH_2O$	4,48	44					262	0,78	T3	IIB

Table A.1 – Flammability data (continued)

Ref.	Gas or vapour	Formula	Rho	FP	Flammability limits				Ign.	MESG	T class	Group
			ρ		Lower	Upper	Lower	Upper	temp.			
				°C	Volume per cent		mg/l		°C	mm		
41	Butyl glycolate	$HOCH_2COOC_4H_9$	4,45	61						0,88		IIB
42	Isobutylisobutyrate	$(CH_3)_2CHCOOCH_2CH(CH_3)_2$	4,93	34	0,80		47		424	1,00	T2	IIA
43	Butylmethacrylate	$CH_2=C(CH_3)COO(CH_2)_3CH_3$	4,90	53	1,00	6,8	58	395	289	0,95	T3	IIA
44	Tert-butyl methyl ether	$CH_3OC(CH_3)_2$	3,03	–27	1,50	8,4	54	310	385	1,00	T2	IIA
45	n-Butylpropionate	$C_2H_5COOC_4H_9$	4,48	40	1,10	7,7	58	409	389	0,93	T2	IIA
46	But-1-yne	$CH_3CH_2C=CH$								0,71		IIB
47	Butyraldehyde	$CH_3CH_2CH_2CHO$	2,48	–16	1,80	12,5	54	378	191	0,92	T4	IIA
48	Isobutyraldehyde	$(CH_3)_2CHCHO$	2,48	–22	1,6	11,0	47	320	176	0,92	T4	IIA
49	Isobutyric acid	$(CH_3)_2CHCOOH$	3,03	58					460	1,02	T2	IIA
50	Butyryl fluoride	C_3H_7COF	3,10	<–14	2,60		95		440	1,14	T1	IIA
51	Carbon disulphide (see 4.4)	CS_2	2,64	–30	0,60	60,0	19	1 900	95	0,20 0,34	T6	IIC
52	Carbon monoxide (saturated at 18 °C) (see 4.5)	CO	0,97		10,90	74,0	126	870	805	0,84	T1	IIB
53	Carbonyl sulphide	COS	2,07		6,5	28,5	180	700	209	1,35	T3	IIA
54	Chlorobenzene	C_6H_5Cl	3,88	28	1,40	11,0	66	520	637		T1	IIA
55	1-Chlorobutane	$CH_3(CH_2)_2CH_2Cl$	3,20	–12	1,80	10,0	69	386	250	1,06	T3	IIA
56	2-Chlorobutane	$CH_3CHClC_2H_5$	3,19	<–18	2,20	8,8	82	339	368	1,16	T2	IIA
57	1-Chloro-2,3-epoxypropane	OCH_2CHCH_2Cl	3,30	28	2,30	34,4	86	1 325	385	0,74	T2	IIB
58	Chloroethane	CH_3CH_2Cl	2,22		3,60	15,4	95	413	510		T1	IIA
59	2-Chloroethanol	CH_2ClCH_2OH	2,78	55	5,00	16,0	160	540	425		T2	IIA
60	Chloroethylene	$CH_2=CHCl$	2,15	–78 gas	3,60	33,0	94	610	415	0,96	T2	IIA

Table A.1 – Flammability data (continued)

Ref.	Gas or vapour	Formula	Rho	FP	Flammability limits				Ign.	MESG	T class	Group
					Lower	Upper	Lower	Upper				
			ρ						temp.			
				°C	Volume per cent		mg/l		°C	mm		
61	Chloromethane	CH_3Cl	1,78	–24 gas	7,60	19,0	160	410	625	1,00	T1	IIA
62	Chlormethyl methyl ether	CH_3OCH_2Cl	2,78	–8								IIA
63	1-Chloro-2-methylpropane	$(CH_3)_2CHCH_2Cl$	3,19	<–14	2,00	8,6	75	340	416	1,25	T2	IIA
64	2-Chloro-2-methylpropane	$(CH_3)_2CCl$	3,19	<–18					541	1,40	T1	IIA
65	3-Chloro-2-methylprop-1-ene	$CH_2=C(CH_3)CH_2Cl$	3,12	–16	2,10		77		478	1,16	T1	IIA
66	5-Chloropentan-2-one	$CH_3CO(CH_2)_3Cl$	4,16	61	2,00		98		440	1,10	T2	IIA
67	1-Chloropropane	$CH_3CH_2CH_2Cl$	2,70	–32	2,40	11,1	78	365	520		T1	IIA
68	2-Chloropropane	$(CH_3)_2CHCl$	2,70	<–20	2,80	10,7	92	350	590	1,23	T1	IIA
69	Chlorotrifluoroethyl-ene	$CF_2=CFCl$	4,01	gas	4,6	84,3	220	3 117	607	1,50	T1	IIA
70	1-Chloro-2,2,2-trifluoroethyl methyl ether	$CF_3CHClOCH_3$	5,12	4	8,00		484		430	2,80	T2	IIA
71	α-Chlorotoluene	$C_6H_5CH_2Cl$	4,36	60	1,20		63		585		T1	IIA
72	Coal tar naphtha								272		T3	IIA
73	Coke oven gas (see 4.1)											
74	Cresols (mixed isomers)	$CH_3C_5H_4OH$	3,73	81	1,10		50		555		T1	IIA
75	Crofonaldehyde	$CH_3CH=CHCHO$	2,41	13	2,10	16,0	82	470	280	0,81	T3	IIB
76	Cumene	$C_6H_5CH(CH_3)_2$	4,13	31	0,80	6,5	40	328	424	1,05	T2	IIA
77	Cyclobutane	$CH_2(CH_2)_2CH_2$	1,93		1,80		42					IIA

Table A.1 – Flammability data (continued)

Ref.	Gas or vapour	Formula	Rho	FP	Flammability limits				Ign.	MESG	T class	Group
			ρ		Lower	Upper	Lower	Upper	temp.			
				°C	Volume per cent		mg/l		°C	mm		
78	Cycloheptane	$CH_2(CH_2)_5CH_2$	3,39	<10	1,10	6,7	44	275				IIA
79	Cyclohexane	$CH_2(CH_2)_4CH_2$	2,90	–18	1,20	8,3	40	290	259	0,94	T3	IIA
80	Cycloehexanol	$CH_2(CH_2)_4CHOH$	3,45	61	1,20	11,1	50	460	300		T3	IIA
81	Cyclohexanone	$CH_2(CH_2)_4CO$	3,38	43	1,00	9,4	42	386	419	0,98	T2	IIA
82	Cyclohexene	$CH_2(CH_2)_3CH=CH$	2,83	–17	1,20		41		244		T3	IIA
83	Cyclohexylamine	$CH_2(CH_2)_4CHNH_2$	3,42	32	1,60	9,4	63	372	293		T3	IIA
84	1,3-Cyclopentadiene	$CH_2CHCHCHCH$	2,30	–50					485	0,99	T1	IIA
85	Cyclopentane	$CH_2(CH_2)_3CH_2$	2,40	–37	1,4		41		320	1,01	T2	IIA
86	Cyclopentene	$CH=CHCH_2CH_2CH$	2,30	<–22	1,48		41		309	0,96	T2	IIA
87	Cyclopropane	$CH_2CH_2CH_2$	1,45		2,40	10,4	42	183	498	0,91	T1	IIA
88	Cyclopropyl methyl ketone	$CH_3COCHCH_2CH_2$	2,90	15	1,70		58		452	0,97	T1	IIA
89	p-Cymene	$CH_3CH_6H_4CH(CH_3)_2$	4,62	47	0,70	6,5	39	366	436		T2	IIA
90	2,2,3,3,4,4,5,5,6,6,7,7-Dodecafluoro-heptyl methacrylate	$CH_2=C(CH_3)COOCH_2(CF_2)_6H$	9,93	49	1,60		185		390	1,46	T2	IIA
91	Decahydro-naphthalene trans	$CH_2(CH_2)_3CHCH(CH_2)_3CH_2$	4,76	54	0,70	4,9	40	284	288		T3	IIA
92	Decane (mixed isomers)	$C_{10}H_{22}$	4,90	46	0,70	5,6	41	433	201	1,05	T3	IIA

