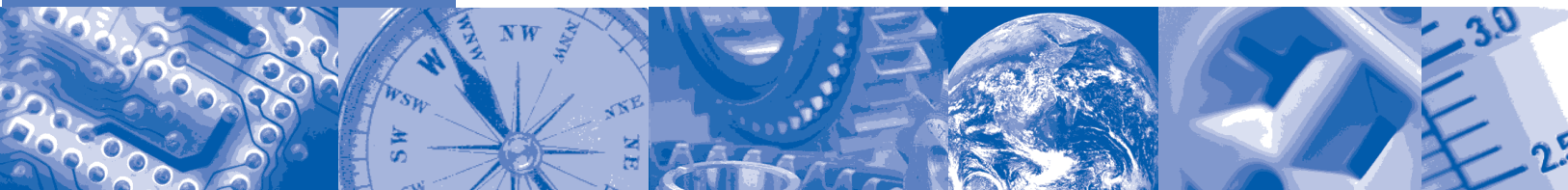


**ANSI/ISA-12.13.01-2003
(IEC 61779-1 through 5 Mod)**



Performance Requirements for Combustible Gas Detectors



**ISA—The Instrumentation,
Systems, and
Automation Society**

Approved 26 February 2003

ANSI/ISA-12.13.01 (IEC 61779-1 through 5 Mod)
Performance Requirements for Combustible Gas Detectors

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Preface

This preface is included for information purposes and is not part of ANSI/ISA-12.13.01 (IEC 61779-1 through 5 Mod).

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Foreword

All text of IEC 61779-1 through IEC 61779-5 is included in this document. U.S. National Deviations are shown by ~~strikeout~~ through deleted text and underline under added text. Tables or portions of tables that are to be deleted are shown as shaded; figures to be deleted are marked with the overlay “Figure X Deleted.” All added tables are numbered by a table number corresponding to the applicable subclause for improved clarity and are NOT underlined. Notes appear in the table titles showing the tables as added material.

For Part 1, there are four annexes and an introduction. Annex A is normative and Annexes B, C, D and the introduction are informative and are not considered part of this document. For Part 2 through 5, Annex A for each part is informative and is not considered part of this document.

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Introduction

This section provides an informative historical perspective on the development of combustible gas detection performance standards.

Need for Gas Detection Standards

From the early 1920's to the mid 1970's, gas detection requirements were mostly limited to the detection of combustible gases to warn of explosion hazards. This need created an industry aimed at providing portable and fixed apparatus that intermittently or continuously sample potentially hazardous areas and provide alarms and indications.

The Mine Safety and Health Administration (formerly known as the U.S. Bureau of Mines) has been certifying apparatus for use in mines since the late 1930's.

Since the mid 1970's, detectors submitted to some of the independent nationally recognized test laboratories (or NRTL's) for general hazardous area certifications also had to be tested to the lab's own performance standard.

Several standards organizations have provided standards and recommended practices to help users in the selection and application of these apparatus.

Existing Gas Detector Standards

Parts 22 and 27 of Title 30 of the U.S. Code of Federal Regulations provided some of the earliest requirements for apparatus that detect methane in mines. Part 22 - issued in 1935, applied to Portable Methane Detectors and part 27 - issued in 1966, applied to Methane Monitoring Systems. These two documents do still exist, but are fairly general in nature. They are each about 4 to 6 pages long and provide brief instructions on construction and performance requirements, but also include instructions on submitting apparatus for evaluation and notification of design changes after approval. No new work on these documents is in process at this time.

The Canadian standard - C22.2 No 152 - Combustible Gas Detection Instruments - was first issued in 1976 and last revised in 1988. The revision added an exclusion of open path detectors, revised the step change response test so that the acceptance criteria will now be to reach 90% of applied concentration (100% LFL gas), and Temperature Variation test was changed to include portables.

Factory Mutual issued its Combustible Gas Detectors Approval Standard 6310/6320 in 1982 and updated it in 1989 and 2001.

The American National Standards Institute (ANSI) adopted the ISA's S12.13, part 1 - titled Performance Requirements, Combustible Gas Detectors which was issued in 1986 and part 2 - Installation, Operation, and Maintenance of Combustible Gas Detection Instruments - issued in 1987.

The ANSI/ISA S12.13 part I performance standard - originally issued in 1975 - was based on the CSA document. It was revised slightly and released in October 1995 while work continued on issues that were balloted and released in 2000.

The document is cited in two sections of the U.S. federal regulations pertaining to offshore and loading platforms and preliminary discussions have proposed that it be adopted in other areas such as Parts 22 and 27 of Title 30 of the Code of Federal Regulations for mines and the parts of the National Electrical Code pertaining to equipment in hazardous locations.

The British Standards Institute issued EN50054 - Electrical Apparatus for the Detection and Measurement of Combustible Gases general requirements and test methods - in 1991 which supersedes the withdrawn BS 6020 which was issued in 1981. The associated documents EN50055 and EN50056 cover performance requirements for mines products indicating up to 5% by volume and 100% by volume methane. EN50057 and EN50058 document performance requirements for group II (non-mines) apparatus indicating up to 100% LEL and 100% by volume respectively.

The Australian Standard 2275 is titled Electrical Equipment for Explosive Atmospheres - Combustible Gas Detection Instruments. Part 1 is General Requirements for Explosion Protection of Electrical Apparatus and Systems. Part 2 is Performance Requirements. UL 1484 and BS 7348 are residential combustible gas detector standards and BS 6959 is a recommended practice for non-mines combustible gas detector applications. These documents are slightly outside the main focus of the SP12.13 subcommittee.

U.S. efforts in support of combustible gas detection applications

In the United States, a subcommittee of the ISA (the Instrumentation, Systems and Automation Society - formerly known as the Instrument Society of America) is working to support users and manufacturers of combustible gas detectors. The SP12.13 (Performance Requirements for Combustible Gas Detectors) subcommittee is a subcommittee of ISA's SP12 (Electrical Equipment for Hazardous Locations) committee. In turn, the ISA is accredited by the American National Standards Institute (ANSI) as a standard writing body and provides technical advisory groups to ANSI. Also, ANSI established the United States National Committee of the IEC, which serves as the ANSI sponsored, U.S. electrotechnical industry supported and staffed, interface with its international parent organization the International Electrotechnical Commission - IEC. The USNC also serves as the U.S. electrotechnical industry interface with the European Committee for Electrotechnical Standardization - CENELEC, the Pacific Area Standards Congress – PASC, the Pan American Standards Commission - COPANT, and the Council for Harmonization of Electrotechnical Standardization of North America - CANENA. For those not familiar with the IEC, it could be considered the sister organization to ISO. Based in Geneva, Switzerland, the IEC handles all topics pertaining to electrotechnical devices and ISO handles everything else. In short, the SP12.13 subcommittee serves as the technical advisory group (TAG) to the U.S. National Committee of the IEC. Other organizations throughout the world include subcommittees similar to SP12.13 (for example CENELEC TC 31-9 in Europe and subcommittees in Australia, South Africa and others).

The purpose of the SP12.13 subcommittee is “to actively monitor applications, be a source for technical information, and prepare documents as needed to improve minimum performance of combustible gas detection instruments.” The scope of the subcommittee includes:

Preparing standards and recommended practices for performance, installation, operation, and maintenance of combustion gas detection instruments.

Promoting current technology for proper use and maintenance to enhance safety of hazardous areas.

Serving as a source of technical information.

Supporting efforts to obtain international standards for these instruments.

The types of instruments and applications that the subcommittee is involved with are those involving industrial safety and do not include residential monitors or process analysis equipment.

The subcommittee maintains a balance between users, manufacturers, and others (government agencies, third party test labs, etc.) in accordance with ISA and ANSI requirements, although this is not necessary at the subcommittee level. The group meets formally twice a year in conjunction with SP12 meetings.

The ISA SP92 subcommittee is involved with detectors of oxygen and toxic gases.

The SP12.13 subcommittee is currently involved in the support of four documents:

The ANSI/ISA S12.13 part I performance standard as mentioned earlier in this text.

The document is cited in two sections of the U.S. federal regulations pertaining to offshore and loading platforms and preliminary discussions have been started to propose that it be adopted in other areas such as Parts 22 and 27 of Title 30 of the Code of Federal Regulations for mines and the parts of the National Electrical code pertaining to equipment in hazardous locations.

The RP 12.13 part II recommended practice was last issued in 1987 and should have been reaffirmed in 1997, but recommended practices are not as firm as standards on review rules. The first section had been placed into electronic media in preparation for editing, but we decided that we would adopt the IEC guide when it issues. The remainder of the document (Bureau of Mines 627) and Bureau of Mines 680 were released as technical reports as they contain very useful information pertaining to flame and explosion hazards.

Edition 1 of the IEC 31L performance standard (61779-1 through 5) was approved and published in 1998. Work to generate the U.S. version has been completed with National Deviations in ANSI/ISA-12.13.01-2002.

The IEC 61779-6 guide was released in 1999.

Some of the technical issues related to existing and new technologies continue to be debated by SP12.13 for clarifications or adjustment of testing procedures, but several more significant issues are worth mention.

EMI

By subjecting some gas detectors to radio or electromagnetic interference or electrostatic discharge, one could cause the apparatus to go into alarm or stop functioning all together. Many older standards either do not include requirements, or the requirements are considered to be inadequate. The present version of ANSI/ISA-12.13.01-2002 requires only that the apparatus indication not vary by more than 10% when a 5-watt radio is transmitting 1 meter away at two frequencies. Most committee members agree that the requirements should include a sweep of frequencies and that the field strength should be specified rather than the power rating of a radio because the resulting field depends on the efficiency of the last stage and antenna of the radio. Also, with the introduction of more communications products, wider frequencies need to be considered. Because more stringent requirements are likely to add cost to the products, care is being taken to propose only minimum EMI requirements that will satisfy most applications.

The subcommittee had developed a matrix of available EMI standards that could be cited, but this leaves the task of identifying the adequate test conditions and acceptance criteria. Another reference being considered is EN50270-1999. Manufacturers of communications equipment are being polled for information on expected field characteristics in the typical user's environment.

IR technology response

The introduction of infrared gas detectors brought with it improved long-term stability, but also slightly longer step recovery times on some models. This is because the sensor does not promote diffusion of the gas to the sensor surface as in catalytic sensors and because the sensor signal is non-linear. Some manufacturers propose that recovery time requirements should be relaxed in order to allow users to take advantage of lower maintenance costs and sensor poison resistance of IR sensors. Another important detail is that IR sensors do not detect hydrogen, but this is not a concern in most applications.

Open path

Open path monitors measure hydrocarbon concentrations over a fixed distance. The application of this technology for safety monitoring is debated because there could be a high concentration at one point on the path and none along the rest of the path, resulting in a low indication when in fact, a hazard exists. Others note that part of the open path question is similar to that of how many point detectors are needed to insure safety.

Entity concept & modular systems

The question being debated here is if it is wise to allow for approval of components of gas detection systems that could be matched with other components selected by the user. Detector heads might only contain the sensor, or could include additional electronics, which might require more testing. When the user matches these components with control units or data acquisition systems, the complete system is not guaranteed to perform within stated requirements.

Software quality requirements

With the increasing use of microprocessors and software in apparatus, subcommittee members have voiced concern that the gas detector standards should include requirements that will assure software quality. Also, should the standard prohibit connection of safety devices on same bus with non-safety components? Existing documents being considered include UL1998, prEN50271, ANSI/ISA-84.01-1996, and IEC 61508.

Harmonization

In many cases, harmonization and use of mutual recognition agreements between third party test labs will likely increase the amount of testing and cost associated with certifying a detector with one lab. However, because the one certificate would be accepted throughout the world, overall cost will be lower for those companies that address the world market. The users benefit because they can buy detectors from manufacturers anywhere in the world and be assured of product quality by citing the IEC standards.

Guidance for the selection, installation, use and maintenance of gas detecting apparatus are set out in IEC Publication 61779-6 ANSI/ISA-RP12.13.02 (IEC 61779-6 Mod).

Part 1 (IEC 61779-1 Mod)
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~~ ANSI/ISA-12.13.01 (IEC 61779-1 through 5 Mod) 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~~ 2.1.3) ~~and in mines susceptible to firedamp~~. This document is supplemented by the following parts, concerning the specific requirements for performance of the various types of apparatus:

~~Part 2: Performance requirements for group I (mines) apparatus indicating up to a volume fraction of 5 % methane in air~~

~~Part 3: Performance requirements for group I (mines) apparatus indicating up to a volume fraction of 100 % methane in air~~

Part 4: Performance requirements for group II (non-mining) apparatus indicating up to a volume fraction of 100% lower explosive limit

Part 5: Performance requirements for group II (non-mining) apparatus indicating up to a volume fraction of 100% gas

NOTE 1 ~~IEC 61779-1~~ Part 1 of ANSI/ISA-12.13.01 (IEC 61779-1 through 5 Mod), in association with the parts 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 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 and 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 document, 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.

NOTE 4 For the purpose of this document, the terms "explosive gas atmosphere" and "flammable gas atmosphere" are deemed to be synonymous.

1.1.2 This document 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 document 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 potential explosion hazard and in some cases to initiate automatic or manual protective action(s).

1.1.4 This document is applicable to apparatus, including the integral sampling systems of aspirated apparatus, intended to be used for commercial and industrial (non-residential) safety applications.

1.1.5 This document does not apply to external sampling systems, or to apparatus of laboratory or scientific type, or to apparatus used only for process control purposes. It also does not apply to open path (line of sight) area monitors (refer to CENELEC prEN 50241-1 and prEN 50241-2, February 1996). For apparatus used for sensing the presence of multiple gases, this document applies only to the portion sensing the presence of flammable gas or vapor.

1.2 ~~Normative~~ references

The following ~~normative~~ documents contain provisions, which, through reference in this text, constitute provisions of this part of ~~IEC 61779~~ ANSI/ISA-12.13.01 (IEC 61779-1 through 5 Mod). 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~~ ANSI/ISA-12.13.01 (IEC 61779-1 through 5 Mod) 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. ANSI maintains registers of currently valid U.S. National Standards.

IEC 60050(351): ~~1975~~, International Electrotechnical Vocabulary (IEV) — Chapter 351: Automatic control

ANSI/ISA-12.00.01-2002 (IEC 60079-0 Mod): 1983, Electrical Apparatus for Use in Class I, Zones 0 & 1 Hazardous (Classified) Locations: ~~explosive gas atmospheres~~ — Part 0: General requirements.

ANSI/ISA-12.22.01-2002 (IEC 60079-1 Mod): 1990, Electrical Apparatus for Use in Class I, Zone 1 Hazardous (Classified) Locations: ~~explosive gas atmospheres~~ — Part 1: ~~Construction and verification test of flameproof enclosures of electrical apparatus~~ Type of Protection – Flameproof “d”.

IEC 60079-2: 1983, ~~Electrical apparatus for explosive gas atmospheres~~ — Part 2: ~~Electrical apparatus type of protection “p”~~ NFPA 496-1998 Standard for Purged and Pressurized Enclosures for Electrical Equipment.

ANSI/ISA-12.25.01-1998 (IEC 60079-5 Mod): 1967, Electrical Apparatus for Use in Class I, Zone 1 Hazardous (Classified) Locations: ~~explosive gas atmospheres~~ — Part 5: ~~Sand filled apparatus~~ Type of Protection – Powder Filling “q”.

ANSI/ISA-12.26.01-1998 (IEC 60079-6 Mod): 1995, Electrical Apparatus for Use in Class I, Zone 1 Hazardous (Classified) Locations: ~~explosive gas atmospheres~~ — Part 6: ~~Type of Protection – Oil immersion “o”~~.

ANSI/ISA-12.16.01-2002 (IEC 60079-7 Mod): 1990, Electrical Apparatus for Use in Class I, Zone 1 Hazardous (Classified) Locations: ~~explosive gas atmospheres~~ — Part 7: ~~Type of Protection – Increased safety “e”~~.

ANSI/ISA-TR12.24.01-1998 (IEC 60079-10 Mod): 1995, ~~Electrical apparatus for explosive gas atmospheres~~ — Part 10: ~~Classification of hazardous areas~~ Recommended Practice for Classification of Locations for Electrical Installations Classified as Class I, Zone 0, Zone 1, or Zone 2.