Table A.1 – Flammability data (continued)

Ref.	Gas or vapour	Formula	Rho	FP	Flammability limits				Ign.	MESG	T class	Group
			ρ		Lower	Upper	Lower	Upper	temp.			
				°C	Volume per cent		mg/l		°C	mm		
93	Dibutyl ether	$(CH_3(CH_2)_3)_2O$	4,48	25	0,90	8,5	48	460	198	0,68	T4	IIB
94	Di-tert-butyl peroxide	$(CH_3)_3COOC(CH_3)_3$	5,0	18					170	0,84	T4	IIB
95	Dichlorobenzenes (isomer not stated)	$C_6H_4Cl_2$	5,07	86	2,20	9,2	134	564	648		T1	IIA
96	3,4-Dichlorobut-1-ene	$CH_2=CHCHClCH_2Cl$	4,31	31	1,30	7,2	66	368	469	1,38	T1	IIA
97	1,3-Dichlorobut-2-ene	$CH_3CCl=CHCH_2Cl$	4,31	27					469	1,31	T1	IIA
98	Dichlorodiethyl-silane	$(C_2H_5)SiCl_2$		24	3,40		223			0,45		IIC
99	1,1-Dichloroethane	CH_3CHCl_2	3,42	–10	5,60	16,0	230	660	440		T2	IIA
100	1,2-Dichloroethane	CH_2ClCH_2Cl	3,42	13	6,20	16,0	255	654	438	1,82	T2	IIA
101	Dichloroethylene	$ClCH=CHCl$	3,55	–10	9,70	12,8	391	516	440	3,91	T2	IIA
102	1,2-Dichloro-propane	$CH_3CHClCH_2Cl$	3,90	15	3,40	14,5	160	682	557		T1	IIA
103	Dicyclopentadiene (technical)	$C_{10}H_{12}$	4,55	36	0,80		43		455	0,91	T1	IIA
104	1,2-Diethoxyethane	$C_2H_5O(CH_2)_2OC_2H_5$	4,07	16					170	0,81	T4	IIB
105	Diethylamine	$(C_2H_5)_2NH$	2,53	–23	1,70	10,0	50	306	312		T2	IIA
106	Diethylcarbonate	$(CH_3CH_2O)_2CO$	4,07	24	1,4	11,7	69	570	450	0,83	T2	IIB
107	Diethyl ether	$(CH_3CH_5)_2O$	2,55	–45	1,70	36,0	60	1 118	160	0,87	T4	IIB
108	Diethyl oxylate	$(COOCH_2CH_3)_2$	5,04	76						0,90		IIA
109	Diethyl sulphate	$(CH_3CH_2)_2SO_4$	5,31	104					360	1,11	T2	IIA
110	1,1-Difluoro-ethylene	$CH_2=CF_2$	2,21		3,90	25,1	102	665	380	1,10	T2	IIA
111	Dihexyl ether	$(CH_3(CH_2)_5)_2O$	6,43	75					187		T4	IIA

Table A.1 – Flammability data (continued)

Ref.	Gas or vapour	Formula	Rho	FP	Flammability limits				Ign.	MESG	T class	Group
			ρ		Lower	Upper	Lower	Upper	temp.			
				°C	Volume per cent		mg/l		°C	mm		
112	Diisobutylamine	$((CH_3)_2CHCH_2)_2NH$	4,45	26	0,80	3,6	42	190	256	1,12	T3	IIA
113	Diisobutyl carbinol	$((CH_3)_2CHCH_2)_2CHOH$	4,97	75	0,70	6,1	42	370	290	0,93	T3	IIA
114	Diisopentyl ether	$(CH_3)_2CH(CH_2)_2O(CH_2)_2CH(CH_3)_2$	5,45	44	1,27		104		185	0,92	T4	IIA
115	Diisopropylamine	$((CH_3)_2CH)_2NH$	3,48	–20	1,20	8,3	49	260	285	1,02	T3	IIA
116	Diisopropyl ether	$((CH_3)_2CH)_2O$	3,52	–28	1,00	21,0	45	900	405	0,94	T2	IIA
117	Dimethylamine	$(CH_3)_2NH$	1,55	–18 gas	2,80	14,4	53	272	400	1,15	T2	IIA
118	1,2-Dimethylethane	$CH_3O(CH_2)_2OCH_3$	3,10	–6	1,6	10,4	60	390	197	0,72	T4	IIB
119	Dimethoxymethane	$CH_2(OCH)_3)_2$	2,60	–21	3,00	16,9	93	535	247	0,88	T3	IIB
120	2-Dimethylamino-ethanol	$(CH_3)_2NC_2H_4OH$	3,03	39					220		T3	IIA
121	3-(Dimethylamino) propiononitrile	$(CH_3)_2NHCH_2CH_2CN$	3,38	50	1,57		62		317	1,14	T2	IIA
122	Dimethyl ether	$(CH_3)_2O$	1,59	–42 gas	2,70	32,0	51	610	240	0,84	T3	IIB
123	N,N-Dimethyl formamide	$HCON(CH_3)_2$	2,51	58	1,80	16,0	55	500	440	1,08	T2	IIA
124	3,4-Dimethyl hexane	$CH_3CH_2CH(CH_3)CH(CH_3)CH_2CH_3$	3,87	2	0,80	8,5	38	310	305		T2	IIA
125	N,N-Dimethyl hydrazine	$(CH_3)_2NNH_2$	2,07	–18	2,4	20	60	490	240	0,85		IIB
126	1,4-Dimethyl piperazine	$NH(CH_3)CH_2CH_2NH(CH_3)CH_2CH_2$	3,93	9					199	1,00	T4	IIA
127	N,N-Dimethyl propane-1,3-diamine	$(CH_3)_2N(CH_2)_3NH_2$	3,52	26	1,20		50		219	0,95	T3	IIA
128	Dimethyl sulphate	$(CH_3O)_2SO_2$	4,34	39					449	1,00	T2	IIA
129	1,4-Dioxane	$OCH_2CH_2OCH_2CH_2$	3,03	11	1,90	22,5	74	813	379	0,70	T2	IIB
130	1,3-Dioxolane	$OCH_2CH_2OCH_2$	2,55	–5	2,3	30,5	70	935	245		T3	IIB

Table A.1 – Flammability data (continued)

Ref.	Gas or vapour	Formula	Rho	FP	Flammability limits				Ign.	MESG	T class	Group
			ρ		Lower	Upper	Lower	Upper	temp.			
				°C	Volume per cent		mg/l		°C	mm		
131	Dipentene, crude	$C_{10}H_{16}$	4,66	42	0,75	6,1	43	348	255	1,18	T3	IIA
132	Dipentyl ether	$(CH_3(CH_2)_4)_2O$	5,45	57					171		T4	
133	Dipropylamine	$(CH_3CH_2CH_2)_2NH$	3,48	4	1,60	9,1	66	376	280	0,95	T3	IIA
134	Dipropyl ether	$(C_3H_7)_2O$	3,53	<–5					215		T3	IIB
135	1,2-Epoxypropene	$CH_3\underline{CHCH_2O}$	2,00	–37	1,90	37,0	49	901	430	0,70	T2	IIB
136	Ethane	CH_3CH_3	1,04		2,50	15,5	31	194	515	0,91	T1	IIA
137	Ethanethiol	CH_3CH_2SH	2,11	<–20	2,80	18,0	73	466	295	0,90	T3	IIB
138	Ethanol	CH_3CH_2OH	1,59	12	3,1	19,0	59	359	363	0,91	T2	IIA
139	2-Ethoxyethanol	$CH_3CH_2OCH_2CH_2OH$	3,10	40	1,80	15,7	68	593	235	0,84	T3	IIB
140	2-Ethoxyethyl acetate	$CH_3COOCH_2CH_2OCH_2CH_3$	4,72	47	1,20	12,7	65	642	380	0,97	T2	IIA
141	2-(2-Ethoxyethoxy) ethanol	$CH_3CH_2OCH_2CH_2OCH_2CH_2OH$	4,62	94					190	0,94	T4	IIA
142	Ethyl acetate	$CH_3COOCH_2CH_3$	3,04	–4	2,20	11,0	81	406	460	0,99	T1	IIA
143	Ethyl acetoacetate	$CH_3COCH_2COOCH_2CH_3$	4,50	65	1,00	9,5	54	519	350	0,96	T2	IIA
144	Ethyl acrylate	$CH_2=CHCOOCH_2CH_3$	3,45	9	1,40	14,0	59	588	350	0,86	T2	IIB
145	Ethylamine	$C_2H_5NH_2$	1,50	<–20	2,68	14,0	49	260	425	1,20	T2	IIA
146	Ethylbenzene	$CH_2CH_3C_6H_5$	3,66	23	1,00	7,8	44	340	431		T2	IIA
147	Ethyl butyrate	$CH_3CH_2CH_2COOC_2H_5$	4,00	21	1,40		66		435	0,92	T2	
148	Ethylcyclobutane	$CH_3CH_2\underline{CHCH_2CH_2}CH_2$	290	<–16	1,20	7,7	42	272	212		T3	IIA
149	Ethylcyclohexane	$CH_3CH_2\underline{CH(CH_2)_4}CH_2$	3,87	<24	0,90	6,6	42	310	238		T3	IIA
150	Ethylcyclopentane	$CH_3CH_2\underline{CH(CH_2)_3}CH_2$	3,40	<5	1,05	6,8	42	280	262		T3	IIA

Table A.1 – Flammability data (continued)

Ref.	Gas or vapour	Formula	Rho	FP	Flammability limits				Ign.	MESG	T class	Group
					Lower	Upper	Lower	Upper				
			ρ	°C	Volume per cent		mg/l		°C	mm		
151	Ethylene	$CH_2=CH_2$	0,97		2,3	36,0	26	423	425	0,65	T2	IIB
152	Ethylenediamine	$NH_2CH_2CH_2NH_2$	2,07	34	2,7	16,5	64	396	403	1,18	T2	IIA
153	Ethylene oxide	CH_2CH_2O	1,52	<–18	2,60	100,0	47	1 848	435	0,59	T2	IIB
154	Ethyl formate	$HCOOCH_2CH_3$	2,65	–20	2,70	16,5	87	497	440	0,91	T2	IIA
155	2-Ethylexyl acetate	$CH_3COOCH_2CH(C_2H_5)C_4H_5$	5,94	44	0,75	6,2	53	439	335	0,88	T2	IIB
156	Ethyl isobutyrate	$(CH_3)_2CHCOOC_2H_5$	4,00	10	1,60		75		438	0,86	T2	IIA
157	Ethyl methacrylate	$CH_2=CCH_3COOCH_2CH_3$	3,90	(20)	1,50		70			1,01		IIA
158	Ethyl methyl ether	$CH_3OCH_2CH_3$	2,10		2,00	10,1	50	255	190		T4	IIB
159	Ethyl nitrite (see 4.2)	CH_3CH_2ONO	2,60	–35	3,00	50,0	94	1 555	95	0,96	T6	IIA
160	0-Ethyl phosphoro-dichloridothinate	$C_2H_5OPSCl_2$	7,27	75					234	1,20	T3	IIA
161	Ethylpropylacrolein (isomer not stated)	$C_8H_{14}O$	4,34	40					184	0,86	T4	IIB
162	Formaldehyde	HCHO	1,03		7,00	73,0	88	920	424	0,57	T2	IIB
163	Formic acid	HCOOH	1,60	42	10,0	57,0	190	1 049	520	1,86	T1	IIA
164	2-Furaldehyde	OCH=CHCH=CHCHO	3,30	60	2,10	19,3	85	768	316	0,88	T2	IIB
165	Furan	CH=CHCH=CHO	2,30	<–20	2,30	14,3	66	408	390	0,68	T2	IIB
166	Furfuryl alcohol	$OC(CH_2OH)CHCHCH$	3,38	61	1,8	16,3	70	670	370	0,8	T2	IIB
167	1,2,3-Trimethyl-benzene	$CHCHCHC(CH_3)C(CH_3)C(CH_3)$	4,15	51	0,80	7,0			470		T1	IIA
168	Heptane (mixed isomers)	C_7H_{16}	3,46	–4	1,10	6,7	46	281	215	0,91	T3	IIA
169	Heptan-1-ol	$CH_3(CH_2)_5CH_2OH$	4,03	60					275	0,94		IIA

Table A.1 – Flammability data (continued)

Ref.	Gas or vapour	Formula	Rho	FP	Flammability limits				Ign.	MESG	T class	Group
			ρ		Lower	Upper	Lower	Upper	temp.			
				°C	Volume per cent		mg/l		°C	mm		
170	Hept-2-one	$CH_3CO(CH_2)_4CH_3$	3,94	39	1,10	7,9	52	378	533		T1	IIA
171	Hept-2-ene	$CH_3(CH_2)_3CH=CHCH_3$	3,40	<0					263	0,97	T3	IIA
172	Hexane (mixed isomers)	$CH_3(CH_2)_4CH_3$	2,97	–21	1,00	8,4	35	290	233	0,93	T3	IIA
173	1-Hexanol	$C_6H_{13}OH$	3,50	63	1,20		51		293	0,98	T3	IIA
174	Hexan-2-one	$CH_3CO(CH_2)_3CH_3$	3,46	23	1,20	8,0	50	336	533		T1	IIA
175	Hydrogen	H_2	0,07		4,00	77,0	3,4	63	560	0,28	T1	IIC
176	Hydrogen cyanide	HCN	0,90	<–20	5,40	46,0	60	520	538	0,80	T1	IIB
177	Hydrogen sulfide	H_2S	1,19		4,00	45,5	57	650	270	0,89	T3	IIB
178	4-Hydroxy-4-methyl-penta-2-one	$CH_3COCH_2C(CH_3)_2OH$	4,00	58	1,80	6,9	88	336	680		T1	IIA
179	Kerosene			38	0,70	5,0			210		T3	IIA
180	1,3,5-Trimethylbenzene	$CHC(CH_3)CHC(CH_3)CHC(CH_3)$	4,15	44	0,8	7,3	40	365	499	0,98	T1	IIA
181	Metaldehyde	$(C_2H_4O)_4$	6,10	36								IIA
182	Methacryloyl chloride	CH_2CCH_3COCl	3,60	17	2,50		108		510	0,94	T1	IIA
183	Methane (firedamp)	CH_4	0,55		4,40	17,0	29	113	537	1,14	T1	I
184	Methane (see 4.6)	CH_4			4,40	17,0	29	113	537		T1	IIA
185	Methanol	CH_3OH	1,11	11	5,50	38,0	73	484	386	0,92	T2	IIA
186	Methanethiol	CH_3SH	1,60		4,1	21,0	80	420	340	1,15	T2	IIA
187	2-Methoxyethanol	$CH_3OCH_2CH_2OH$	2,63	39	2,40	20,6	76	650	285	0,85	T3	IIB
188	Methyl acetate	CH_3COOCH_3	2,56	–10	3,20	16,0	99	475	502		T1	IIA
189	Methyl acetoacetate	$CH_3COOCH_2COCH_3$	4,00	62	1,30	14,2	62	685	280	0,85	T3	IIB
190	Methyl acrylate	$CH_2=CHCOOCH_3$	3,00	–3	2,40	25,0	85	903	415	0,85	T2	IIB
191	Methylamine	CH_3NH_2	1,00	–18 gas	4,20	20,7	55	270	430		T2	IIA