ANSI/ISA-12.02.01-2002 (IEC 60079-11 Mod): 1994, Electrical Apparatus for Use in Class I, Zones 0, 1, and 2 Hazardous (Classified) Locations: ~~explosive gas atmospheres~~ — Part 11: ~~Type of Protection – 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).

ANSI/ISA-12.12.01-2000, Nonincendive Electrical Equipment for Use in Class I and II, Division 2 and Class III, Divisions 1 and 2 Hazardous (Classified) Locations. ~~IEC 60079-15: 1987, Electrical apparatus for explosive gas atmospheres — Part 15: Electrical apparatus, with Type of Protection "n"~~

ANSI/ISA-12.23.01-2002 (IEC 60079-18 Mod): 1992, Electrical Apparatus for Use in Class I, Zone 1 Hazardous (Classified) Locations: explosive gas atmospheres — Part 18: Type of Protection – 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.~~ NFPA 497-1997, Recommended Practice for the Classification of Flammable Liquids, Gases, Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas.

IEC ~~801-4: 1984~~ 61000-4-1: 1992, Electromagnetic compatibility for industrial-process measurement and control equipment — Part 1: General introduction

IEC ~~801-3: 1984~~ 61000-4-3: 1995, Electromagnetic compatibility for industrial-process measurement and control equipment — Part 3: Radiated electromagnetic field requirements

IEC ~~801-4: 1988~~ 61000-4-4: 1995, Electromagnetic compatibility for industrial process measurement and control equipment — Part 4: Electrical fast transient/burst requirements

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~~ ANSI/ISA-12.13.01 (IEC 61779-1 through 5 Mod), 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 fibers in suspension in air. Mists are not covered by this document.

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 document 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~~ does not be formed form, expressed as a percentage (see Annex A).

NOTE This is also known as lower explosive limit (LEL).

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~~ does not be formed form, expressed as a percentage (see also note 2 to 2.1.3 Annex A).

NOTE This is also known as upper explosive limit (UEL).

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 recommended by the manufacturer 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 parts 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~~ which 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 carried from place to place and to be used while it is being carried. A portable apparatus is battery ~~powered~~ operated and includes, but is not limited to

- a) ~~a~~ hand-held apparatus, typically less than 1 kg, suitable for ~~one-handed~~ single-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 larger~~ apparatus that can be operated by the user while it is ~~carried either~~ suspended by hand, ~~or by means of a shoulder strap or by a carrying harness; it and which~~ by a carrying harness; it and which may or may not have a hand directed probe

2.2.9 spot-reading apparatus:

apparatus intended to ~~operate~~ be used for short periods of only a few minutes for irregular intervals time as required (typically 5 min or less).

2.2.10 transportable apparatus:

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

2.2.11 stand-alone gas detection apparatus:

fixed gas detection apparatus that provide a conditioned electronic signal or output indication intended to be utilized with stand-alone control units, or signal processing data acquisition, central monitoring and similar systems which typically process information from various locations and sources including, but not limited to, gas detection apparatus.

2.2.12 stand-alone control unit:

fixed gas detection control units intended to provide meter indication, alarm functions and/or output contacts when utilized with stand-alone gas detection apparatus.

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 that~~ may also contain associated circuit components.

2.4 Supply of gas to instrument

2.4.1 sample line:

~~pipeline by a~~ means by 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 $\pm 1\%$ 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).

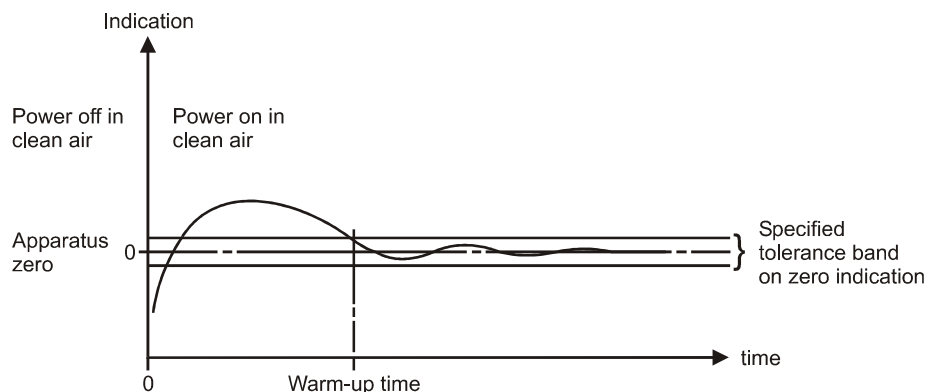


Figure 1 — Warm-up time in clean air (typical)

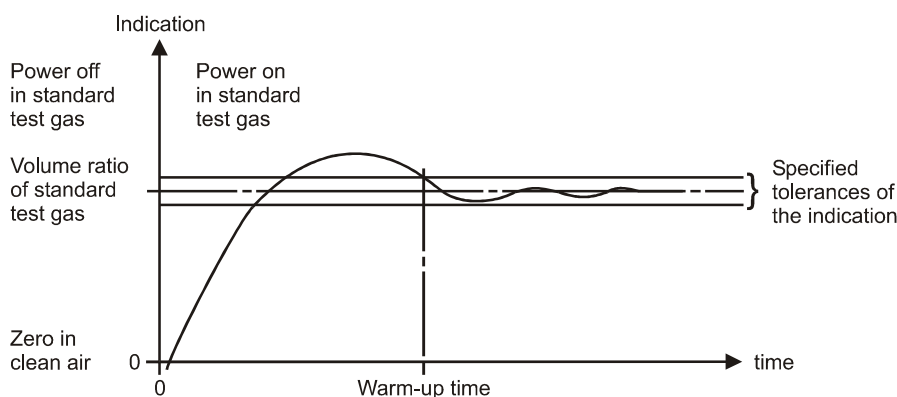


Figure 2 — Warm-up time in standard test gas (typical)

3 General requirements

3.1 Introduction

3.1.1 Apparatus shall comply with both the requirements of this document and the appropriate part(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 to the construction and explosion protection as specified in the appropriate parts listed in 1.1.1 and in the appropriate standards of IEC 60079. The appropriate standards are as follows:

~~IEC 60079-0~~ ANSI/ISA-12.00.01-2002 (IEC 60079-0 Mod)

~~IEC 60079-1~~ ANSI/ISA-12.22.01-2002 (IEC 60079-1 Mod)

~~IEC 60079-2~~ ANSI/NFPA 496

NOTE The requirements for pressurization can be found within ANSI/NFPA 496, "Pressurized Enclosures for Electrical Equipment" along with additional guidance in ISA-RP12.4, "Pressurized Enclosures".

~~IEC 60079-5~~ ANSI/ISA-12.25.01-1998 (IEC 60079-5 Mod)

~~IEC 60079-6~~ ANSI/ISA-12.26.01-1998 (IEC 60079-6 Mod)

~~IEC 60079-7~~ ANSI/ISA-12.16.01-2002 (IEC 60079-7 Mod)

~~IEC 60079-11~~ ANSI/ISA-12.02.01-2002 (IEC 60079-11 Mod)

~~IEC 60079-13~~

~~IEC 60079-15~~ ANSI/ISA-12.12.01-2000

~~IEC 60079-18~~ ANSI/ISA-12.23.01-2002 (IEC 60079-18 Mod)

~~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, special account shall be taken of the risks arising from faults in the program.

NOTE No specific test requirements have been developed, but they are under consideration. When sufficient information is available, a new IEC work item proposal will be initiated.

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 byproducts 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 readout device is inadequate to demonstrate compliance with this document, the manufacturer shall identify suitable points for connecting indicating or recording devices for the purpose of testing the compliance of the apparatus with this document. The indication on the readout device shall not contradict the results obtained by additional indicating or recording devices.

~~3.2.2.3 Where a readout 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 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 labeled 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 nonlatching - 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 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 designed to indicate when full scale has been exceeded and which therefore is 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, loss of continuity in one or more of the wires to any sensor, or 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 with:

- a) fixed and transportable apparatus — an integral flow-indicating device that produces a fault signal in the event of flow failure;
- b) portable apparatus — 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, in the case of a keyboard instrument, or mechanical 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, they 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 tested according to 4.4.19, it shall comply with the requirements of the appropriate parts of this document listed in 1.1.1.

3.2.7 Stand-alone gas detection apparatus for use with separate control units

3.2.7.1 General

3.2.7 includes apparatus that provide a conditioned electronic signal or output indication intended to be used with stand-alone control units, separate signal processing, data acquisition, central monitoring or other similar systems which typically process information from various locations and sources including, but not limited to, gas detection instrumentation.

3.2.7.2 Transfer function specification

A specification shall be supplied with the apparatus that describes the relationship the gas concentration (detected by the apparatus) has with the corresponding output signal or indication (transfer function). Such specification shall be detailed to the extent that the accuracy of this transfer function can be verified. As a minimum, the manufacturer shall provide data showing the relationship between the output signal and the gas concentrations corresponding to 0, 10%, 25%, 50%, 75% and 100% of full-scale output indication. Full-scale output shall also be as specified by the manufacturer.

3.2.7.3 Provision for transfer function verification

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

3.2.7.4 Tests

Stand alone gas detection apparatus shall be tested to the requirements of 4.4.2 through 4.4.13, 4.4.15, 4.4.16, 4.4.18, 4.4.20, 4.4.21, 4.4.22 and 4.4.25 using the parameters of the transfer function.

3.2.8 Separate control units for use with stand-alone gas detection apparatus

3.2.8.1 General

3.2.8 includes those apparatus to be used with stand-alone gas detection apparatus (as defined in 3.2.7) to complete a "performance evaluated" combustible gas detection system.

3.2.8.2 Tests

The control units shall be tested to the requirements of 4.4.2, 4.4.3, 4.4.6, 4.4.7, 4.4.13, 4.4.20, 4.4.21 and 4.4.25 using the parameters of the transfer function pertinent to the specific type of gas detector.

3.3 Labeling and marking

The apparatus shall comply with the marking requirements contained in the relevant 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 “ANSI/ISA-12.13.01 Part x”, where x represents the applicable part(s) 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) the specific marking describing the type of explosive protection.
- f) the specific marking "CAUTION — READ AND UNDERSTAND INSTRUCTION MANUAL BEFORE OPERATING OR SERVICING."
- g) for portables apparatus indicating 0-100% LFL, the specific marking "CAUTION — OFF-SCALE READINGS MAY INDICATE EXPLOSIVE CONCENTRATION."

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 ANSI/ISA-RP12.13.02 (IEC 61779-6 Mod).

- 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 apparatus, replacement parts, and accessories, including, where applicable, the following:
- 1) Temperature
 - 2) Humidity
 - 3) Time
 - 4) Pressure
- f) the 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 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 them and state their effects on the instrument characteristics (e.g. including response time and sensitivity) and provide means for identification of these (e.g. part numbers included in manual);
- p) details of certification and marking and any special conditions of service;
- q) the 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.~~

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 part of this document 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 to operate (4.4.17)
- Addition of sampling probe (4.4.22)
- Field calibration kit (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)
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 through 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 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 document. 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 nearly as possible as for typical service, 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" impedance yielding the worst case load conditions for the respective test 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 judgment 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~~ Unless otherwise noted, optional parts shall be either attached or removed according to which condition will give the most unfavorable 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 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 document, where it is appropriate to use zero gas rather than clean air, references to clean air may be regarded as references to zero gas.

NOTE 2 The gas mixture may be prepared by any suitable method, for example, in accordance with the methods outlined in ISO 6142, 6145, 6146 or 6147.

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

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 $(1.5 \pm 0.15)\%$ or a volume fraction of $(2.0 \pm 0.2)\%$, as agreed between the manufacturer and the testing laboratory;~~
- ~~b) for other group I and all group II apparatus: 45% to 55% of measuring range, wherever possible, not within the explosive range;~~
- c) the volume ratios shall be known to an accuracy of $\pm 2\%$ 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 $\pm 2^\circ\text{C}$ 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 $\pm 10\%$ 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.

4.3.11 Communications options

For apparatus having serial or parallel communications options, tests in 4.4.3 and 4.4.16 shall be performed with all communication ports connected to test apparatus which initiates the maximum transaction rate, cabling and activity level specified by the instrument's manufacturer.

4.3.12 Gas detection apparatus as part of systems

For gas detection apparatus which are part of systems, tests in 4.4.3 and 4.4.16 shall be performed with the maximum system communications transaction rate and activity level which would result from the largest and most complex system configuration permitted 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 in the standard test gas unless otherwise stated. The values of the indications used for verification of compliance with the performance parts of this document 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 $-25^{\circ}\text{C} \pm 3^{\circ}\text{C}$ for 24 h;
- b) ambient temperature for at least 24 h;
- c) a temperature of $60^{\circ}\text{C} \pm 2^{\circ}\text{C}$ for 24 h;
- d) ambient temperature for at least 24 h.

The above temperatures may be varied only after 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)

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, during which, at approximately 10 min intervals, the apparatus shall be exposed to the standard test gas until stabilized. Indications in air and standard test gas shall be taken for each exposure (six applications).

~~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 on 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 on, 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 5 % (v/v) methane and all group~~ Group II spot-reading apparatus

The apparatus shall be exposed to clean air for 1 min followed by 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 100 % (v/v) methane~~

~~The apparatus shall be exposed to clean air for 1 min, followed by 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 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:

- a) 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, the alarm shall activate following application of the standard test gas;
- b) 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;
- c) 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 $(120 \pm 10)\%$ 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 the alarm(s) actuate(s) or twice $t(90)$, whichever is less.

4.4.7 Temperature

This test shall be performed in a temperature chamber with the capability of holding the sensor or apparatus at the specified temperature within $\pm 2^\circ\text{C}$. When the apparatus (or the portion under test) has reached the temperature specified in the parts of this document 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 the 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 standard test gas respectively.

4.4.9 Humidity

Air with three different humidities evenly distributed over the range specified shall separately be supplied 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 $\pm 3\%$ 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 standard test gas to meet the requirements of the parts of this document listed in 1.1.1.

For apparatus having integral sensors 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 automatic aspirated apparatus

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

The apparatus flow rate shall be tested by varying the flow rate

- a) from 130% of nominal flow rate or, if this is not possible, from the nominal flow rate,
- b) 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 $\pm 15^\circ$ from the nominal orientation, if the manufacturer has stated orientation limits of $\pm 15^\circ$ or less.

4.4.13 Vibration

4.4.13.1 ~~Apparatus~~ Test equipment

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 procedure.

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 set to no higher than 20% of full-scale range.

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 a standard part 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:

- a) 10 Hz to 30 Hz, 1.0 mm total excursion
- b) 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:

- a) 10 Hz to 30 Hz, 1.0 mm total excursion;
- b) 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 shall 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 shall be ~~set to no higher than~~ 20% of full-scale range.

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 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).

~~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 the 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 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 ~~5 % (v/v) 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 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 between 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. It shall then be subjected to the tests specified in 4.4.20.2 and 4.4.20.3.

4.4.20.2 a.c. 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 voltage 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~~ shall be set to no higher than 20% of full-scale range.

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 hexamethyldisiloxane 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.

~~4.4.24.3 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 of 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 susceptibility 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 to no higher than 20% of full-scale range.

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 control unit shall be submitted for 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.

4.4.26 Dielectric strength

Following completion of all applicable tests from the preceding clauses, the equipment shall be subjected to dielectric strength tests as specified by ANSI/ISA-82.02.01-1999 (IEC 61010-1 Mod) or other comparable recognized standard.

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 NFPA 497-1997 Recommended Practice for the Classification of Flammable Liquids, Gases, Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas ~~table A.1 only~~ for performing the type testing according to this document.