Table A.1 – Flammability data (continued)

Ref.	Gas or vapour	Formula	Rho	FP	Flammability limits				Ign.	MESG	T class	Group
			ρ		Lower	Upper	Lower	Upper	temp.			
				°C	Volume per cent		mg/l		°C	mm		
192	2-Methylbutane	$(CH_3)_2CHCH_2CH_3$	2,50	<–51	1,30	8,0	38	242	420	0,98	T2	IIA
193	2-Methylbutan-2-ol	$CH_3CH_2C(OH)(CH_3)_2$	3,03	16	1,40	10,2	50	374	392	1,10	T2	IIA
194	3-Methylbutan-1-ol	$(CH_3)_2CH(CH_2)_2OH$	3,03	42	1,30	10,5	47	385	339	1,06	T2	IIA
195	2-Methylbut-2-ene	$(CH_3)_2C=CHCH_3$	2,40	–53	1,30	6,6	37	189	290	0,96	T3	IIA
196	Methyl chloro-formate	CH_3OOCC	3,30	10	7,5	26	293	1 020	475	1,20	T1	IIA
197	Methylcyclobutane	$CH_3CH_2CH_2CH_2$										IIA
198	Methylcyclohexane	$CH_3CH(CH_2)_4CH_2$	3,38	–4	1,16	6,7	47	275	258		T3	IIA
199	Methylcyclohexanol	$CH_3C_3H_{10}OH$	3,93	68					295		T3	IIA
200	Methylcyclo-pentadienes (isomer not stated)	C_6H_6	2,76	<–18	1,30	7,6	43	249	432	0,92	T2	IIA
201	Methylcyclopentane	$CH_3CH(CH_2)_3CH_2$	2,90	<–10	1,00	8,4	35	296	258		T3	IIA
202	Methylenecyclo-butane	$C(=CH_2)CH_2CH_2CH_2$	2,35	<0	1,25	8,6	35	239	352	0,76	T2	IIB
203	4-Methylenetetra-hydropyran	$OCH_2CH_2C(=CH_2)CH_2CH_2$	3,78	2	1,60		60		255	0,89	T3	IIB
204	2-Methyl-1-buten-3-yne	$HC=CC(CH_3)CH_2$	2,28	–54	1,40		38		272	0,78	T3	IIB
205	Methyl formate	$HCOOCH_3$	2,07	–20	5,00	23,0	125	580	450		T2	IIA
206	2-Methylfuran	$OC(CH_3)CHCHCH$	2,83	<–16	1,40	9,7	47	325	318	0,95	T2	IIA
207	2-Methylhexa-3,5-dien-2-ol	$CH_2=CHC=CC(OH)(CH_3)_2$	3,79	24					347	1,14	T2	IIA
208	Methylisocyanate	CH_3NCO	1,98	–7	5,30	26,0	123	605	517	1,21	T1	IIA

Table A.1 – Flammability data (continued)

Ref.	Gas or vapour	Formula	Rho	FP	Flammability limits				Ign.	MESG	T class	Group
			ρ		Lower	Upper	Lower	Upper	temp.			
				°C	Volume per cent		mg/l		°C	mm		
209	Methyl methacrylate	$CH_3{=}CCH_3COOCH_3$	3,45	10	1,70	12,5	71	520	430	0,95	T2	IIA
210	Methyl 2-methoxy-propionate	$CH_3CH(CH_3O)COOCH_3$	4,06	48	1,20		58		211	1,07	T3	IIA
211	4-Methylpentan-2-ol	$(CH_3)_2CHCH_2CHOHCH_3$	3,50	37	1,14	5,5	47	235	334	1,01	T2	IIA
212	4-Methylpentan-2-one	$(CH_3)_2CHCH_2COCH_3$	3,45	16	1,20	8,0	50	336	475	1,01	T1	IIA
213	2-Methylpent-2-enal	$CH_3CH_2CHC(CH_3)COH$	3,78	30	1,46		58		206	0,84	T3	IIB
214	4-Methylpent-3-en-2-one	$(CH_3)_2(CCHCOCH)_3$	3,78	24	1,60	7,2	64	289	306	0,93	T2	IIA
215	2-Methylpropan-1-ol	$(CH_3)_2CHCH_2OH$	2,55	28	1,70	9,8	52	305	408	0,96	T2	IIA
216	2-Methylprop-1-ene	$(CH_3)_2C{=}CH_2$	1,93	gas	1,6	10	37	235	483	1,0	T1	IIA
217	2-Methylpyridine	$NCH(CH_3)CHCHCHCH$	3,21	27	1,20		45		533	1,08	T1	IIA
218	3-Methylpyridine	$NCHCH(CH_3)CHCHCH$	3,21	43	1,40	8,1	53	308	537	1,14	T1	IIA
219	4-Methylpyridine	$NCHCHCH(CH_3)CHCH$	3,21	43	1,10	7,8	42	296	534	1,12	T1	IIA
220	α-Methyl styrene	$C_6H_5C(CH_3){=}CH_2$	4,08	40	0,90	6,6	44	330	445	0,88	T2	IIB
221	Methyl tert-pentyl ether	$(CH_3)_2C(OCH_3)CH_2CH_3$	3,50	<–14	1,50		62		345	1,01	T2	IIA
222	2-Methylthiophene	$SC(CH_3)CHCHCH$	3,40	–1	1,30	6,5	52	261	433	1,15	T2	IIA
223	2-Methyl-5-vinyl-pyridine	$NC(CH_3)CHCHC(CH_2{=}CH)CH$	4,10	61					520	1,30	T1	IIA
224	Morpholine	$OCH_2CH_2NHCH_2CH_2$	3,00	31	1,80	15,2	65	550	230	0,92	T3	IIA
225	Naphtha		2,50	<–18	0,90	6,0			290		T3	IIA
226	Naphthalene	$C_{10}H_8$	4,42	77	0,90	5,9	48	317	528		T1	IIA

Table A.1 – Flammability data (continued)

Ref.	Gas or vapour	Formula	Rho	FP	Flammability limits				Ign.	MESG	T class	Group
			ρ		Lower	Upper	Lower	Upper	temp.			
				°C	Volume per cent		mg/l		°C	mm		
227	Nitrobenzene	$CH_3CH_2NO_2$	4,25	88	1,70	40,0	87	2 067	480	0,94	T1	IIA
228	Nitroethane	$C_2H_5NO_2$	2,58	27	3,40		107		410	0,87	T2	IIB
229	Nitromethane	CH_3NO_2	2,11	36	7,30	63,0	187	1 613	415	1,17	T2	IIA
230	1-Nitropropane	$CH_3CH_2CH_2NO_2$	3,10	36	2,20		82		420	0,84	T2	IIB
231	Nonane	$CH_3(CH_2)_7CH_2$	4,43	30	0,70	5,6	37	301	205		T3	IIB
232	2,2,3,3,4,4,5,5-Octafluoro-1,1-dimethylpentan-1-ol	$H(CF_2CF_2)_2C(CH_3)_2OH$	8,97	61					465	1,50	T1	IIA
233	Octaldehyde	$CH_3(CH_2)_5CHO$	4,42	52								IIA
234	Octane	$CH_3(CH_2)_3CH_3$	3,93	13	0,80	6,5	38	311	206	0,94	T3	IIA
235	1-Octanol	$CH_3(CH_2)_6CH_2OH$	4,50	81	0,9	7,4	49	385	270	1,05	T3	IIA
236	Octene (mixed isomers)	C_5H_{16}	3,66	–18	1,10	5,9	50	270	264	0,95	T3	IIA
237	Paraformaldehyde	poly(CH_2O)		70	7,00	73,0			380	0,57	T2	IIB
238	Penta-1,3-diene	CH_2=CH-CH=CH-CH_3	2,34	<–31	1,2	9,4	35	261	361	0,97	T2	IIA
239	Pentanes (mixed isomers)	C_5H_{12}	2,48	–40	1,40	7,8	42	236	258	0,93	T3	IIA
240	Pentane-2,4-dione	$CH_3COCH_2COCH_3$	3,50	34	1,70		71		340	0,96	T2	IIA
241	Pentan-1-ol	$CH_3(CH_2)_3CH_2OH$	3,03	38	1,06	10,5	38	385	298	1,30	T3	IIA
242	Pentanols (mixed isomers)	$C_5H_{11}OH$	3,04	34	1,20	10,5	44	388	300	1,02	T3	IIA
243	Pentan-3-one	$(CH_3CH_2)_2CO$	3,00	12	1,60		58		445	0,90	T2	IIA
244	Pentyl acetate	CH_3COO-$(CH_2)_4$-CH_3	4,48	25	1,00	7,1	55	387	360	1,05	T2	IIA
245	Petroleum		2,8	<–20	1,2	8,0			560		T1	IIA
246	Phenol	C_6H_5OH	3,24	75	1,3	9,5	50	370	595		T1	IIA
247	Phenylacetylene	C_6H_5C=CH	3,52	41					420	0,66	T2	IIB

Table A.1 – Flammability data (continued)

Ref.	Gas or vapour	Formula	Rho	FP	Flammability limits				Ign.	MESG	T class	Group
					Lower	Upper	Lower	Upper				
			ρ	°C	Volume per cent		mg/l		°C	mm		
248	Propane	$CH_3CH_2CH_3$	1,56	–104 gas	1,70	10,9	31	200	470	0,92	T1	IIA
249	Propan-1-ol	$CH_3CH_2CH_2OH$	2,07	22	2,20	17,5	55	353	405	0,89	T2	IIB
250	Propan-2-ol	$(CH_3)_2CHOH$	2,07	12	2,00	12,7	50	320	425	1,00	T2	IIA
251	Propene	$CH_2=CHCH_3$	1,50		2,00	11,0	35	194	455	0,91	T1	IIA
252	Propionic acid	CH_3CH_2COOH	2,55	52	2,1	12,0	64	370	435	1,10	T2	IIA
253	Propionic aldehyde	C_2H_5CHO	2,00	<–26	2,00		47		188	0,86	T4	IIB
254	Propyl acetate	$CH_3COOCH_2CH_2CH_3$	3,60	10	1,70	8,0	70	343	430	1,04	T2	IIA
255	Isopropyl acetate	$CH_3COOCH(CH_3)_2$	3,51	4	1,8	8,1	75	340	467	1,18	T1	IIA
256	Propylamine	$CH_3(CH_2)_2NH_2$	2,04	–37	2,00	10,4	49	258	318	1,13	T2	IIA
257	Isopropylamine	$(CH_3)_2CHNH_2$	2,03	<–24	2,30	8,6	55	208	340	1,05	T2	IIA
258	Isopropyl chloro-acetate	$ClCH_2COOCH(CH_3)_2$	4,71	42	1,60		89		426	1,24	T2	IIA
259	Isopropyl formate	$HCOOCH(CH_3)_2$	3,03	<–6					489	1,10	T1	IIA
260	2-Isopropyl-5-methylhex-2-enal	$(CH_3)_2CH\text{-}C(CHO)CHCH_2CH(CH_3)_2$	5,31	41	3,05		192		188	<1,0	T4	IIA
261	Isopropyl nitrate	$(CH_3)_2CHONO_2$		11	2,00	100,0	75	3 738	175		T4	IIB
262	Propyne	$CH_3C=CH$	1,38		1,70	16,8	28	280				IIB
263	Prop-2-yn-1-ol	$HC=CCH_2OH$	1,89	33	2,40		55		346	0,58	T2	IIB
264	Pyridine	C_5H_5N	2,73	17	1,70	12,0	58	398	550		T1	IIA
265	Styrene	$C_6H_5CH=CH_2$	3,60	30	1,10	8,0	48	350	490		T1	IIA
266	2,2,3,3-Tetrafluoro-1,1-dimethylpropan-1-ol	$HCF_2CF_2C(CH_3)_2OH$	5,51	35					447	1,42	T2	IIA
267	Tetrafluoroethylene	$CF_2=CF_2$	3,40		10,00	59,0	420	2 245	255	0,60	T3	IIB

Table A.1 – Flammability data (continued)

Ref.	Gas or vapour	Formula	Rho	FP	Flammability limits				Ign.	MESG	T class	Group
			ρ		Lower	Upper	Lower	Upper	temp.			
				°C	Volume per cent		mg/l		°C	mm		
268	1,1,2,2-Tetrafluoro-ethoxybenzene	$C_6H_5OCF_2CF_2H$	6,70	47	1,80		126		483	1,22	T1	IIA
269	2,2,3,3-Tetrafluoro-propan-1-ol	$HCF_2CF_2CH_2OH$	4,55	43					437	1,90	T2	IIA
270	2,2,3,3-Tetrafluoro-propyl acrylate	$CH_2=CHCOOCH_2CF_2CF_2H$	6,41	45	2,40		182		357	1,18	T2	IIA
271	2,2,3,3-Tetrafluoro-propyl methacrylate	$CH_2=C(CH_2)COOCH_2CF_2CF_2H$	6,90	46	1,90		155		389	1,18	T2	IIA
272	Tetrahydrofuran	$CH_2(CH_2)_2CH_2O$	2,49	–20	1,50	12,4	46	370	224	0,87	T3	IIB
273	Tetrahydrofurfuryl alcohol	$OCH_2CH_2CH_2CHCH_2OH$	3,52	70	1,50	9,7	64	416	280	0,85	T3	IIB
274	Tetrahydro-thiophene	$CH_2(CH_2)_2CH_2S$	3,04	13	1,10	12,3	42	450	200	0,99	T3	IIA
275	N,N,N′,N′-Tetra-methylmethane-diamine	$(CH_3)_2NCH_2N(CH_3)_2$	3,5	<–13	1,61		67		180	1,06	T4	IIA
276	Thiophene	$CH=CHCH=CHS$	2,90	–9	1,5	12,5	50	420	395	0,91	T2	IIA
277	Toluene	$C_6H_5CH_3$	3,20	4	1,1	7,6	42	300	535		T1	IIA
278	1,1,3-Triethoxy-butane	$(CH_3CH_2O)_2CHCH_2CH(CH_3CH_2O)CH_3$	6,56	33	0,78	5,8	60	451	165	0,95	T4	IIA
279	Triethylamine	$(CH_3CH_2)_3N$	3,50	–7	1,20	8,0	51	339				IIA
280	1,1,1-Trifluoro-ethane	CF_3CH_3	2,90		6,80	17,6	234	605	714	<2,00	T1	IIA
281	2,2,2-Trifluoro-ethanol	CF_3CH_2OH	3,45	30	8,4	28,8	350	1 195	463	3,00	T1	IIA
282	Trifluoroethylene	$CF_2=CFH$	2,83		15,30	27,0	502	904	319	1,40	T2	IIA
283	3,3,3-Trifluoro-prop-1-ene	$CF_3CH=CH_2$	3,31		4,70		184		490	1,75	T1	IIA

Table A.1 – Flammability data (concluded)