~~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, — 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. temp.	MESG	T-class	Group
					Lower	Upper	Lower	Upper				
			<i>p</i>	°C	Volume per cent		mg/l		°C	mm		
1	Acetaldehyde	CH ₃ CHO	1,52	–38	4,00	60,00	74	1108	204	0,92	T3	IIA
2	Acetic acid	CH ₃ COOH	2,07	40	4,00	17,0	100	428	464	1,78	T1	IIA
3	Acetic anhydride	(CH ₃ CO) ₂ O	3,52	49	2,00	10,0	85	428	334	1,23	T2	IIA
4	Acetone	(CH ₃) ₂ CO	2,00	≤–20	2,50	13,0	80	316	535	1,01	T1	IIA
5	Acetonitrile	CH ₃ CN	1,42	2	3,00	16,0	51	275	523	1,50	T1	IIA
6	Acetyl chloride	CH ₃ COCl	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 ₃ COF	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	0,86	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 ₂ CHCOCl	3,12	–8	2,68	18,0	220	662	463	1,06	T1	IIA
13	Allyl acetate	CH ₂ =CHCH ₂ OOCCH ₃	3,45	13	1,70	9,3	69	3 800	348	0,96	T2	IIA
14	Allyl alcohol	CH ₂ =CHCH ₂ CH	2,00	21	2,50	18,0	61	438	378	0,84	T2	IIb
15	Allyl chloride	CH ₂ =CHCH ₂ Cl	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-CHCH ₂ CH ₂ O	3,94	45					249	0,70	T3	IIb
17	2-Aminoethanol	NH ₂ CH ₂ CH ₂ OH	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 ₆ H ₅ CH ₂ CH(NH ₂)CH ₃	4,67	≤100								IIA
20	Aniline	C ₆ H ₅ NH 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 ρ	FP °C	Flammability limits				Ign. temp. °C	MESG mm	T-class	Group
					Lower Volume per cent	Upper	Lower mg/l	Upper				
21	Azepane	$\text{CH}_2(\text{CH}_2)_5\text{NH}$	3,41	23					279	1,00	T3	IIA
22	Benzaldehyde	$\text{C}_6\text{H}_5\text{CHO}$	3,66	64	1,40		62		492		T4	IIA
23	Benzene	C_6H_6	2,70	-11	1,20	8,6	39	280	560	0,99	T1	IIA
24	1-Bromobutane	$\text{CH}_3(\text{CH}_2)_2\text{CH}_2\text{Br}$	4,72	13	2,50	6,6	143	380	265		T3	IIA
25	2-Bromo-1,1-diepoxyethane	$(\text{CH}_3\text{CH}_2\text{O})_2\text{CHCH}_2\text{Br}$	7,34	57					175	1,00	T4	IIA
26	Bromoethane	$\text{CH}_3\text{CH}_2\text{Br}$	3,75	<-20	6,70	11,3	306	517	511		T1	IIA
27	Buta-1,3-diene	$\text{CH}_2=\text{CHCH}=\text{CH}_2$	1,87	-85 gas	1,40	16,3	31	365	430	0,79	T2	IIIB
28	Butane	C_4H_{10}	2,05	-80 gas	1,40	9,3	33	225	372	0,96	T2	IIA
29	Isobutane	$(\text{CH}_3)_2\text{CHCH}_3$	2,00	gas	1,3	9,8	31	236	460	0,95	T1	IIA
30	Butan-1-ol	$\text{CH}_3(\text{CH}_2)_2\text{CH}_2\text{OH}$	2,55	29	1,70	12,0	52	372	359	0,94	T2	IIA
31	Butanone	$\text{CH}_3\text{CH}_2\text{COCH}_3$	2,48	-9	1,80	10,0	50	302	404	0,84	T2	IIIB
32	But-1-ene	$\text{CH}_2=\text{CHCH}_2\text{CH}_3$	1,95	-80 gas	1,60	10,0	38	235	440	0,94	T2	IIA
33	But-2-ene (isomer not stated)	$\text{CH}_3\text{CH}=\text{CHCH}_3$	1,94	gas	1,60	10,0	40	228	325	0,89	T2	IIIB
34	But-3-en-2-olide	$\text{CH}_2=\text{CCH}(\text{O})\text{O}$	2,90	33					282	0,84	T3	IIIB
35	2-(2-Butoxyethoxy)ethanol	$\text{CH}_3(\text{CH}_2)_3\text{OCH}_2\text{CH}_2\text{OCH}_2\text{CH}_2\text{OH}$	5,59	78					225	1,11	T3	IIA
36	Butyl acetate	$\text{CH}_3\text{COOCH}_2(\text{CH}_2)_2\text{CH}_3$	4,01	22	1,3	7,5	64	390	370	1,04	T2	IIA
37	n-Butyl acrylate	$\text{CH}_2=\text{CHCOOC}_4\text{H}_9$	4,41	38	1,2	8,0	63	425	268	0,88	T3	IIIB
38	Butylamine	$\text{CH}_3(\text{CH}_2)_3\text{NH}_2$	2,52	-12	1,7	9,8	49	286	312	0,92	T2	IIA
39	Isobutylamine	$(\text{CH}_3)_2\text{CHCH}_2\text{NH}_2$	2,52	-20	1,47	10,8	44	330	374	1,15	T2	IIA
40	Butyl-2,3-epoxypropyl ether	$\text{CH}_3(\text{CH}_2)_3\text{OCH}_2\text{CHCH}_2\text{O}$	4,48	44					262	0,78	T3	IIIB

Table A.1 — Flammability data (continued)

Ref	Gas or vapour	Formula	Rho ρ	FP °C	Flammability limits				Ign. temp. °C	MESG mm	T-class	Group
					Lower Volume per cent	Upper	Lower mg/l	Upper				
41	Butyl glycolate	$\text{HOCH}_2\text{COOC}_4\text{H}_9$	4,45	64						0,88		II B
42	Isobutyl isobutyrate	$(\text{CH}_3)_2\text{CHCOOCH}_2\text{CH}(\text{CH}_3)_2$	4,93	34	0,80		47		424	1,00	T2	II A
43	Butyl methacrylate	$\text{CH}_2=\text{C}(\text{CH}_3)\text{COO}(\text{CH}_2)_3\text{CH}_3$	4,90	53	1,00	6,8	58	395	289	0,95	T3	II A
44	Tert-butyl methyl ether	$\text{CH}_3\text{OC}(\text{CH}_3)_2$	3,03	-27	1,50	8,4	54	310	385	1,00	T2	II A
45	n-Butyl propionate	$\text{C}_2\text{H}_5\text{COOC}_4\text{H}_9$	4,48	40	1,10	7,7	58	409	389	0,93	T2	II A
46	But-1-yne	$\text{CH}_3\text{CH}_2\text{C}\equiv\text{CH}$								0,74		II B
47	Butyraldehyde	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CHO}$	2,48	-16	1,80	12,5	54	378	191	0,92	T4	II A
48	Isobutyraldehyde	$(\text{CH}_3)_2\text{CHCHO}$	2,48	-22	1,6	11,0	47	320	176	0,92	T4	II A
49	Isobutyric acid	$(\text{CH}_3)_2\text{CHCOOH}$	3,03	58					460	1,02	T2	II A
50	Butynyl fluoride	$\text{C}_3\text{H}_7\text{COF}$	3,10	<-14	2,60		95		440	1,14	T4	II A
51	Carbon disulphide (see 4.4)	CS_2	2,64	-30	0,60	60,0	19	1 900	95	0,20 0,34	T6	II C
52	Carbon monoxide (saturated at 18 °C) (see 4.5)	CO	0,97		10,00	74,0	126	870	805	0,84	T4	II B
53	Carbonyl sulphide	CO S	2,07		6,5	28,5	180	700	209	1,35	T3	II A
54	Chlorobenzene	$\text{C}_6\text{H}_5\text{Cl}$	3,88	28	1,40	11,0	66	520	637		T4	II A
55	1-Chlorobutane	$\text{CH}_3(\text{CH}_2)_2\text{CH}_2\text{Cl}$	3,20	-12	1,80	10,0	69	386	250	1,06	T3	II A
56	2-Chlorobutane	$\text{CH}_3\text{CHClCH}_2\text{CH}_3$	3,19	<-18	2,20	8,8	82	339	368	1,16	T2	II A
57	1-Chloro-2,3-epoxypropane	$\text{OCH}_2\text{CHCH}_2\text{Cl}$	3,30	28	2,30	34,4	86	1 325	385	0,74	T2	II B
58	Chloroethane	$\text{CH}_3\text{CH}_2\text{Cl}$	2,22		3,60	15,4	95	413	510		T4	II A
59	2-Chloroethanol	$\text{CH}_2\text{ClCH}_2\text{OH}$	2,78	55	5,00	16,0	160	540	425		T2	II A
60	Chloroethylene	$\text{CH}_2=\text{CHCl}$	2,15	-78 gas	3,60	33,0	94	610	415	0,96	T2	II A

Table A.1—Flammability data (continued)

Ref	Gas or vapour	Formula	Rho ρ	FP °C	Flammability limits				Ign. temp. °C	MESG mm	T-class	Group
					Lower Volume per cent	Upper	Lower mg/l	Upper				
61	Chloromethane	CH_3Cl	1,78	-24 gas	7,60	19,0	160	410	625	1,00	T1	IIA
62	Chloromethyl methyl ether	$\text{CH}_3\text{OCH}_2\text{Cl}$	2,78	-8								IIA
63	1-Chloro-2-methylpropane	$(\text{CH}_3)_2\text{CHCH}_2\text{Cl}$	3,19	<-14	2,00	8,6	75	340	416	1,25	T2	IIA
64	2-Chloro-2-methylpropane	$(\text{CH}_3)_3\text{CCl}$	3,19	<-18					541	1,40	T1	IIA
65	3-Chloro-2-methylprop 1-ene	$\text{CH}_2=\text{C}(\text{CH}_3)\text{CH}_2\text{Cl}$	3,12	-16	2,10		77		478	1,16	T1	IIA
66	5-Chloropentan-2-one	$\text{CH}_3\text{CO}(\text{CH}_2)_3\text{Cl}$	4,16	61	2,00		98		440	1,10	T2	IIA
67	1-Chloropropane	$\text{CH}_3\text{CH}_2\text{CH}_2\text{Cl}$	2,70	-32	2,40	11,1	78	365	520		T1	IIA
68	2-Chloropropane	$(\text{CH}_3)_2\text{CHCl}$	2,70	<-20	2,80	10,7	92	360	590	1,23	T1	IIA
69	Chlorotrifluoroethylene	$\text{CF}_2=\text{CFCl}$	4,01	gas	4,6	84,3	220	3 117	607	1,50	T1	IIA
70	1-Chloro-2,2,2-trifluoroethyl methyl ether	$\text{CF}_3\text{CHClOCH}_3$	5,12	4	8,00		484		430	2,80	T2	IIA
71	α -Chlorotoluene	$\text{C}_6\text{H}_5\text{CH}_2\text{Cl}$	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)	$\text{CH}_3\text{C}_6\text{H}_4\text{OH}$	3,73	81	1,10		50		555		T1	IIA
75	Crotonaldehyde	$\text{CH}_3\text{CH}=\text{CHCHO}$	2,41	13	2,10	16,0	82	470	280	0,84	T3	IIA
76	Cumene	$\text{C}_6\text{H}_5\text{CH}(\text{CH}_3)_2$	4,13	31	0,80	6,6	40	328	424	1,05	T2	IIA
77	Cyclobutane	$\text{CH}_2(\text{CH}_2)_2\text{CH}_2$	1,93		1,80		42					IIA

Table A.1 — Flammability data (continued)

Ref	Gas or vapour	Formula	Rho ρ	FP °C	Flammability limits				Ign. temp. °C	MESG mm	T-class	Group
					Lower Volume per cent	Upper	Lower mg/l	Upper				
78	Cycloheptane	$\text{CH}_2(\text{CH}_2)_5\text{CH}_2$	3,39	<10	1,10	6,7	44	275				IIA
79	Cyclohexane	$\text{CH}_2(\text{CH}_2)_4\text{CH}_2$	2,90	-18	1,20	8,3	40	290	259	0,94	T3	IIA
80	Cyclohexanol	$\text{CH}_2(\text{CH}_2)_4\text{CHOH}$	3,45	61	1,20	11,1	50	460	300		T3	IIA
81	Cyclohexanone	$\text{CH}_2(\text{CH}_2)_4\text{CO}$	3,38	43	1,00	9,4	42	386	419	0,98	T2	IIA
82	Cyclohexene	$\text{CH}_2(\text{CH}_2)_3\text{CH=CH}$	2,83	-17	1,20		41		244		T3	IIA
83	Cyclohexylamine	$\text{CH}_2(\text{CH}_2)_4\text{CHNH}_2$	3,42	32	1,60	9,4	63	372	293		T3	IIA
84	1,3-Cyclopentadiene	$\text{CH}_2\text{CHCHCHCH}$	2,30	-50					485	0,99	T1	IIA
85	Cyclopentane	$\text{CH}_2(\text{CH}_2)_3\text{CH}_2$	2,40	-37	1,4		41		320	1,01	T2	IIA
86	Cyclopentene	$\text{CH=CHCH}_2\text{CH}_2\text{CH}$	2,30	<-22	1,48		41		309	0,96	T2	IIA
87	Cyclopropane	$\text{CH}_2\text{CH}_2\text{CH}_2$	1,45		2,40	10,4	42	183	498	0,91	T1	IIA
88	Cyclopropyl-methyl ketone	$\text{CH}_3\text{COCHCH}_2\text{CH}_2\text{CH}_2$	2,80	15	1,70		58		452	0,97	T1	IIA
89	p-Cymene	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}(\text{CH}_3)_2$	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-Dodecafluoroheptyl-methacrylate	$\text{CH}_2=\text{C}(\text{CH}_3)\text{COOCH}_2(\text{CF}_2)_6\text{H}$	9,93	49	1,60		185		390	1,46	T2	IIA
91	Decahydro-naphthalene-trans	$\text{CH}_2(\text{CH}_2)_3\text{CHCH}(\text{CH}_2)_3\text{CH}_2$	4,76	54	0,70	4,9	40	284	288		T3	IIA
92	Decane (mixed isomers)	$\text{C}_{10}\text{H}_{22}$	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 ρ	FP °C	Flammability limits				Ign. temp. °C	MESG mm	T-class	Group
					Lower Volume per cent	Upper	Lower mg/l	Upper				
93	Dibutyl ether	$(\text{CH}_3(\text{CH}_2)_3)_2\text{O}$	4,48	25	0,90	8,5	48	460	198	0,68	T4	II B
94	Di-tert-butyl peroxide	$(\text{CH}_3)_3\text{COOC}(\text{CH}_3)_3$	5,0	48					170	0,84	T4	II B
95	Dichlorobenzenes (isomer not stated)	$\text{C}_6\text{H}_4\text{Cl}_2$	5,07	86	2,20	9,2	134	564	648		T1	II A
96	3,4-Dichlorobut-1-ene	$\text{CH}_2=\text{CHCHClCH}_2\text{Cl}$	4,34	34	1,30	7,2	66	368	469	1,38	T1	II A
97	1,3-Dichlorobut-2-ene	$\text{CH}_3\text{CCl}=\text{CHCH}_2\text{Cl}$	4,34	27					469	1,34	T1	II A
98	Dichlorodiethylsilane	$(\text{C}_2\text{H}_5)_2\text{SiCl}_2$		24	3,40		223			0,45		II C
99	1,1-Dichloroethane	CH_3CHCl_2	3,42	-10	5,60	16,0	230	660	440		T2	II A
100	1,2-Dichloroethane	$\text{CH}_2\text{ClCH}_2\text{Cl}$	3,42	13	6,20	16,0	255	654	438	1,82	T2	II A
101	Dichloroethylene	$\text{ClCH}=\text{CHCl}$	3,55	-10	9,70	12,8	394	516	440	3,94	T2	II A
102	1,2-Dichloropropane	$\text{CH}_3\text{CHClCH}_2\text{Cl}$	3,90	15	3,40	14,5	160	682	557		T1	II A
103	Dicyclopentadiene (technical)	$\text{C}_{10}\text{H}_{12}$	4,55	36	0,80		43		455	0,94	T1	II A
104	1,2-Diethoxyethane	$\text{C}_2\text{H}_5\text{O}(\text{CH}_2)_2\text{OC}_2\text{H}_5$	4,07	16					170	0,84	T4	II B
105	Diethylamine	$(\text{C}_2\text{H}_5)_2\text{NH}$	2,53	-23	1,70	10,0	50	306	342		T2	II A
106	Diethylcarbonate	$(\text{CH}_3\text{CH}_2\text{O})_2\text{CO}$	4,07	24	4,4	11,7	69	570	450	0,83	T2	II B
107	Diethyl ether	$(\text{CH}_3\text{CH}_2)_2\text{O}$	2,55	-45	1,70	36,0	60	1 118	160	0,87	T4	II B
108	Diethyl oxalate	$(\text{COOCH}_2\text{CH}_3)_2$	5,04	76						0,90		II A
109	Diethyl sulphate	$(\text{CH}_3\text{CH}_2)_2\text{SO}_4$	5,34	104					360	1,11	T2	II A
110	1,1-Difluoroethylene	$\text{CH}_2=\text{CF}_2$	2,24		3,90	25,4	102	665	380	1,10	T2	II A
111	Dihexyl ether	$(\text{CH}_3(\text{CH}_2)_5)_2\text{O}$	6,43	75					187		T4	II A