Ref.	Gas or vapour	Formula	Rho	FP	Flammability limits				Ign.	MESG	T class	Group
			ρ		Lower	Upper	Lower	Upper	temp.			
				°C	Volume per cent		mg/l		°C	mm		
284	Trimethylamine	$(CH_3)_3N$	2,04		2,00	12,0	50	297	190	1,05	T4	IIA
285	4,4,5-Trimethyl-1,3-dioxane	$OCH_2OCH(CH_3)C(CH_3)_2CH_2$	4,48	35					284	0,90	T3	IIA
286	2,2,4-Trimethyl-pentane	$(CH_3)_2CHCH_2C(CH_3)_3$	3,90	–12	1,0	6,0	47	284	411	1,04	T2	IIA
287	2,4,6-Trimethyl-1,3,5-trioxane	$OCH(CH_3)OCH(CH_3)OCH(CH_3)$	4,56	27	1,30		72		235	1,01	T3	IIA
288	1,3,5-Trioxane	$OCH_2OCH_2OCH_2$	3,11	45	3,20	29,0	121	1 096	410	0,75	T2	IIB
289	Turpentine			35	0,80				254		T3	IIA
290	Isovaleraldehyde	$(CH_3)_2CHCH_2CHO$	2,97	–12	1,70		60		207	0,98	T3	IIA
291	Vinyl acetate	$CH_3COOCH=CH_2$	3,00	–8	2,60	13,4	93	478	425	0,94	T2	IIA
292	Vinyl cyclohexenes (isomer not stated)	$CH_2CHC_6H_9$	3,72	15	0,80		35		257	0,96	T3	IIA
293	Vinylidene chloride	$CH_2=CCl_2$	3,40	–18	7,30	16,0	294	645	440	3,91	T2	IIA
294	2-Vinyloxyethanol	$CH_2=CH-OCH_2CH_2OH$	3,04	52					250	0,86	T3	IIB
295	2-Vinylpyridine	$NC(CH_2=CH)CHCHCHCH$	3,62	35	1,20		51		482	0,96	T1	IIA
296	4-Vinylpyridine	$NCHCHC(CH_2=CH)CHCH$	3,62	43	1,10		47		501	0,95	T1	IIA
297	Water gas			1,2							T1	IIC
298	Xylenes	$C_6H_4(CH_3)_2$	3,66	30	1,00	7,6	44	335	464	1,09	T1	IIA
299	Xylidenes	$C_6H_3(CH_3)_2NH_2$	4,17	96	1,00	7,0	50	355	370		T2	

Annex B
(informative)

Determination of time of response

B.1 Aspirated apparatus (see also figure B.1)

The apparatus is attached to the equipment, for example as shown schematically in figure B.1.

If the on/off operation is independent of the aspirator control, the apparatus is switched on and stabilized.

The two-way valve is adjusted to connect the apparatus to the clean air reservoir. Aspiration is performed until the apparatus is stabilized. The apparatus "zero" control is adjusted as necessary. Aspiration is stopped.

The two-way valve is adjusted to connect the apparatus to the test gas and aspiration is commenced. The *t*(50) and *t*(90) times of response are taken as the time intervals between the start of aspiration and the time when the apparatus reaches 50 % or 90 %, respectively, of the final indication.

A correction should be made to the time of response to allow for the aspiration of the dead volume between A and B in figure B.1.

B.2 Apparatus that samples by diffusion

B.2.1 Calibration mask method

Clean air is supplied to the apparatus, at the manufacturer's recommended linear flow rate but not exceeding 1 m/s, via the mask (see 4.2.3 and 4.3.4) until the apparatus is stabilized. The apparatus zero is adjusted as necessary. The test gas is then applied via a two-way valve. The *t*(50) and *t*(90) times response are taken as the time intervals between the time of application of the test gas and the time when the apparatus reaches 50 % or 90 %, respectively, of the final indication.

If the size of the mask is such that the time required to purge it with gas (with the apparatus in position) exceeds 25 % of the time of response of the apparatus, this test method is not acceptable and an alternative method is to be used.

It is essential to correct the time response to allow for the dead volume between the two-way tap and the entry port of the mask.

B.2.2 Applicator method (see also figures B.2 to B.4)

The apparatus is switched on and stabilized.

The clean air supply is applied to the apparatus via an applicator, for example as shown in figure B.2. The applicator is held in position until the apparatus is stabilized. The apparatus "zero" is adjusted as necessary.

The test gas is applied to the apparatus via a second, identical applicator in a *t*(50) and *t*(90) change over movement, for example as illustrated in figure B.3. The *t*(50) and *t*(90) times of

response are taken as the time interval between the time of application of the test gas applicator and the time when the apparatus reaches 50 % or 90 %, respectively, of the final indication.

NOTE 1 – The base of the applicator is in contact with the apparatus and completely surrounds the sensor inlet. The area of the base is at least twice the area of the sensor inlet.

NOTE 2 – The linear flow of clean air/test gas at the base of the applicators is 50 mm/s ± 5 mm/s.

NOTE 3 – The gaps at the base of the applicator are sufficient to prevent an overpressure within the applicator of more than 50 Pa (which corresponds to approximately a 5 mm head of water) with the applicator flush against the apparatus or sensor as shown by figure B.3.

NOTE 4 – The distance between the shoulder of the applicator and the sensor inlet is typically 10 diameters of the applicator, for example as shown in figure B.4.

NOTE 5 – It is envisioned that a range of applicators, based on the above parameters, will be required to test the full range of apparatus or sensors.

B.2.3 Test chamber method

B.2.3.1 Test chamber

The construction of the chamber may encompass a wide variety in design from sophisticated permanent installations to a simple specially constructed enclosure that, in the opinion of the testing laboratory, is capable of introducing the gases or the sensors in a rapid and reproducible manner.

An example of a test chamber is illustrated in figure B.5.

B.2.3.2 Procedure

Test chambers may be used in either of two ways:

a) the chamber is first filled with the standard test gas and the sensor is then plunged inside rapidly, or

b) the apparatus is put inside the chamber with the inlet of the sensor covered; the chamber is then filled with the standard test gas, and the sensor inlet is rapidly uncovered.

B.3 Step change response (see also figure B.6)

The apparatus used for this test is shown schematically in figure B.6 and operates as follows:

a) the lower vessel (1) is filled with water;

b) the toy balloon (2) is filled with a 100 % LFL gas/air mixture until it fills the lower end of the tube (3);

c) the gas/air mixture is forced into the lower vessel until the balloon is forced up the tube as far as it will go;

d) the balloon is fully inflated to seal the lower part of the tube;

e) the gas/air mixture is pumped into the lower vessel displacing the water into the upper vessel (4);

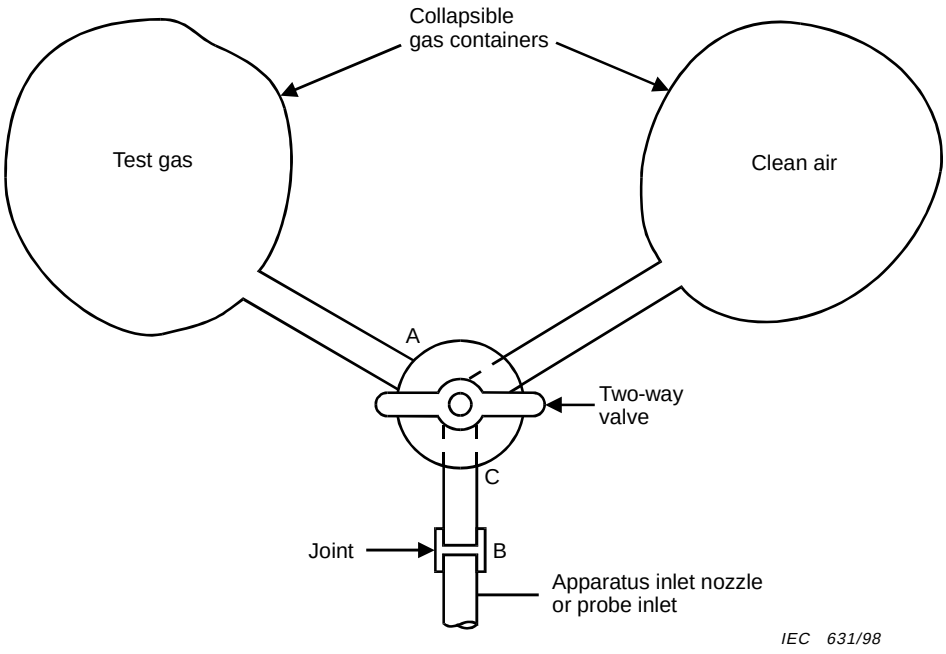
f) the detector head (5) is positioned in the tube about 5 cm above the upper end of the balloon and the output of the instrument is connected to a recorder;