Table A.1 — Flammability data (continued)

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

Table A.1 — Flammability data (continued)

Ref.	Gas or vapour	Formula	Rho ρ	FP °C	Flammability limits				Ign. temp. °C	MESG mm	T-class	Group
					Lower	Upper	Lower	Upper				
					Volume per cent		mg/l					
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	IIIB
135	1,2-Epoxypropene	CH_3CHCH_2O	2,00	-37	1,90	37,0	49	901	430	0,70	T2	IIIB
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	IIIB
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	IIIB
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 acetate	$CH_3COOCH_2COOCH_2CH_3$	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	IIIB
145	Ethylamine	$C_2H_5NH_2$	1,50	<-20	2,68	14,0	49	260	425	1,20	T2	IIA
146	Ethylbenzene	$CH_2CH_2C_6H_5$	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	$CH_3CH_2CHCH_2CH_2CH_2$	290	<-16	1,20	7,7	42	272	212		T3	IIA
149	Ethylcyclohexane	$CH_3CH_2CH(CH_2)_4CH_2$	3,87	<-24	0,90	6,6	42	310	238		T3	IIA
150	Ethylcyclopentane	$CH_3CH_2CH(CH_2)_3CH_2$	3,40	<-5	1,05	6,8	42	280	262		T3	IIA

Table A.1 — Flammability data (continued)

Ref.	Gas or vapour	Formula	Rho ρ	FP °C	Flammability limits				Ign. temp. °C	MESG mm	T-class	Group
					Lower	Upper	Lower	Upper				
					Volume per cent		mg/l					
151	Ethylene	$\text{CH}_2=\text{CH}_2$	0,97		2,3	36,0	26	423	425	0,65	T2	II B
152	Ethylenediamine	$\text{NH}_2\text{CH}_2\text{CH}_2\text{NH}_2$	2,07	34	2,7	16,5	64	396	403	1,18	T2	II A
153	Ethylene oxide	$\text{CH}_2\text{CH}_2\text{O}$	1,52	<-18	2,60	100,0	47	1 848	435	0,59	T2	II B
154	Ethyl formate	$\text{HCOOCH}_2\text{CH}_3$	2,65	-20	2,70	16,5	87	497	440	0,91	T2	II A
155	2-Ethylexyl acetate	$\text{CH}_3\text{COOCH}_2\text{CH}(\text{C}_2\text{H}_5)\text{C}_4\text{H}_9$	5,94	44	0,75	6,2	53	439	335	0,88	T2	II B
156	Ethyl isobutyrate	$(\text{CH}_3)_2\text{CHCOOC}_2\text{H}_5$	4,00	10	1,60		75		438	0,86	T2	II A
157	Ethyl methacrylate	$\text{CH}_2=\text{C}(\text{CH}_3)\text{COOCH}_2\text{CH}_3$	3,90	(20)	1,50		70			1,01		II A
158	Ethyl methyl ether	$\text{CH}_3\text{OCH}_2\text{CH}_3$	2,10		2,00	10,1	50	255	190		T4	II B
159	Ethyl nitrite (see 4.2)	$\text{CH}_3\text{CH}_2\text{ONO}$	2,60	-35	3,00	50,0	94	1 555	95	0,96	T6	II A
160	O-Ethyl phosphorodichloridate	$\text{C}_2\text{H}_5\text{OPSCl}_2$	7,27	75					234	1,20	T3	II A
161	Ethylpropylacrolein (isomer not stated)	$\text{C}_8\text{H}_{14}\text{O}$	4,34	40					184	0,86	T4	II B
162	Formaldehyde	HCHO	1,03		7,00	73,0	88	920	424	0,57	T2	II B
163	Formic acid	HCOOH	1,60	42	10,0	57,0	190	1 049	520	1,86	T1	II A
164	2-Furaldehyde	$\text{OCH}=\text{CHCH}=\text{CHCHO}$	3,30	60	2,10	19,3	85	768	316	0,88	T2	II B
165	Furan	$\text{CH}=\text{CHCH}=\text{CHO}$	2,30	<-20	2,30	14,3	66	408	390	0,68	T2	II B
166	Furfuryl alcohol	$\text{OC}(\text{CH}_2\text{OH})\text{CHCHCH}$	3,38	61	1,8	16,3	70	670	370	0,8	T2	II B
167	1,2,3-Trimethylbenzene	$\text{CHCHCH}(\text{CH}_3)\text{C}(\text{CH}_3)\text{C}(\text{CH}_3)$	4,15	51	0,80	7,0			470		T1	II A
168	Heptane (mixed isomers)	C_7H_{16}	3,46	-4	1,10	6,7	46	281	215	0,91	T3	II A
169	Heptan-1-ol	$\text{CH}_3(\text{CH}_2)_5\text{CH}_2\text{OH}$	4,03	60					275	0,94		II A

Table A.1 — Flammability data (continued)

Ref.	Gas or vapour	Formula	Rho ρ	FP °C	Flammability limits				Ign. temp. °C	MESG mm	T-class	Group
					Lower	Upper	Lower	Upper				
					Volume per cent		mg/l					
170	Hept-2-one	$\text{CH}_3\text{CO}(\text{CH}_2)_4\text{CH}_3$	3,94	39	1,10	7,9	52	378	533		T1	IIA
171	Hept-2-ene	$\text{CH}_3(\text{CH}_2)_3\text{CH}=\text{CHCH}_3$	3,40	<0					263	0,97	T3	IIA
172	Hexane (mixed isomers)	$\text{CH}_3(\text{CH}_2)_4\text{CH}_3$	2,97	-21	1,00	8,4	35	290	233	0,93	T3	IIA
173	1-Hexanol	$\text{C}_6\text{H}_{13}\text{OH}$	3,50	63	1,20		51		293	0,98	T3	IIA
174	Hexan-2-one	$\text{CH}_3\text{CO}(\text{CH}_2)_3\text{CH}_3$	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	$\text{CH}_3\text{COCH}_2\text{C}(\text{CH}_3)_2\text{OH}$	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	$\text{CH}_3(\text{CH}_3)_3\text{CHC}(\text{CH}_3)_2\text{CHC}(\text{CH}_3)_2$	4,15	44	0,8	7,3	40	365	499	0,98	T1	IIA
181	Metalddehyde	$(\text{C}_2\text{H}_4\text{O})_4$	6,10	36								IIA
182	Methacryloyl chloride	$\text{CH}_2\text{C}(\text{CH}_3)\text{COCl}$	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	†
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	$\text{CH}_3\text{OCH}_2\text{CH}_2\text{OH}$	2,63	39	2,40	20,6	76	650	285	0,85	T3	IIb
188	Methyl acetate	$\text{CH}_3\text{COOCH}_3$	2,56	-10	3,20	16,0	99	475	502		T1	IIA
189	Methyl acetate	$\text{CH}_3\text{COOCH}_2\text{COCH}_3$	4,00	62	1,30	14,2	62	685	280	0,85	T3	IIb
190	Methyl acrylate	$\text{CH}_2=\text{CHCOOCH}_3$	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 ρ	FP °C	Flammability limits				Ign. temp. °C	MESG mm	T-class	Group
					Lower	Upper	Lower	Upper				
					Volume per cent	per cent	mg/l	mg/l				
192	2-Methylbutane	$(CH_3)_2CHCH_2CH_3$	2,50	<-51	1,30	8,0	38	242	420	0,08	T2	IIA
193	2-Methylbutan-2-ol	$CH_3C(CH_3)_2C(OH)(CH_3)_2$	3,03	16	1,40	10,2	50	374	392	1,10	T2	IIA
194	3-Methylbutan-1-ol	$(CH_3)_2CHCH_2CH_2OH$	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 chloroformate	CH_3OOC	3,30	10	7,5	26	293	1 020	475	1,20	T1	IIA
197	Methylcyclobutane	$CH_3C_3H_7CH_2CH_2$										IIA
198	Methylcyclohexane	$CH_3C_6H_{11}CH_2$	3,38	-4	1,16	6,7	47	275	258		T3	IIA
199	Methylcyclohexanol	$CH_3C_6H_{11}OH$	3,93	68					295		T3	IIA
200	Methylcyclopentadienes (isomer not stated)	C_6H_6	2,76	<-18	1,30	7,6	43	249	432	0,92	T2	IIA
201	Methylcyclopentane	$CH_3C_4H_9CH_2$	2,90	<-10	1,00	8,4	35	296	258		T3	IIA
202	Methylenecyclobutane	$C(=CH_2)CH_2CH_2CH_2$	2,35	<0	1,25	8,6	35	239	352	0,76	T2	IIIB
203	4-Methylenetetrahydropyran	$OCH_2CH_2C(=CH_2)CH_2CH_2$	3,78	2	1,60		60		255	0,89	T3	IIIB
204	2-Methyl-1-buten-3-yne	$HC\equiv CC(CH_3)CH_2$	2,28	-54	1,40		38		272	0,78	T3	IIIB
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 ρ	FP °C	Flammability limits				Ign. temp. °C	MESG mm	T-class	Group
					Lower	Upper	Lower	Upper				
					Volume per cent	per cent	mg/l	mg/l				
209	Methyl methacrylate	$\text{CH}_3=\text{C}(\text{CH}_3)\text{COOCH}_3$	3,45	40	1,70	12,5	71	520	430	0,95	T2	IIA
210	Methyl 2-methoxypropionate	$\text{CH}_3\text{CH}(\text{CH}_3\text{O})\text{COOCH}_3$	4,06	48	1,20		58		211	1,07	T3	IIA
211	4-Methylpentan-2-ol	$(\text{CH}_3)_2\text{CHCH}_2\text{CHOHCH}_3$	3,50	37	1,14	5,5	47	235	334	1,01	T2	IIA
212	4-Methylpentan-2-one	$(\text{CH}_3)_2\text{CHCH}_2\text{COCH}_3$	3,45	16	1,20	8,0	50	336	475	1,01	T1	IIA
213	2-Methylpent-2-enal	$\text{CH}_3\text{CH}_2\text{CH}(\text{CH}_3)\text{CHO}$	3,78	30	1,46		58		206	0,84	T3	IIIB
214	4-Methylpent-3-en-2-one	$(\text{CH}_3)_2\text{C}(\text{CH}_3\text{COCH}_2)_2$	3,78	24	1,60	7,2	64	289	306	0,93	T2	IIA
215	2-Methylpropan-1-ol	$(\text{CH}_3)_2\text{CHCH}_2\text{OH}$	2,55	28	1,70	9,8	52	305	408	0,96	T2	IIA
216	2-Methylprop-1-ene	$(\text{CH}_3)_2\text{C}=\text{CH}_2$	1,93	gas	1,6	10	37	235	483	1,0	T1	IIA
217	2-Methylpyridine	$\text{NC}(\text{CH}_3)\text{CHCHCHCH}$	3,21	27	1,20		45		533	1,08	T1	IIA
218	3-Methylpyridine	$\text{NCCHCH}(\text{CH}_3)\text{CHCHCH}$	3,21	43	1,40	8,1	53	308	537	1,14	T1	IIA
219	4-Methylpyridine	$\text{NCCHCHCH}(\text{CH}_3)\text{CHCH}$	3,21	43	1,10	7,8	42	296	534	1,12	T1	IIA
220	α -Methylstyrene	$\text{C}_6\text{H}_5\text{C}(\text{CH}_3)=\text{CH}_2$	4,08	40	0,90	6,6	44	330	445	0,88	T2	IIIB
221	Methyl tert-pentyl ether	$(\text{CH}_3)_2\text{C}(\text{OCH}_3)\text{CH}_2\text{CH}_3$	3,50	< -14	1,50		62		345	1,01	T2	IIA
222	2-Methylthiophene	$\text{SC}(\text{CH}_3)\text{CHCHCH}$	3,40	-1	1,30	6,5	52	261	433	1,15	T2	IIA
223	2-Methyl-5-vinylpyridine	$\text{NC}(\text{CH}_3)\text{CHCHCH}(\text{CH}_2=\text{CH})\text{CH}$	4,10	61					520	1,30	T1	IIA
224	Morpholine	$\text{OCH}_2\text{CH}_2\text{NHCH}_2\text{CH}_2$	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 <i>p</i>	FP °C	Flammability limits				Ign. temp. °C	MESG	T class	Group
					Lower	Upper	Lower	Upper				
					Volume per cent		mg/l			mm		
227	Nitrobenzene	CH ₃ CH ₂ NO ₂	4,25	88	1,70	40,0	87	2 067	480	0,94	T1	IIA
228	Nitroethane	C ₂ H ₅ NO ₂	2,58	27	3,40		107		410	0,87	T2	IIB
229	Nitromethane	CH ₃ NO ₂	2,11	36	7,30	63,0	187	1 613	415	1,17	T2	IIA
230	1-Nitropropane	CH ₃ CH ₂ CH ₂ NO ₂	3,10	36	2,20		82		420	0,84	T2	IIB
231	Nonane	CH ₃ (CH ₂) ₇ CH 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 ₂ CF ₂) ₂ C(CH ₃) ₂ OH	8,97	61					465	1,50	T1	IIA
233	Octaldehyde	CH ₃ (CH ₂) ₅ CHO	4,42	52								IIA
234	Octane	CH ₃ (CH ₂) ₃ CH ₃	3,93	13	0,80	6,5	38	311	206	0,94	T3	IIA
235	1-Octanol	CH ₃ (CH ₂) ₆ CH ₂ OH	4,50	81	0,9	7,4	49	385	270	1,05	T3	IIA
236	Octene (mixed isomers)	C ₈ H ₁₆	3,66	-18	1,10	5,9	50	270	264	0,95	T3	IIA
237	Paraformaldehyde	poly(CH ₂ O)		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 ₅ H ₁₂	2,48	-40	1,40	7,8	42	236	258	0,93	T3	IIA
240	Pentane-2,4-dione	CH ₃ COCH ₂ COCH ₃	3,50	34	1,70		71		340	0,96	T2	IIA
241	Pentan-1-ol	CH ₃ (CH ₂) ₃ CH ₂ OH	3,03	38	1,06	10,5	38	385	298	1,30	T3	IIA
242	Pentanols (mixed isomers)	C ₅ H ₁₁ OH	3,04	34	1,20	10,5	44	388	300	1,02	T3	IIA
243	Pentan-3-one	(CH ₃ CH ₂) ₂ CO	3,00	12	1,60		58		445	0,90	T2	IIA
244	Pentyl acetate	CH ₃ COO-(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 ₆ H ₅ OH	3,24	75	1,3	9,5	50	370	595		T1	IIA
247	Phenylacetylene	C ₆ H ₅ C=CH	3,52	41					420	0,66	T2	IIB

Table A.1 — Flammability data (continued)

Ref.	Gas or vapour	Formula	Rho ρ	FP °C	Flammability limits				Ign. temp., °C	MESG mm	T-class	Group
					Lower	Upper	Lower	Upper				
					Volume per cent	per cent	mg/l					
248	Propane	CH ₃ CH ₂ CH ₃	1.56	-104 gas	1.70	10.9	31	200	470	0.92	T1	IIA
249	Propan-1-ol	CH ₃ CH ₂ CH ₂ OH	2.07	22	2.20	17.5	55	353	405	0.89	T2	IIIB
250	Propan-2-ol	(CH ₃) ₂ CHOH	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 ₃ CH ₂ COOH	2.55	52	2.1	12.0	64	370	435	1.10	T2	IIA
253	Propionic aldehyde	C ₂ H ₅ CHO	2.00	<-26	2.00		47		188	0.86	T4	IIIB
254	Propyl acetate	CH ₃ COOCH ₂ CH ₂ CH ₃	3.60	10	1.70	8.0	70	343	430	1.04	T2	IIA
255	Isopropyl acetate	CH ₃ COOCH(CH ₃) ₂	3.51	4	1.8	8.1	75	340	467	1.18	T1	IIA
256	Propylamine	CH ₃ (CH ₂) ₂ NH ₂	2.04	-37	2.00	10.4	49	258	318	1.13	T2	IIA
257	Isopropylamine	(CH ₃) ₂ CHNH ₂	2.03	<-24	2.30	8.6	55	208	340	1.05	T2	IIA
258	Isopropyl chloroacetate	ClCH ₂ COOCH(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) ₂ CH-C(CH ₃) ₂ CH ₂ CH ₂ CH ₂ CHO	5.31	41	3.05		192		188	<1.0	T4	IIA
261	Isopropyl nitrate	(CH ₃) ₂ CHONO ₂		11	2.00	100.0	75	3 738	175		T4	IIIB
262	Propyne	CH ₃ C≡CH	1.38		1.70	16.8	28	280				IIIB
263	Prop-2-yn-1-ol	HC≡CCH ₂ OH	1.89	33	2.40		55		346	0.58	T2	IIIB
264	Pyridine	C ₅ H ₅ N	2.73	17	1.70	12.0	58	398	550		T1	IIA
265	Styrene	C ₆ H ₅ CH=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 ₂ CF ₂ C(CH ₃) ₂ OH	5.51	35					447	1.42	T2	IIA
267	Tetrafluoroethylene	CF ₂ =CF ₂	3.40		10.00	50.0	420	2 245	255	0.60	T3	IIIB

Table A.1 — Flammability data (continued)

Ref.	Gas or vapour	Formula	Rho ρ	FP °C	Flammability limits				Ign. temp. °C	MESG mm	T-class	Group
					Lower	Upper	Lower	Upper				
					Volume per cent		mg/l					
268	1,1,2,2-Tetrafluoroethoxybenzene	$C_6H_5OFCF_2CF_2H$	6,70	47	1,80		426		483	1,22	T1	IIA
269	2,2,3,3-Tetrafluoropropan-1-ol	$HCF_2CF_2CH_2OH$	4,55	43					437	1,90	T2	IIA
270	2,2,3,3-Tetrafluoropropyl acrylate	$CH_2=CHCOOCH_2CF_2CF_2H$	6,41	45	2,40		482		357	1,18	T2	IIA
271	2,2,3,3-Tetrafluoropropyl methacrylate	$CH_2=C(CH_3)COOCH_2CF_2CF_2H$	6,90	46	1,90		455		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	IIIB
273	Tetrahydrofurfuryl alcohol	$OCH_2CH_2CH_2CHCH_2OH$	3,52	70	1,50	9,7	64	416	280	0,85	T3	IIIB
274	Tetrahydrothiophene	$CH_2(CH_2)_2CH_2S$	3,04	13	1,10	12,3	42	450	200	0,99	T3	IIA
275	N,N,N',N'-Tetramethylmethane-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	0,94	T2	IIA
277	Toluene	$C_6H_5CH_3$	3,20	4	1,1	7,6	42	300	535		T1	IIA
278	1,1,3-Triethoxybutane	$(CH_3CH_2O)_2CHCH_2CH(CH_3CH_2O)CH_3$	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-Trifluoroethane	CF_3CH_3	2,90		6,80	17,6	234	605	714	<2,00	T1	IIA
281	2,2,2-Trifluoroethanol	CF_3CH_2OH	3,45	30	8,4	28,8	350	1195	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		484		490	1,75	T1	IIA

Table A-1 — Flammability data (concluded)

Ref.	Gas or vapour	Formula	Rho ρ	FP °C	Flammability limits				Ign. temp. °C	MESG mm	T-class	Group
					Lower	Upper	Lower	Upper				
					Volume per cent		mg/l					
284	Trimethylamine	$(\text{CH}_3)_3\text{N}$	2,04		2,00	12,0	50	297	190	1,05	T4	IIA
285	4,4,5-Trimethyl-1,3-dioxane	$\text{OCH}_2\text{OCH}(\text{CH}_3)\text{C}(\text{CH}_3)_2\text{CH}_2$	4,48	35					284	0,90	T3	IIA
286	2,2,4-Trimethyl-pentane	$(\text{CH}_3)_2\text{CHCH}_2\text{C}(\text{CH}_3)_3$	3,90	-12	1,0	6,0	47	284	411	1,04	T2	IIA
287	2,4,6-Trimethyl-1,3,5-trioxane	$\text{OCH}(\text{CH}_3)\text{OCH}(\text{CH}_3)\text{OCH}(\text{CH}_3)$	4,56	27	1,30		72		235	1,01	T3	IIA
288	1,3,5-Trioxane	$\text{OCH}_2\text{OCH}_2\text{OCH}_2$	3,11	45	3,20	29,0	421	1 096	410	0,75	T2	IIIB
289	Turpentine			35	0,80				254		T3	IIA
290	Isovaleraldehyde	$(\text{CH}_3)_2\text{CHCH}_2\text{CHO}$	2,97	-12	1,70		60		207	0,98	T3	IIA
291	Vinyl acetate	$\text{CH}_3\text{COOCH}=\text{CH}_2$	3,00	-8	2,60	13,4	93	478	425	0,94	T2	IIA
292	Vinyl cyclohexenes (isomer not stated)	$\text{CH}_2\text{CHC}_6\text{H}_9$	3,72	15	0,80		35		257	0,96	T3	IIA
293	Vinylidene chloride	$\text{CH}_2=\text{CCl}_2$	3,40	-18	7,30	16,0	294	645	440	3,91	T2	IIA
294	2-Vinyl-oxyethanol	$\text{CH}_2=\text{CH}-\text{OCH}_2\text{CH}_2\text{OH}$	3,04	52					250	0,86	T3	IIIB
295	2-Vinylpyridine	$\text{NC}(\text{CH}_2=\text{CH})\text{CHCHCHCH}$	3,62	35	1,20		51		482	0,96	T1	IIA
296	4-Vinylpyridine	$\text{NCHCHC}(\text{CH}_2=\text{CH})\text{CHCH}$	3,62	43	1,10		47		501	0,95	T1	IIA
297	Water gas			1,2							T1	IIIC
298	Xylenes	$\text{C}_6\text{H}_4(\text{CH}_3)_2$	3,66	30	1,00	7,6	44	335	464	1,09	T1	IIA
299	Xylenes	$\text{C}_6\text{H}_3(\text{CH}_3)_2\text{NH}_2$	4,17	96	1,00	7,0	50	355	370		T2	

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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 interval 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 1m/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 of response are taken as the time interval between the time of application of the test gas and the time when the apparatus reaches 50% or 90%, respectively, of 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 movement¹⁾ -- 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 $\pm$ 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 m³ 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 traveling 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.

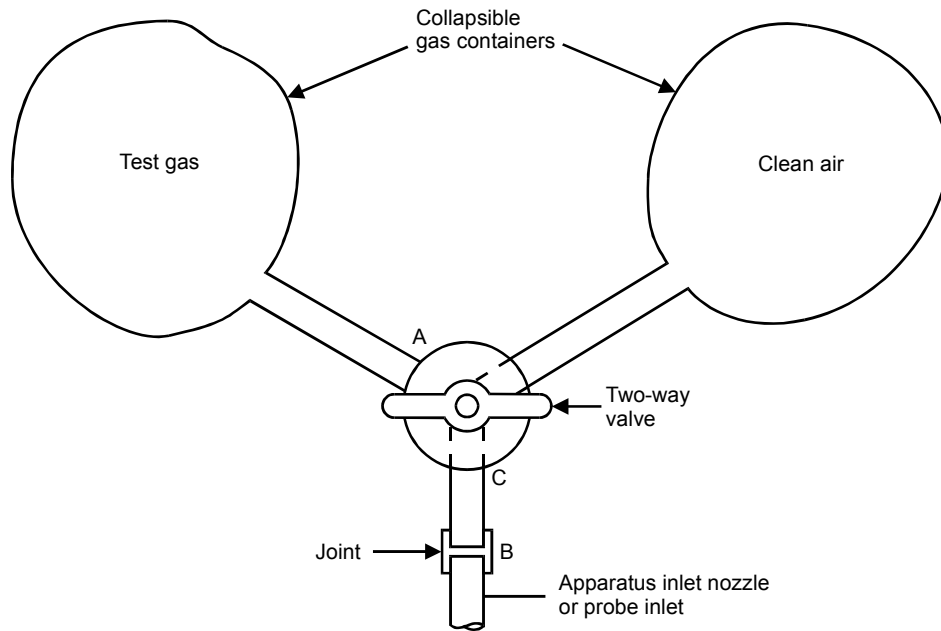


Figure B.1 — Schematic example of equipment for use with aspirated apparatus (also see B.1)

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.

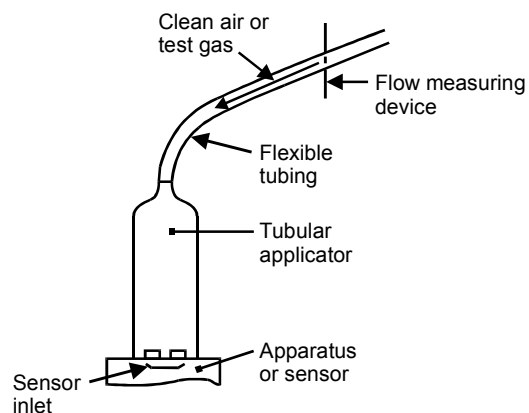


Figure B.2 — Schematic example of equipment during application of clean air or test gas (also see B.2.2)

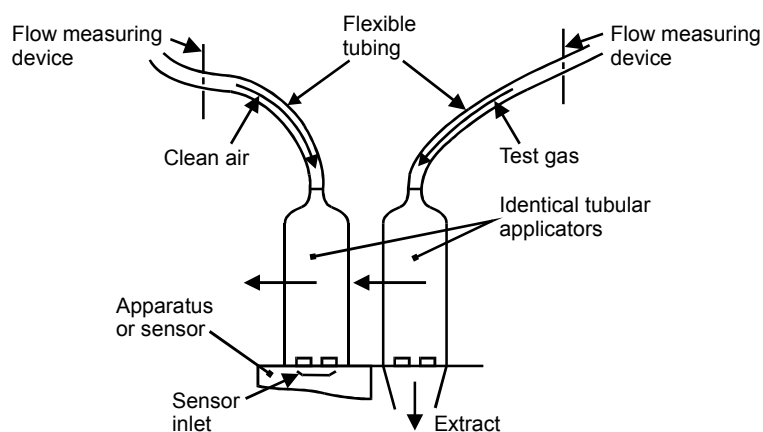


Figure B.3 — Schematic example of equipment showing change-over from clean air to test gas to begin the time of response measurement (arrows indicate movement of applicators) (also see B.2.2)

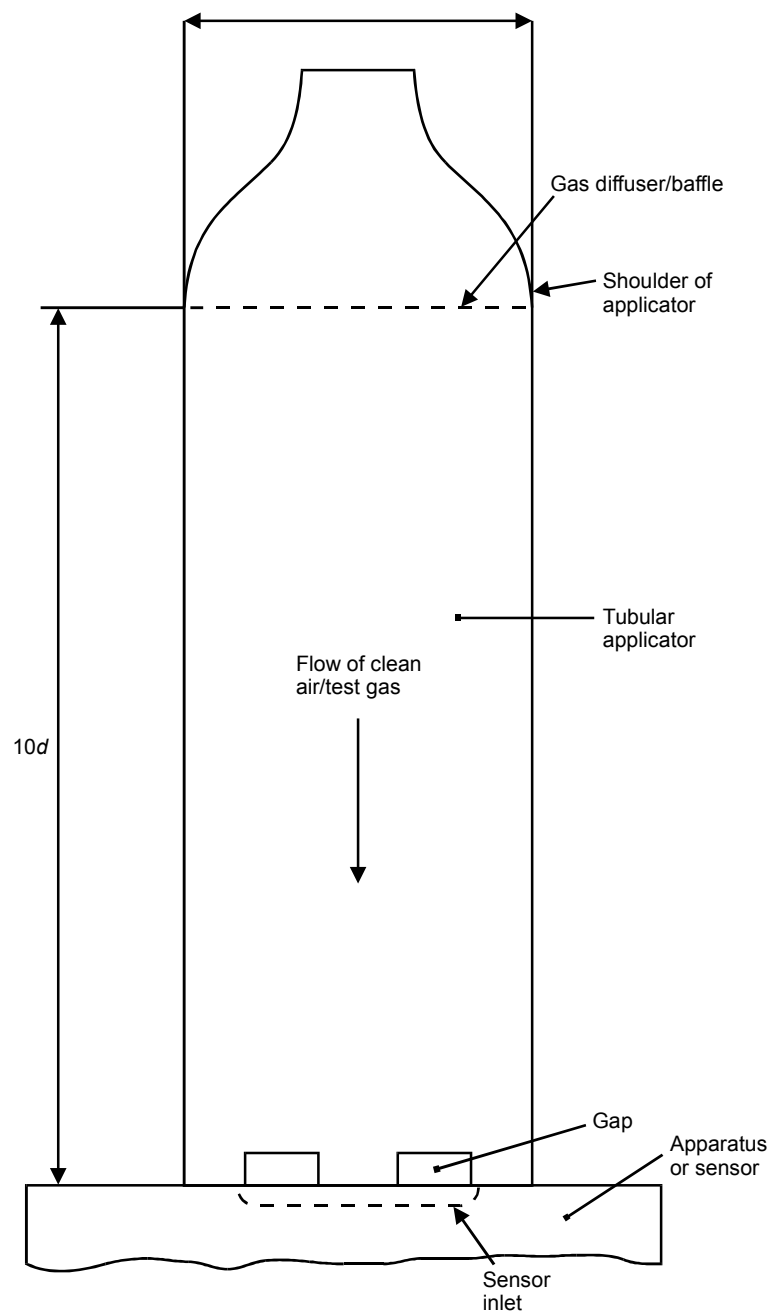


Figure B.4 — Schematic example of applicator and sensor inlet during application of test gas or clean air (also see B.2.2)