g) the balloon is broken by inserting a pin into the tube at point (6). This results in an immediate release of the gas/air mixture from the balloon and from the 0,1 m^3 of volume in the lower vessel which is at approximately 7 kPA pressure. This immediately purges the tube and as the water returns to the lower vessel (which takes about 20 s) the tube is provided with a continuous flow of “fresh” mixture travelling at a speed of approximately 20 m/s. The duration of the flow can be extended to 30 s (the maximum test time), if necessary, by placing a restriction in the hose (7) between the two vessels. A recorder,

connected to the instrument output, will provide timing lines at 1 s intervals and this can be used to determine the time required to reach the 50 % LFL and 90 % LFL readings. As an alternative, the toy balloon in the 75 mm diameter tube may be replaced by a 75 mm (type size) ball valve. This simplifies the procedure considerably and the same results have been obtained by the rapid opening of the ball valve as by the bursting of the toy balloon.

B.4 Flooding (see also figure B.6)

This test is performed in the same manner as the step change response test in clause B.3, except that the test gas is used for filling the balloon and the lower vessel, instead of a gas/air mixture.



NOTE 1 – The volume of each gas reservoir is greater (by at least a factor of ten) than the volume of gas swept out during a time of response determination.

NOTE 2 – The bore of all tubing and connections is greater than the bore of the apparatus inlet nozzle or probe inlet.

NOTE 3 – The volume between the valve and the apparatus inlet (between B C) is kept to a minimum consistent with a good connection to the apparatus.

Figure B.1 – Schematic example of equipment for use with aspirated apparatus (see also B.1)

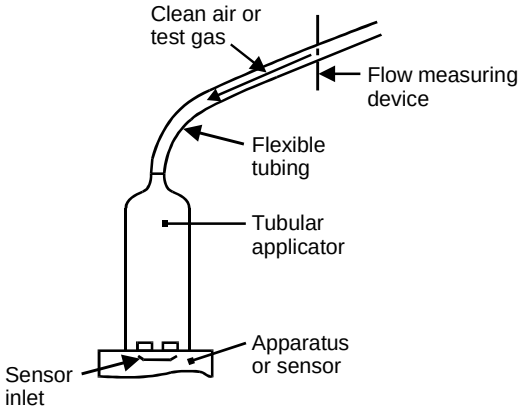


Figure B.2 – Schematic example of equipment during application of clean air or test gas (see also B.2.2)

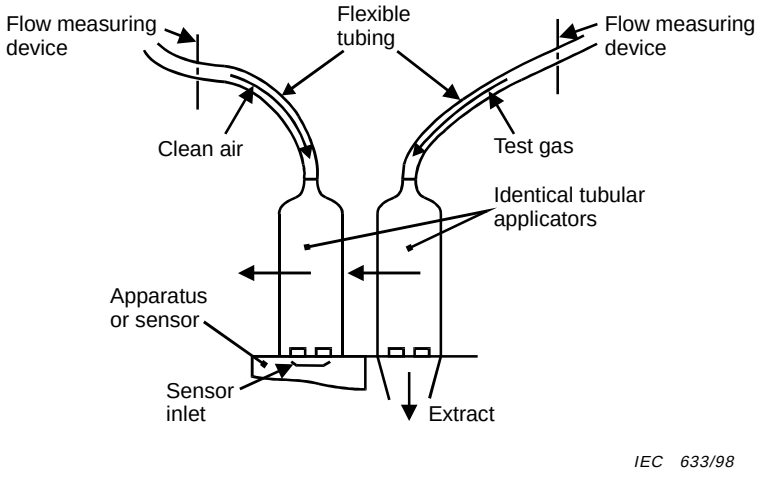


Figure B.3 – Schematic example of equipment showing change-over from clean air to test gas to begin the time of response measurement (arrows indicate movement of applicators) (see also B.2.2)

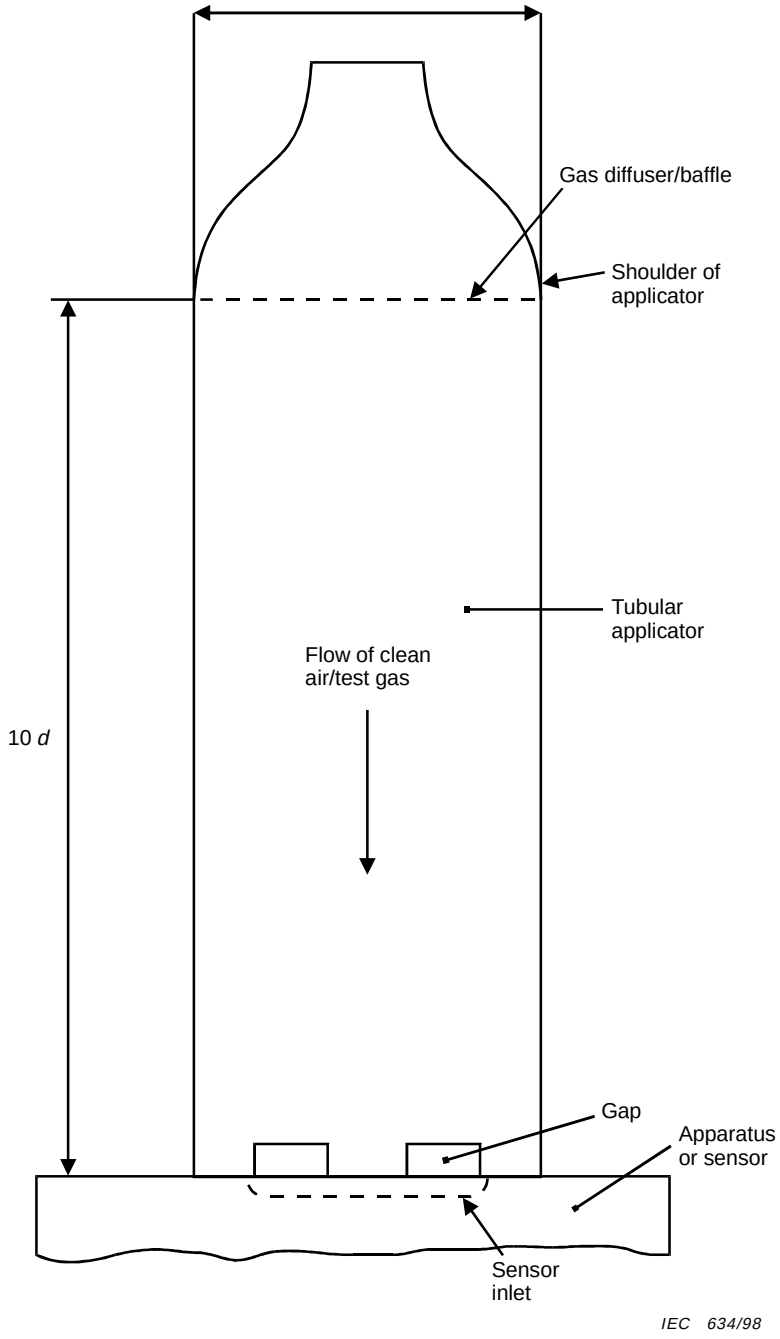


Figure B.4 – Schematic example of applicator and sensor inlet during application of test gas or clean air (see also B.2.2)