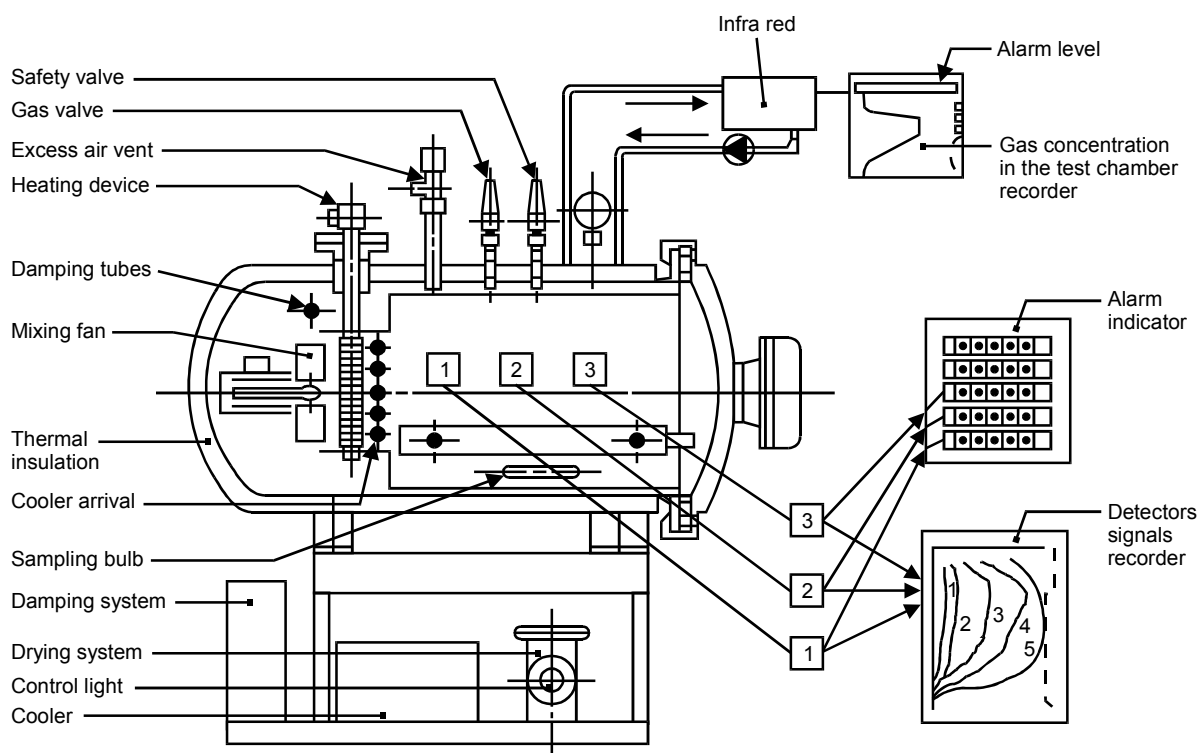
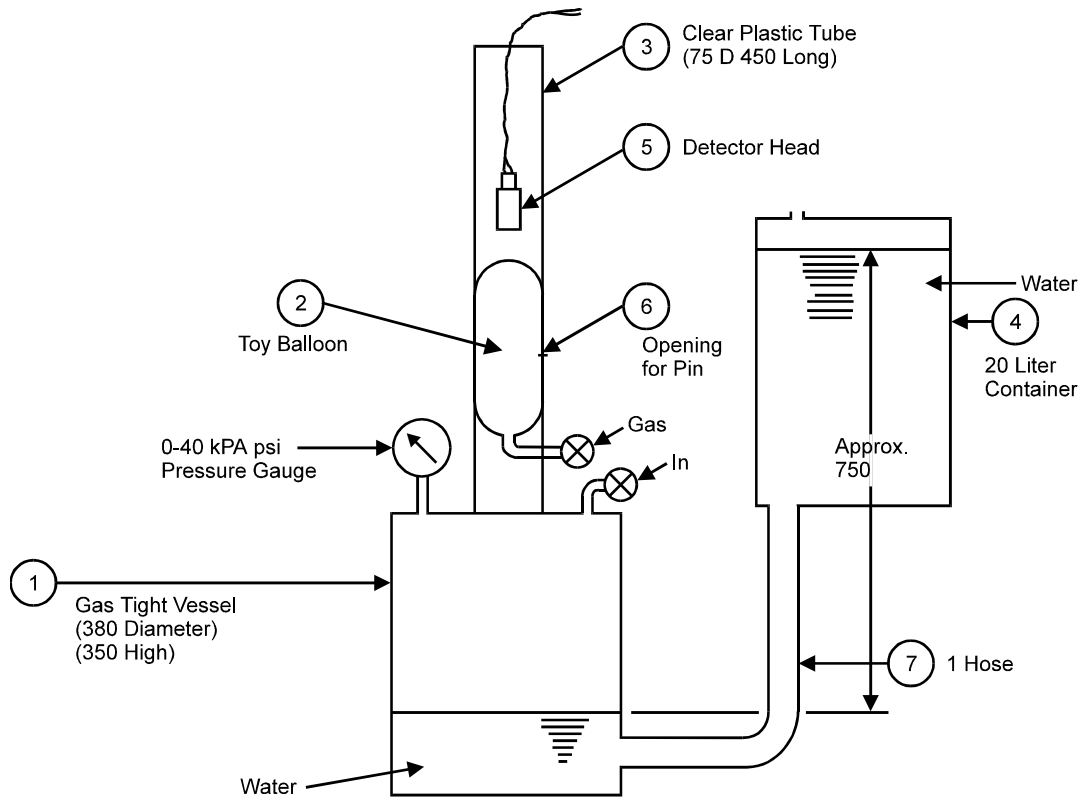


Figure B.5 — An example of an automated test chamber (also see B.2.3.1)



NOTE: All dimensions in millimeters

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

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Annex C (informative) — Bibliography

ANSI/ISA-12.13.01 (IEC 61779-1 through 5 Mod) is based on the IEC international standards 61779-1 through 5, which were developed using the following national standards:

IEC 60068-2-6:1995, *Environmental testing – Part 2: Tests – Test Fc: Vibration (sinusoidal)*

EUROPEAN STANDARDS USED AS REFERENCE BASIS IN THIS DOCUMENT

EN 50014:1977, *Electrical apparatus for potentially explosive atmospheres. General requirements* (1st edition)

Amendment 1 (1979)

Amendment 2 (1982)

Amendment 3 (1982)

Amendment 4 (1982)

Amendment 5 (1986)

EN 50014:1992, *Electrical apparatus for potentially explosive atmospheres. General requirements* (2nd edition)

EN 50015:1994, *Electrical apparatus for potentially explosive atmospheres. Oil immersion "o"* (to be read in conjunction with EN 50014:1992)

EN 50016:1995, *Electrical apparatus for potentially explosive atmospheres. Pressurized apparatus 'p'* (to be read in conjunction with EN 50014:1992)

EN 50017:1977, *Electrical apparatus for potentially explosive atmospheres. Powder filling "q"* (to be read in conjunction with EN 50014:1992)

EN 50018:1994, *Electrical apparatus for potentially explosive atmospheres. Flameproof enclosure 'd'* (to be read in conjunction with EN 50014:1992)

EN 50019:1994, *Electrical apparatus for potentially explosive atmospheres. Increased safety 'e'* (to be read in conjunction with EN 50014:1992)

EN 50 020:1994, *Electrical apparatus for potentially explosive atmospheres. Intrinsic safety 'i'* (to be read in conjunction with EN 50014:1992)

EN 50028:1987, *Electrical apparatus for potentially explosive atmospheres. Encapsulation 'm'* (to be read in conjunction with EN 50014:1977)

EN 50039:1980, *Electrical apparatus for potentially explosive atmospheres. Intrinsically safe electrical systems 'i'* (to be read in conjunction with EN 50014:1977)

EN 50055:1991, *Electrical apparatus for the detection and measurement of combustible gases. Performance requirements for Group I apparatus indicating up to 5 % (v/v) methane in air*

EN 50056:1991, *Electrical apparatus for the detection and measurement of combustible gases. Performance requirements for Group I apparatus indicating up to 100 % (v/v) methane*

EN 50057:1991, *Electrical apparatus for the detection and measurement of flammable gases. Performance requirements for Group II apparatus indicating up to 100 % lower explosive limit*

EN 50058:1991, *Electrical apparatus for the detection and measurement of flammable gases. Performance requirements for Group I apparatus indicating up to 100 % (v/v) gas*

BRITISH STANDARDS USED AS REFERENCE BASIS IN THIS DOCUMENT

BS 5345:1989, *Code of practice for the selection, installation and maintenance of electrical apparatus for use in potentially explosive atmospheres (other than mining applications or explosive proc.) – Part 1: General recommendations*

CANADIAN STANDARDS USED AS REFERENCE BASIS IN THIS DOCUMENT

CSA C22.2 NO. 152-M:1984, *Combustible gas detection instruments*

UNITED STATES STANDARDS USED AS REFERENCE BASIS IN THIS DOCUMENT

ISA

~~ANSI/ISA-S12.13, Part I-1995, *Performance requirements, Combustible gas detectors*~~

ANSI/ISA-12.13.01-2002, *Performance Requirements for Combustible Gas Detectors*

FACTORY MUTUAL RESEARCH CORPORATION

Combustible gas detectors (Class numbers 6310, 6320)

Annex D (informative) — National deviations

The following provides as an explanation of the ISA SP12.13 committee deviations from the IEC standard:

Group I (mining) requirements within this document have been removed in their entirety since electrical equipment for use in Group I (mining) applications must conform with Title 30, Code of Federal Regulations, *Mineral Resources*.

Subclauses 2.2.11, 2.2.12, 3.2.7 and 3.2.8: Stand alone gas detection components are widely used, but are not addressed in this document.

Subclause 4.4.11: The flow alarm requirement has been removed since there is currently no U.S. requirement and IEC is considering removal of this requirement.

Subclause 4.4.16: Recovery time testing is not part of the existing U.S. or CENELEC standards. Work is in progress to poll the IEC Maintenance Team to determine international consensus at this time.

Subclause 4.4.23: The test does not adequately determine the resistance to adverse effects of the accumulation of dust. Refer to ANSI/ISA-RP12.13.02 for recommendations on installation and maintenance of gas detection equipment within dust environments.

Subclause 4.4.24: This applies to Group I (mining) requirements which are excluded from these U.S. requirements at this time (see above).

Subclause 4.4.26: Dielectric strength testing is necessary to ensure that the conductance of performance testing does not compromise equipment electrical safety.

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Part 2 (IEC 61779-2 Mod)
Electrical apparatus for the detection and measurement of flammable gases —
Part 2: Performance requirements for group I apparatus indicating a volume
fraction up to 100% lower explosive limit

1—Scope

~~1.1— This part of IEC 61779 specifies requirements for group I (as defined in part 1) portable, transportable and fixed apparatus for the detection and measurement of methane concentrations in mine air. The apparatus, or parts thereof, are intended for use in mines susceptible to firedamp. The requirements and test methods applicable to the apparatus covered by this standard are specified in part 1.~~

~~NOTE—The use of group I apparatus may not be permitted without the additional and prior approval of the relevant authority in mines under its jurisdiction, see note 1 of 1.1.1 of part 1.~~

~~1.2— This standard is restricted to apparatus intended for the detection and measurement of volume ratios of methane in air from a volume fraction of 0 % up to, but not exceeding, a volume fraction of 5 %.~~

2—Definitions

~~For the purpose of this part of IEC 61779, the definitions given in part 1 apply.~~

3—General requirements

~~The apparatus shall comply with the general requirements specified in part 1 and with the performance requirements specified in clause 4 of this standard.~~

~~Compliance shall be determined in accordance with the appropriate test requirements and methods, including initial calibration, specified in part 1.~~

~~It shall be verified that the contents of the manufacturer's instruction manual are in accordance with the requirements specified in part 1.~~

4—Performance requirements

General

~~The normal conditions for tests are specified in 4.3 of part 1. Compliance shall be determined in accordance with the test methods specified in 4.4 of part 1.~~

Unpowered storage

~~After being submitted to the conditions specified in 4.4.2 of part 1, the apparatus shall meet the requirements specified in 4.3 to clause 5 of this standard.~~

Calibration curve (not applicable to alarm only apparatus)

~~After initial adjustment with the standard test gas, each individual indication in the three sets of indications (after correction using the manufacturer's calibration curve, if necessary) obtained for each of the four gas volume ratios distributed over the measuring range shall not differ from these volume ratios by more than a volume fraction of $\pm 0,1$ % methane or ± 5 % of the indication, whichever is the greater.~~

Stability (continuous duty apparatus)

Continuous duty apparatus shall comply with the following requirements:

a) ~~short term stability~~

~~The short term variation shall not exceed a volume fraction of $\pm 0,1$ % methane or ± 5 % of the indication, whichever is the greater.~~

b) ~~long term stability (fixed and transportable apparatus)~~

~~The long term variation shall not exceed a volume fraction of $\pm 0,1$ % methane or ± 5 % of the indication, whichever is the greater.~~

c) ~~long term stability (portable apparatus)~~

~~The long term variation shall not exceed a volume fraction of $\pm 0,1$ % methane or ± 5 % of the indication, whichever is the greater.~~

Stability (spot reading apparatus)

~~The variation shall not exceed a volume fraction of $\pm 0,1$ % methane or ± 5 % of the indication, whichever is the greater.~~

Alarm

~~The alarm(s) shall operate during the test. If a latching alarm is provided, the manual reset action shall be checked.~~

Temperature

~~The variation of the indication from that at 20°C , over the temperature range -10°C to $+40^{\circ}\text{C}$, (temperatures for test: -10°C , 20°C , 40°C), shall not exceed a volume fraction of $\pm 0,2$ % methane or ± 10 % of the indication, whichever is the greater.~~

Pressure

~~The variation of the indications at 80 kPa and 120 kPa from the indication at 100 kPa shall not exceed a volume fraction of $\pm 0,2$ % methane or ± 30 % of the indication, whichever is the greater, in air and in the standard test gas.~~

Humidity

~~The variation of the indications at 20 % RH and 90 % RH from the indication at 50 % RH, at $+40^{\circ}\text{C}$, shall not exceed a volume fraction of $\pm 0,2$ % methane or ± 10 % of the indication, whichever is the greater.~~

Air velocity

~~The variation of the indication shall not exceed a volume fraction of $\pm 0,1$ % methane or ± 5 % of the indication, whichever is the greater.~~

Flow rate

~~The variation of the indication shall not exceed a volume fraction of $\pm 0,1$ % methane or ± 5 % of the indication, whichever is the greater.~~

Orientation

The variation of the indication shall not exceed a volume fraction of $\pm 0,1$ % methane or ± 5 % of the indication, whichever is the greater.

Vibration

During the vibration test, the apparatus shall not suffer any loss of function and shall not give a false alarm or fault signal. The apparatus shall not suffer damage resulting in a hazard (e.g. loss of explosion protection or electrical safety) or loss of function.

The variation of the indication shall not exceed a volume fraction of $\pm 0,1$ % methane or ± 5 % of the indication, whichever is the greater.

Drop test (applicable to portable apparatus and remote sensors)

The apparatus shall not suffer damage resulting in a hazard or loss of function.

The variation of the indication shall not exceed a volume fraction of $\pm 0,1$ % methane or ± 5 % of the indication, whichever is the greater.

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

Fixed and transportable apparatus

The apparatus shall warm up in clean air to indicate zero to within a volume fraction of $\pm 0,1$ % methane in a time not exceeding 5 min or as specified by the manufacturer, and no false alarms shall be generated.

The apparatus shall warm up in the standard test gas to give a final indication to within a volume fraction of $\pm 0,1$ % methane or ± 5 % of the indication, whichever is the greater, in a time not exceeding 5 min or as specified by the manufacturer, and no false alarms shall be generated.

Continuous duty portable apparatus

The apparatus shall warm up in clean air to indicate zero to within a volume fraction of $\pm 0,1$ % methane in a time not exceeding 2 min, and no false alarms shall be generated.

The apparatus shall warm up in the standard test gas to give a final indication to within a volume fraction of $\pm 0,1$ % methane or ± 5 % of the indication, whichever is the greater, in a time not exceeding 3 min, and no false alarms shall be generated.

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

The time of response $t(50)$ in either direction shall be not greater than 20 s, and $t(90)$ in either direction shall be not greater than 60 s.

Minimum time to operate (spot-reading apparatus)

For apparatus without a probe or sample line, the indication shall reach 90 % of the final value in a time not exceeding 15 s.

High gas concentrations above the measuring range

Non-ambiguity test

~~When tested in accordance with 4.4.18.1 of part 1, all methane concentrations above full scale shall be indicated by a full scale meter indication and, where fitted, an alarm. If the indication is digital, a clear indication shall be given that the upper limit of the measuring range has been exceeded.~~

~~Residual effect test~~

~~The variations of the indications from those recorded in clean air and in the standard test gas, at the beginning of the test, shall not exceed a volume fraction of $\pm 0,2$ % methane or ± 10 % of the indication, whichever is the greater.~~

~~Battery capacity~~

~~Battery powered portable continuous duty apparatus~~

~~The variation shall not exceed a volume fraction of $\pm 0,1$ % methane or ± 5 % of the indication, whichever is the greater, at the end of the 8 h or 10 h period, as appropriate.~~

~~At the end of the further 10 min following the indication of low battery condition, the variation shall not exceed a volume fraction of $\pm 0,2$ % methane or ± 10 % of the indication, whichever is the greater.~~

~~Battery powered portable spot-reading apparatus~~

~~The variation shall not exceed a volume fraction of $\pm 0,1$ % methane or ± 5 % of the indication, whichever is the greater, at the end of 200 operations.~~

~~After a further 10 operations following the indication of low battery condition, the variation shall not exceed a volume fraction of $\pm 0,2$ % methane or ± 10 % of the indication, whichever is the greater.~~

~~Power supply variations~~

~~General~~

~~No requirement.~~

~~a.c. and external d.c. powered apparatus~~

~~The variation of the indication shall not exceed a volume fraction of $\pm 0,1$ % methane or ± 5 % of the indication, whichever is the greater.~~

~~Other power supply ranges~~

~~The variation of the indication shall not exceed a volume fraction of $\pm 0,1$ % methane or ± 5 % of the indication, whichever is the greater.~~

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

~~The apparatus shall not yield spurious alarms when the specified interruptions, voltage transients or step changes of voltage occur.~~

~~Addition of sampling probe~~

~~The variation of the indication shall not exceed a volume fraction of $\pm 0,1$ % methane or ± 5 % of the indication, whichever is the greater.~~

~~Dust~~

~~The variation of the indication shall not exceed a volume fraction of $\pm 0,1$ % methane or ± 5 % of the indication, whichever is the greater.~~

~~The increase in $t(90)$ shall be not more than 10 s.~~

~~Poisons and other gases~~

~~Poisons~~

~~The variation of the indication shall not exceed a volume fraction of $\pm 0,2$ % methane or ± 10 % of the indication, whichever is the greater.~~

~~Claimed poison tolerances shall be verified.~~

~~Other gases~~

~~The indications obtained for each of the three gas mixtures a) 1), a) 2), and a) 3) according to 4.4.24.3 of part 1 shall be not lower than the actual methane volume ratio by more than 10 % of the actual methane concentration applied.~~

~~Electromagnetic compatibility~~

~~When subjected to the electromagnetic immunity test, the variation of the indication shall not exceed a volume fraction of $\pm 0,1$ % methane. The apparatus shall suffer no loss of function or spurious alarm.~~

~~5 Field calibration kit~~

~~The meter or output indication observed during the use of the field calibration kit shall not differ from the specified concentration by more than a volume fraction of $\pm 0,1$ % methane or ± 5 % of the indication, whichever is the greater.~~

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Annex A (informative) — National deviations

The contents of this part of the document have been removed in their entirety since electrical equipment for use in Group I (mining) applications must conform with Title 30, Code of Federal Regulations, *Mineral Resources*.

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Part 3 (IEC 61779-3 Mod)
Electrical apparatus for the detection and measurement of flammable gases —
Part 3: Performance requirements for group I apparatus indicating a volume
fraction up to 100% methane in air

1—Scope

~~1.1—This part of IEC 61779 specifies requirements for group I (as defined in part 1) portable, transportable and fixed apparatus for the detection and measurement of methane concentrations in mine air. The apparatus, or parts thereof, are intended for use in mines susceptible to firedamp. The requirements and test methods applicable to the apparatus covered by this standard are specified in part 1.~~

~~NOTE—The use of group I apparatus may not be permitted without the additional and prior approval of the relevant authority in mines under its jurisdiction, see note 1 of 1.1.1 of part 1.~~

~~1.2—This standard is restricted to apparatus intended for the detection and measurement of volume ratios of methane in air from a volume fraction of 0 % up to a volume fraction of 100 %.~~

~~NOTE—Apparatus covered by this standard will normally be intended to operate in volume ratios greater than a volume fraction of 5 %.~~

2—Definitions

~~For the purpose of this part of IEC 61779, the definitions given in part 1 apply.~~

3—General requirements

~~The apparatus shall comply with the general requirements specified in part 1 and with the performance requirements specified in clause 4 below.~~

~~Compliance shall be determined in accordance with the appropriate test requirements and methods, including initial calibration, specified in part 1.~~

~~It shall be verified that the contents of the manufacturer's instruction manual are in accordance with the requirements specified in part 1.~~

4—Performance requirements

4.1—General

~~The normal conditions for tests are specified in 4.3 of part 1. Compliance shall be determined in accordance with the test methods specified in 4.4 of part 1.~~

4.2—Unpowered storage

~~After being submitted to the conditions specified in 4.4.2 of part 1, the apparatus shall meet the requirements specified in 4.3 to clause 5 of this standard.~~

4.3—Calibration curve (not applicable to alarm-only apparatus)

~~After initial adjustment with the standard test gas, each individual indication in the three sets of indications (after correction using the manufacturer's calibration curve, if necessary) obtained for each of the four gas~~

~~volume ratios shall not differ from these volume ratios by more than a volume fraction of $\pm 3\%$ methane or $\pm 5\%$ of the indication, whichever is the greater.~~

4.4 — Stability (continuous duty apparatus)

Continuous duty apparatus shall comply with the following requirements:

a) ~~short term stability~~

~~The short term variation shall not exceed a volume fraction of $\pm 3\%$ methane or $\pm 5\%$ of the indication, whichever is the greater.~~

b) ~~long term stability (fixed and transportable apparatus)~~

~~The long term variation shall not exceed a volume fraction of $\pm 3\%$ methane or $\pm 5\%$ of the indication, whichever is the greater.~~

c) ~~long term stability (portable apparatus)~~

~~The long term variation shall not exceed a volume fraction of $\pm 3\%$ methane or $\pm 5\%$ of the indication, whichever is the greater.~~

4.5 — Stability (spot-reading apparatus)

~~The variation shall not exceed a volume fraction of $\pm 3\%$ methane or $\pm 5\%$ of the indication, whichever is the greater.~~

4.6 — Alarm

~~The alarm(s) shall operate during every cycle of the test. If a latching alarm is provided, the manual reset action shall be checked.~~

4.7 — Temperature

~~The variation of the indication from that at $20\text{ }^{\circ}\text{C}$~~

~~a) shall not, at $-10\text{ }^{\circ}\text{C}$, exceed a volume fraction of $\pm 7\%$ methane or $\pm 15\%$ of the indication, and~~

~~b) shall not, at $+40\text{ }^{\circ}\text{C}$, exceed a volume fraction of $\pm 5\%$ methane or $\pm 10\%$ of the indication, whichever is the greater.~~

~~Tests shall be carried out at temperatures of $-10\text{ }^{\circ}\text{C}$, $20\text{ }^{\circ}\text{C}$ and $40\text{ }^{\circ}\text{C}$.~~

4.8 — Pressure

~~The variation of the indications at 80 kPa and 120 kPa from the indication at 100 kPa shall not exceed a volume fraction of $\pm 5\%$ methane or $\pm 30\%$ of the indication, whichever is the greater, in air and in the standard test gas.~~

4.9 — Humidity

~~The variation of the indications at 20% RH and 90% RH from the indication at 50% RH, at $+40\text{ }^{\circ}\text{C}$, shall not exceed a volume fraction of $\pm 5\%$ methane or $\pm 10\%$ of the indication, whichever is the greater.~~

4.10 — Air velocity

~~The variation of the indication shall not exceed a volume fraction of $\pm 3\%$ methane or $\pm 5\%$ of the indication, whichever is the greater.~~

4.11—Flow rate

~~The variation of the indication shall not exceed a volume fraction of $\pm 3\%$ methane or $\pm 5\%$ of the indication, whichever is the greater.~~

4.12—Orientation

4.12.1—Portable apparatus

~~The variation of the indication shall not exceed a volume fraction of $\pm 5\%$ methane or $\pm 10\%$ of the indication, whichever is the greater.~~

4.12.2—Fixed and transportable apparatus

~~The variation of the indication shall not exceed a volume fraction of $\pm 3\%$ methane or $\pm 5\%$ of the indication, whichever is the greater.~~

4.13—Vibration

~~During the vibration test, the apparatus shall not suffer any loss of function and shall not give a false alarm or fault signal. The apparatus shall not suffer damage resulting in a hazard or loss of function.~~

~~The variation of the indication from that determined prior to the test shall not exceed a volume fraction of $\pm 3\%$ methane or $\pm 5\%$ of the indication, whichever is the greater.~~

4.14—Drop test (applicable to portable apparatus and remote sensors)

~~The apparatus shall not suffer damage resulting in a hazard or loss of function.~~

~~The variation of the indication shall not exceed a volume fraction of $\pm 3\%$ methane or $\pm 5\%$ of the indication, whichever is the greater.~~

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

4.15.1—Fixed and transportable apparatus

~~The apparatus shall warm up in clean air to indicate zero to within a volume fraction of $\pm 3\%$ methane, in a time not exceeding 5 min or as specified by the manufacturer, and no false alarms shall be generated.~~

~~The apparatus shall warm up in the standard test gas to give a final indication to within a volume fraction of $\pm 3\%$ methane in a time not exceeding 5 min or as specified by the manufacturer, and no false alarms shall be generated.~~

4.15.2—Continuous duty portable apparatus

~~The apparatus shall warm up in clean air to indicate zero to within a volume fraction of $\pm 3\%$ methane in a time not exceeding 2 min, and no false alarms shall be generated.~~

~~The apparatus shall warm up in the standard test gas to give a final indication to within a volume fraction of $\pm 3\%$ methane in a time not exceeding 2 min, and no false alarms shall be generated.~~

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

~~The time of response $t(50)$ in either direction shall be not greater than 20 s, and $t(90)$ in either direction shall be not greater than 60 s.~~

~~4.17 Minimum time to operate (spot-reading apparatus)~~

~~For apparatus without a probe or sample line, the indication shall reach 90 % of the final value in a time not exceeding 15 s.~~

~~4.18 High gas concentration above the measuring range~~

~~Not applicable.~~

~~4.19 Battery capacity~~

~~4.19.1 Battery powered portable continuous duty apparatus~~

~~The variation shall not exceed a volume fraction of ± 3 % methane or ± 5 % of the indication, whichever is the greater, at the end of the 8 h or 10 h period, as appropriate.~~

~~At the end of a further 10 min following the indication of low battery condition, the variation shall not exceed a volume fraction of ± 6 % methane or ± 10 % of the indication, whichever is the greater.~~

~~4.19.2 Battery powered portable spot-reading apparatus~~

~~The variation shall not exceed a volume fraction of ± 3 % methane, or ± 5 % of the indication, whichever is the greater, at the end of 200 operations.~~

~~After a further 10 operations following the indication of low battery condition, the variation shall not exceed a volume fraction of ± 6 % methane or ± 10 % of the indication, whichever is the greater.~~

~~4.20 Power supply variations~~

~~4.20.1 General~~

~~No requirement.~~

~~4.20.2 a.c. and external d.c. powered apparatus~~

~~The variation of the indication shall not exceed a volume fraction of ± 3 % methane or ± 5 % of the indication, whichever is the greater.~~

~~4.20.3 Other power supply ranges~~

~~The variation of the indication shall not exceed a volume fraction of ± 3 % methane or ± 5 % of the indication, whichever is the greater.~~

~~4.21 Power supply interruptions, voltage transients and step changes of voltage~~

~~The apparatus shall not yield spurious alarms when the specified interruptions, voltage transients or step changes of voltage occur.~~

~~4.22 Addition of sampling probe~~

~~The variation of the indication shall not exceed a volume fraction of ± 3 % methane or ± 5 % of the indication, whichever is the greater.~~

4.23—Dust

The variation of the indication shall not exceed a volume fraction of $\pm 5\%$ methane or $\pm 10\%$ of the indication, whichever is the greater.

The increase in $t(90)$ shall be not more than 10 s.

4.24—Poisons and other gases

4.24.1—Poisons

The variation of the indication from the actual methane concentration shall not exceed a volume fraction of $\pm 3\%$ methane or $\pm 5\%$ of the indication, whichever is the greater.

Claimed poison tolerances shall be verified.

4.24.2—Other gases

The indications obtained for each of the three gas mixtures in b) 1), b) 2), and b) 3) according to 4.4.24.3 of part 1 shall not be lower than the actual volume ratio of methane by more than 10 % of the indication.

4.25—Electromagnetic compatibility

When subjected to the electromagnetic compatibility test, the variation of the indication shall not exceed a volume fraction of $\pm 3\%$ methane. The apparatus shall suffer no loss of function or spurious alarm.

5—Field calibration kit

The meter or output indication observed during the use of the field calibration kit shall not differ from the specified concentration by more than a volume fraction of $\pm 3\%$ methane or $\pm 5\%$ of the indication, whichever is the greater.

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Annex A (informative) — National deviations

The contents of this part of the document have been removed in their entirety since electrical equipment for use in Group I (mining) applications must conform with Title 30, Code of Federal Regulations, *Mineral Resources*.

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Part 4 (IEC 61779-4 Mod)
Electrical apparatus for the detection and measurement of flammable gases —
Part 4: Performance requirements for group II apparatus indicating a volume
fraction up to 100% lower explosive limit

1 Scope

1.1 This part of ~~IEC 61779~~ ANSI/ISA-12.13.01 (IEC 61779-1 through 5 Mod) specifies requirements for group II (as defined in part 1) portable, transportable and fixed apparatus for the detection and measurement of combustible gas or vapour concentrations with air. The apparatus, or parts thereof, may be installed or used in potentially explosive atmospheres, other than mines susceptible to firedamp (i.e. group I). The requirements and test methods applicable to the apparatus covered by this document are specified in part 1.

1.2 This document is restricted to apparatus intended for the detection and measurement of combustible gas or vapour concentrations with air up to 100 % lower explosive limit (LEL).

2 Definitions

For the purpose of this part of ~~IEC 61779~~ ANSI/ISA-12.13.01 (IEC 61779-1 through 5 Mod), the definitions given in part 1 apply.

3 General requirements

The apparatus shall comply with the general requirements specified in part 1 and with the performance requirements specified in Clause 4 of this part of the document.

Compliance shall be determined in accordance with the appropriate test requirements and methods, including initial calibration, specified in part 1.

It shall be verified that the contents of the manufacturer's instruction manual are in accordance with the requirements specified in part 1.

4 Performance requirements

4.1 General

The normal conditions for tests are specified in 4.3 of part 1. Compliance shall be determined in accordance with the test methods specified in 4.4 of part 1.

4.2 Unpowered storage

After being submitted to the conditions specified in 4.4.2 of part 1, the apparatus shall meet the requirements specified in 4.3 ~~to~~ through Clause 5 of this part of the document.

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

4.3.1 Calibration curve

After initial adjustment with the standard test gas, each individual indication in the three sets of indications (after correction using the manufacturer's calibration curve, if necessary) obtained for each of the four gas

volume ratios distributed over the measuring range, shall not differ from these volume ratios by more than $\pm 5\%$ of the measuring range or $\pm 10\%$ of the indication, whichever is the greater.

4.3.2 Response to gases other than the test gas

The apparatus indication (after correction using the manufacturer's calibration curves, if necessary) obtained for each of the three gas volume ratios of each gas tested shall not differ from these volume ratios by more than $\pm 7\%$ of the measuring range or $\pm 15\%$ of the indication, whichever is the greater.

4.4 Stability (continuous duty apparatus)

Continuous duty apparatus shall comply with the following requirements.

a) short-term stability

The short-term variation shall not exceed $\pm 5\%$ of the measuring range or $\pm 10\%$ of the indication, whichever is the greater.

b) long-term stability (fixed and transportable apparatus)

The long-term variation shall not exceed $\pm 10\%$ of the measuring range or $\pm 30\%$ of the indication, whichever is the greater.

c) long-term stability (portable apparatus)

The long-term variation shall not exceed $\pm 5\%$ of the measuring range or $\pm 10\%$ of the indication, whichever is the greater.

4.5 Stability (spot-reading apparatus)

The variation of the indication shall not exceed $\pm 5\%$ of the measuring range or $\pm 10\%$ of the indication, whichever is the greater.

4.6 Alarm

The alarm(s) shall operate during every cycle of the test. If a latching alarm is provided, the manual reset action shall be checked.

4.7 Temperature

The variation of the indication from that at $20\text{ }^{\circ}\text{C}$, over the specified temperature ranges, shall not exceed the following:

- a) for portable or transportable apparatus where the control unit and the sensor are used in the same general environment, the variation over the temperature range $-10\text{ }^{\circ}\text{C}$ to $+40\text{ }^{\circ}\text{C}$ shall not exceed $\pm 5\%$ of the measuring range or $\pm 10\%$ of the indication, whichever is the greater. Tests shall be carried out at temperatures of $-10\text{ }^{\circ}\text{C}$, $20\text{ }^{\circ}\text{C}$ and $40\text{ }^{\circ}\text{C}$;
- b) for fixed apparatus with remote sensors, where the control unit and sensor are not used in the same general environment, the following temperatures shall be applied:

1) Sensors

With the control unit under normal ambient test conditions, the sensor shall be tested in air and in the standard test gas at $-25\text{ }^{\circ}\text{C}$ and $+55\text{ }^{\circ}\text{C}$. The variation shall not exceed $\pm 10\%$ of the measuring range or $\pm 20\%$ of the indication, whichever is the greater.

2) Control units

With the sensor under normal ambient test conditions, the variation at $+5\text{ }^{\circ}\text{C}$ and $+55\text{ }^{\circ}\text{C}$ shall not exceed $\pm 5\%$ of the measuring range or $\pm 10\%$ of the indication, whichever is the greater;

- c) for fixed apparatus with sensors and control units in the same general environment, the variation at $-10\text{ }^{\circ}\text{C}$ and $+55\text{ }^{\circ}\text{C}$ shall not exceed $\pm 5\%$ of the measuring range or $\pm 15\%$ of the indication, whichever is the greater.