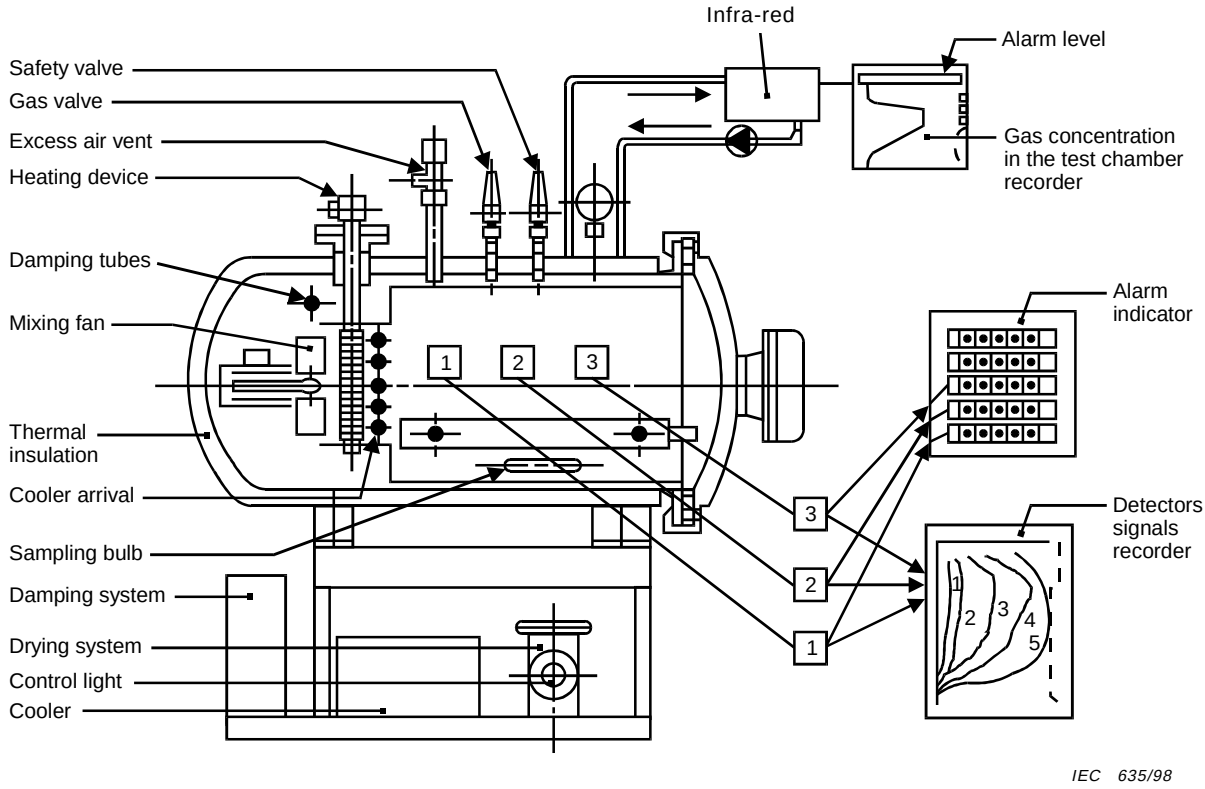
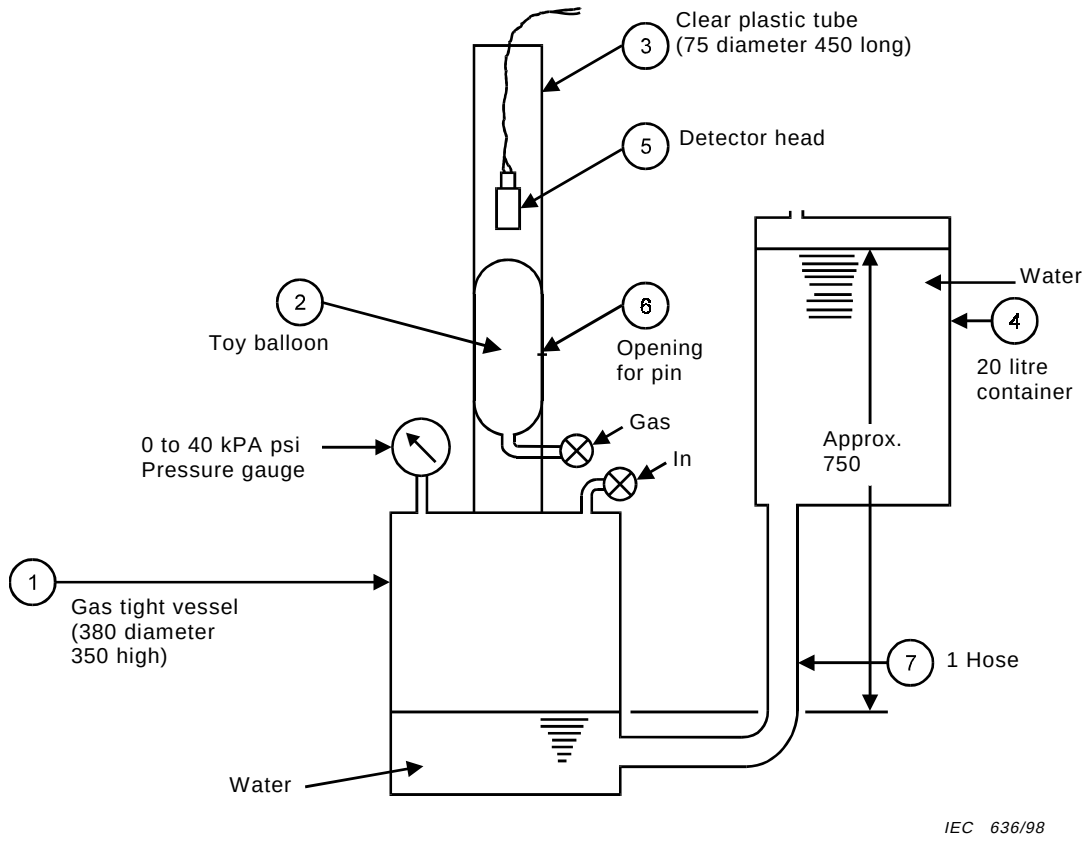


Figure B.5 – Example of automated test chamber (see also B.2.3.1)



Dimensions in millimetres

Figure B.6 – Apparatus for step change and flooding tests

Annex C
(informative)

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FACTORY MUTUAL RESEARCH CORPORATION

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- ☐ almost
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- ☐ mag tapes
- ☐ CD-ROM
- ☐ floppy disk
- ☐ on line

9A.

If your organization currently maintains part or all of its standards collection in electronic media, please indicate the format(s):

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- ☐ full text

10.

In what medium does your organization intend to maintain its standards collection in the future (check all that apply):

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- ☐ mag tape
- ☐ CD-ROM
- ☐ floppy disk
- ☐ on line

10A.

For electronic media which format will be chosen (check one)

- ☐ raster image
- ☐ full text

11.

My organization is in the following sector (e.g. engineering, manufacturing)

.....

12.

Does your organization have a standards library:

- ☐ yes
- ☐ no

13.

If you said yes to 12 then how many volumes:

.....

14.

Which standards organizations published the standards in your library (e.g. ISO, DIN, ANSI, BSI, etc.):

.....

15.

My organization supports the standards-making process (check as many as apply):

- ☐ buying standards
- ☐ using standards
- ☐ membership in standards organization
- ☐ serving on standards development committee
- ☐ other.....

16.

My organization uses (check one)

- ☐ French text only
- ☐ English text only
- ☐ Both English/French text

17.

Other comments:

.....

.....

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