4.8 Pressure

The variation of the indications at ~~80~~ 95 kPa and 110 kPa from the indication at 100 kPa shall not exceed $\pm 5\%$ of the measuring range or $\pm 30\%$ of the indication, whichever is the greater.

4.9 Humidity

The variation of the indications at 20 % RH and 90 % RH from the indication at 50 % RH, at $+40\text{ }^{\circ}\text{C}$, shall not exceed $\pm 7\%$ of the measuring range or $\pm 15\%$ of the indication, whichever is the greater.

4.10 Air velocity

The variation of the indication shall not exceed $\pm 5\%$ of the measuring range or $\pm 10\%$ of the indication, whichever is the greater.

4.11 Flow rate

The variation of the indication shall not exceed $\pm 5\%$ of the measuring range or $\pm 10\%$ of the indication, whichever is the greater.

4.12 Orientation

The variation of the indication shall not exceed $\pm 5\%$ of the measuring range or $\pm 10\%$ of the indication, whichever is the greater.

4.13 Vibration

During the vibration test, the apparatus shall not suffer any loss of function and shall not give a false alarm or fault signal. The apparatus shall not suffer damage resulting in a hazard or loss of function.

At the conclusion of the vibration test and after the apparatus sensor has been exposed to clean air followed by the standard test gas mixture, the deviation of the indication from that determined prior to the test shall not exceed $\pm 5\%$ of the measuring range or $\pm 10\%$ of the indication, whichever is the greater.

4.14 Drop test (applicable to portable apparatus and remote sensors)

The apparatus shall not suffer damage resulting in a hazard or loss of function.

The variation of the indication shall not exceed $\pm 5\%$ of the measuring range or $\pm 10\%$ of the indication, whichever is the greater.

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

4.15.1 Fixed and transportable apparatus

The apparatus shall warm up in clean air to indicate zero to within ± 5 % of the measuring range in a time specified by the manufacturer, and no false alarms shall be generated.

4.15.2 Continuous duty portable apparatus

The apparatus shall warm up in clean air to indicate zero to within ± 5 % of the measuring range in a time not exceeding 2 min, and no false alarms shall be generated.

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

The time of response $t(50)$ in either direction shall be not greater than 20 s, and $t(90)$ in either direction shall be not greater than 60 s.

4.17 Minimum time to operate (spot-reading apparatus)

For apparatus without a probe or sample line, the indication shall reach 90 % of the final value in a time not exceeding 15 s.

For aspirated apparatus using a sample line or probe, an additional 3 s per metre is permitted.

4.18 High gas concentration above the measuring range

4.18.1 Non-ambiguity test

When tested in accordance with 4.4.18.1 of part 1, all gas concentrations above full scale shall be indicated by a full scale meter indication and, where fitted, an alarm. If the indication is digital, a clear indication shall be given that the upper limit of the measuring range has been exceeded.

4.18.2 Residual effect test

The variations of the indications from those recorded in clean air and in the standard test gas, at the beginning of the test, shall not exceed ± 7 % of the measuring range or ± 15 % of the indication, whichever is the greater.

4.19 Battery capacity

4.19.1 Battery-powered portable continuous duty apparatus

The variation shall not exceed ± 5 % of the measuring range or ± 10 % of the indication, whichever is the greater, at the end of the 8 h or 10 h period, as appropriate.

At the end of a further 10 min following the indication of low battery condition, the variation shall not exceed ± 7 % of the measuring range or ± 15 % of the indication, whichever is the greater.

4.19.2 Battery-powered portable spot-reading apparatus

4.19.2.1 No alarm, including low battery indication, shall result from this test.

4.19.2.2 The variation shall not exceed ± 5 % of the measuring range or ± 10 % of the indication, whichever is the greater, at the end of 200 operations.

After a further 10 operations following the indication of low battery condition, the variation shall not exceed ± 7 % of the measuring range or ± 15 % of the indication, whichever is the greater.

4.20 Power supply variations

4.20.1 General

No requirements.

4.20.2 a.c. and external d.c. powered apparatus

The variation of the indication shall not exceed ± 5 % of the measuring range or ± 10 % of the indication, whichever is the greater.

4.20.3 Other power supply ranges

The variation of the indication shall not exceed ± 5 % of the measuring range or ± 10 % of the indication, whichever is the greater.

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

The apparatus shall not yield spurious alarms when the specified interruptions, voltage transients or step changes of voltage occur.

4.22 Addition of sampling probe

The variation of the indication shall not exceed ± 5 % of the measuring range or ± 10 % of the indication, whichever is the greater.

~~4.23 Dust~~

~~The increase in $t(90)$ shall be not more than 10 s.~~

4.24 Poisons and other gases

4.24.1 Poisons

Not applicable.

4.24.2 Other gases

Not applicable.

4.25 Electromagnetic compatibility

When subjected to the electromagnetic compatibility test, the variation of the indication shall not exceed ± 5 % of the measuring range. The apparatus shall suffer no loss of function or spurious alarm.

4.26 Dielectric strength

When subjected to the dielectric strength test, the apparatus shall have no breakdown or repeated flashover.

5 Field calibration kit

The meter or output indication observed during the use of the field calibration kit shall not differ from the specified concentration by more than $\pm 5\%$ of the measuring range or $\pm 10\%$ of the indication, whichever is the greater.

Annex A (informative) — National deviations

The following provides as an explanation of the ISA SP12.13 committee deviations from IEC standard 61779-4:

Subclause 4.16: Recovery time testing is not part of the existing U.S. or CENELEC standards. Work is in progress to poll the IEC Maintenance Team to determine international consensus at this time.

Subclause 4.23: The test does not adequately determine the resistance to adverse effects of the accumulation of dust. Refer to ANSI/ISA-RP12.13.02 (IEC 61779-6 Mod) for recommendations on installation and maintenance of gas detection equipment within dust environments.

Subclause 4.26: Dielectric strength testing is necessary to ensure that the conductance of performance testing does not compromise equipment electrical safety.

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Part 5 (IEC 61779-5 Mod)
Electrical apparatus for the detection and measurement of flammable gases —
Part 5: Performance requirements for group II apparatus indicating a volume
fraction up to 100% gas

1 Scope

1.1 This part of ~~IEC 61779~~ ANSI/ISA-12.13.01 (IEC 61779-1 through 5 Mod) specifies requirements for group II (as defined in part 1) portable, transportable and fixed apparatus for the detection and measurement of combustible gas or vapour concentrations with air. The apparatus, or parts thereof, may be installed or used in potentially explosive atmospheres, other than mines susceptible to firedamp (i.e. group I). The requirements and test methods applicable to the apparatus covered by this document are specified in part 1.

1.2 This document is restricted to apparatus intended for the detection and measurement of volume ratios of combustible gas or vapour in air in volume fractions from 0 % to 100 % .

NOTE 1 Apparatus covered by this document will normally be intended to operate in volume ratios greater than 100 % LEL.

NOTE 2 Although apparatus of the types covered by this document may be suitable for detecting a wide range of combustible gases, particular gases (e.g. methane or propane) are specified in part 1 as the components of the test gases for the purpose of practical convenience. The performance requirements specified in this document should therefore be considered with caution when the apparatus is used to detect other combustible gases, as some parameters – such as time of response – will be modified.

2 Definitions

For the purpose of this part of ~~IEC 61779~~ ANSI/ISA-12.13.01 (IEC 61779-1 through 5 Mod), the definitions given in part 1 apply.

3 General requirements

The apparatus shall comply with the general requirements specified in part 1 and with the performance requirements specified in Clause 4 of this part of the document.

Compliance shall be determined in accordance with the appropriate test requirements and methods, including initial calibration, specified in part 1.

It shall be verified that the contents of the manufacturer's instruction manual are in accordance with the requirements specified in part 1.

4 Performance requirements

4.1 General

The normal conditions for tests are specified in 4.3 of part 1. Compliance shall be determined in accordance with the test methods specified in 4.4 of part 1.

4.2 Unpowered storage

After being submitted to the conditions specified in 4.4.2 of part 1, the apparatus shall meet the requirements specified in 4.3 ~~to~~ through Clause 5 of this part of the document.

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

4.3.1 Calibration curve

After initial adjustment with the standard test gas, each individual indication in the three sets of indications (after correction using the manufacturer's calibration curves, if necessary) obtained for each of the four gas volume ratios distributed over the measuring range, shall not differ from these volume ratios by more than $\pm 5\%$ of the measuring range or $\pm 10\%$ of the indication, whichever is the greater.

4.3.2 Response to gases other than the test gas

The apparatus indications (after correction using the manufacturer's calibration curves, if necessary) obtained for each of the three gas volume ratios of each gas tested shall not differ from these volume ratios by more than $\pm 7\%$ of the measuring range or $\pm 15\%$ of the indication, whichever is the greater.

4.4 Stability (continuous duty apparatus)

Continuous duty apparatus shall comply with the following requirements:

a) short-term stability

The short-term variation shall not exceed $\pm 3\%$ of the measuring range or $\pm 10\%$ of the indication, whichever is the greater.

b) long-term stability (fixed and transportable apparatus)

The long-term variation shall not exceed $\pm 7\%$ of the measuring range or $\pm 15\%$ of the indication, whichever is the greater.

c) long-term stability (portable apparatus)

The long-term variation shall not exceed $\pm 5\%$ of the measuring range or $\pm 10\%$ of the indication, whichever is the greater.

4.5 Stability (spot-reading apparatus)

The variation of the indication shall not exceed $\pm 3\%$ of the measuring range or $\pm 10\%$ of the indication, whichever is the greater.

4.6 Alarm

The alarm(s) shall operate during every cycle of the test. If a latching alarm is provided, the manual reset action shall be checked.

4.7 Temperature

4.7.1 Apparatus where the control unit and sensors are used in the same environment

The variation of the indication from that at $20\text{ }^{\circ}\text{C}$

- a) shall not, at $-10\text{ }^{\circ}\text{C}$, exceed $\pm 7\%$ of the measuring range or $\pm 10\%$ of the indication, whichever is the greater.
- b) shall not, at $+40\text{ }^{\circ}\text{C}$, exceed $\pm 5\%$ of the measuring range or $\pm 10\%$ of the indication, whichever is the greater.

4.7.2 Remote sensors of apparatus where the control unit and sensor are not used in the same environment

The variation of the indication from that at 20 °C, over the temperature range of –25 °C to +55 °C shall not exceed ± 2 % of the measuring range or $\pm 3,5$ % of the indication per 10 °C, whichever is the greater.

NOTE The control unit shall be at ambient temperature.

4.7.3 Control units, of apparatus where the control unit and sensor are not used in the same environment

The variation of the indication from that at 20 °C, at temperatures of +5 °C to +55 °C, shall not exceed ± 3 % of the measuring range or ± 10 % of the indication, whichever is the greater.

4.8 Pressure

The variation of the indications at ~~80~~ 95 kPa and 110 kPa from the indication at 100 kPa shall not exceed $\pm 7,5$ % of the measuring range or ± 30 % of the indication, whichever is the greater.

4.9 Humidity

The variation of the indications at 20 % RH and 90 % RH from the indication at 50 % RH, at +40 °C, shall not exceed ± 5 % of the measuring range or ± 10 % of the indication, whichever is the greater.

4.10 Air velocity

The variation of the indication shall not exceed ± 5 % of the measuring range or ± 10 % of the indication, whichever is the greater.

4.11 Flow rate

The variation of the indication shall not exceed ± 5 % of the measuring range or ± 10 % of the indication, whichever is the greater.

4.12 Orientation

The variation of the indication shall not exceed ± 5 % of the measuring range or ± 10 % of the indication, whichever is the greater.

4.13 Vibration

During the vibration test, the apparatus shall not suffer any loss of function and shall not give a false alarm or fault signal. The apparatus shall not suffer damage resulting in a hazard or loss of function.

At the conclusion of the vibration test and after the apparatus sensor has been exposed to clean air followed by the standard test gas mixture, the deviation of the indication from that determined prior to the test shall not exceed ± 5 % of the measuring range or ± 15 % of the indication, whichever is the greater.

4.14 Drop test (applicable to portable apparatus and remote sensors)

The apparatus shall not suffer damage resulting in a hazard or loss of function.

The variation of the indication shall not exceed ± 5 % of the measuring range or ± 15 % of the indication, whichever is the greater.

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

4.15.1 Fixed and transportable apparatus

The apparatus shall warm up in clean air to indicate zero to within ± 5 % of the measuring range in a time specified by the manufacturer, and no false alarms shall be generated.

4.15.2 Continuous duty portable apparatus

The apparatus shall warm up in clean air to indicate zero to within ± 5 % of the measuring range in a time not exceeding 2 min, and no false alarms shall be generated.

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

The time of response $t(50)$ shall be not greater than 20 s, and $t(90)$ shall be not greater than 60 s.

4.17 Minimum time to operate (spot-reading apparatus)

For apparatus without a probe or sample line, the indication shall reach 90 % of the final value in a time not exceeding 15 s.

For aspirated apparatus using a sample line or probe, an additional 3 s per metre is permitted.

4.18 High gas concentrations above the measuring range

Not applicable.

4.19 Battery capacity

4.19.1 Battery-powered portable continuous duty apparatus

The variation shall not exceed ± 3 % of the measuring range or ± 10 % of the indication, whichever is the greater, at the end of the 8 h or 10 h period, as appropriate.

At the end of a further 10 min following the indication of low battery condition, the variation shall not exceed ± 6 % of the measuring range or ± 20 % of the indication, whichever is the greater.

4.19.2 Battery-powered portable spot-reading apparatus

The variation shall not exceed ± 3 % of the measuring range or ± 10 % of the indication, whichever is the greater, at the end of 200 operations.

After a further 10 operations following the indication of low battery condition, the variation shall not exceed ± 6 % of the measuring range or ± 20 % of the indication, whichever is the greater.

4.20 Power supply variations

4.20.1 General

No requirement.

4.20.2 a.c. and d.c. powered apparatus

The variation of the indication shall not exceed ± 3 % of the measuring range or ± 10 % of the indication, whichever is the greater.

4.20.3 ~~External d.c. powered apparatus~~ Other power supply ranges

The variation of the indication shall not exceed ± 3 % of the measuring range or ± 10 % of the indication, whichever is the greater.

4.20.4 ~~Other power supply ranges~~

~~The variations of the indication shall not exceed ± 3 % of the measuring range or ± 10 % of the indication, whichever is the greater.~~

4.20.5 ~~Battery powered apparatus~~

~~The variation of the indication shall not exceed ± 3 % of the measuring range or ± 10 % of the indication, whichever is the greater.~~

~~For spot reading apparatus, it shall be possible to carry out at least 10 measurements starting from the minimum operating voltage within the above tolerances.~~

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

The apparatus shall not yield spurious alarms when the specified interruptions, voltage transients or step change of voltage occur.

4.22 Addition of sampling probe

The variation of the indication shall not exceed ± 2 % of the measuring range or ± 5 % of the indication, whichever is the greater.

4.23 ~~Dust~~

~~The increase in $t(90)$ shall be not more than 10 s.~~

4.24 Poisons and other gases

Not applicable.

4.24.1 Poisons

Not applicable.

4.24.2 Other gases

Not applicable.

4.25 Electromagnetic compatibility

When subjected to the electromagnetic compatibility test, the variation of the indication shall not exceed ± 3 % of the measuring range. The apparatus shall suffer no loss of function or spurious alarm.

4.26 Dielectric strength

When subjected to the dielectric strength test, the apparatus shall have no breakdown or repeated flashover.

5 Field calibration kit

The meter or output indication observed during the use of the field calibration kit shall not differ from the specified concentration by more than $\pm 5\%$ of the span or $\pm 10\%$ of the indication, whichever is the greater.

Annex A (informative) — National deviations

The following provides an explanation of the ISA SP12.13 committee deviations from IEC standard 61779-5:

Subclause 4.23: The test does not adequately determine the resistance to adverse effects of the accumulation of dust. Refer to ANSI/ISA-RP12.13.02 (IEC 61779-6 Mod) for recommendations on installation and maintenance of gas detection equipment within dust environments.

Subclause 4.26: Dielectric strength testing is necessary to ensure that the conductance of performance testing does not compromise equipment electrical safety.

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