BRITISH STANDARD

BS EN 50381:2004

Incorporating Corrigendum No. 1

Transportable ventilated rooms with or without an internal source of release

The European Standard EN 50381:2004 has the status of a British Standard

ICS 29.260.20

BSI British Standards

National foreword

This British Standard is the official English language version of EN 50381:2004, including Corrigendum December 2005.

The UK participation in its preparation was entrusted by Technical Committee GEL/31, Electrical apparatus for explosive atmospheres, to Subcommittee GEL/31/17, Pressurization and other techniques, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

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

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EUROPEAN STANDARD **EN 50381**

NORME EUROPÉENNE

EUROPÄISCHE NORM August 2004

ICS 29.260.20 Incorporates Corrigendum December 2005

English version

Transportable ventilated rooms with or without an internal source of release

Caissons ventilés transportables avec ou sans source de dégagement interne

Transportable ventilierte Räume mit oder ohne innere Freisetzungsstelle

This European Standard was approved by CENELEC on 2004-03-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

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CENELEC

European Committee for Electrotechnical Standardization
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Europäisches Komitee für Elektrotechnische Normung

Central Secretariat: rue de Stassart 35, B - 1050 Brussels

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Foreword

This European Standard was prepared by WG 31-73, of SC 31-7, Pressurization and other techniques, of the Technical Committee CENELEC TC 31, Electrical apparatus for explosive atmospheres.

The text of the draft was submitted to the Unique Acceptance Procedure and was approved by CENELEC as EN 50381 on 2004-03-01.

The following dates were fixed:

– latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2005-03-01
– latest date by which the national standards conflicting with the EN have to be withdrawn	(dow)	2007-03-01

This standard covers the essential requirements for pressurized rooms without an internal source of release and the additional requirements when an internal source of release is present.

This European Standard was prepared under mandate BC/CEN/CLC/08-92 given to CENELEC by the European Commission and the European Free Trade Association and covers essential requirements of the EC Directive 94/9/EC. See Annex ZZ.

This European Standard is to be read in conjunction with EN 50014, Electrical apparatus for potentially explosive atmospheres – General requirements, or where appropriate, with EN 50021, Electrical apparatus for potentially explosive atmospheres – Type of protection “n”. This European Standard should not be considered in conjunction with any editions of these standards and their amendments published before 1997.

Contents

Introduction

This is a new European Standard for transportable pressurized rooms with and without an internal source of release but is confined to those rooms which are transportable and should not apply to rooms constructed on site and not intended for resale.

Pressurized rooms are locations intended for human occupation under normal operational circumstances. In such circumstances it is important to distinguish between pressurization, which may use air or inert gas and be applied to apparatus not required to support life, from ventilation. Ventilation in the context of this standard, taken together with other safety measures, ensures a safe (and breathable) atmosphere within the pressurized room.

This text is based upon the scope of EN 61285, IEC/TR 61831, IEC 60079-13 and IEC 60079-16 and the essential safety requirements of Directive 94/9/EC.

1 Scope

1.1 This European Standard contains the specific requirements for the construction and testing of transportable ventilated rooms (TVR's), such as skid mounted analyser houses with type of protection 'v' intended for use in potentially explosive atmospheres. Transportable in this sense means manufactured in one location (the manufacturer's premises) for trade and transportation to another location (the user's premises) for installation and use. This European Standard supplements European Standard EN 50014 or where appropriate EN 50021, the requirements of which apply to electrical apparatus with type of protection 'v' except as modified within this standard. This standard does not contain the requirements for equipment group II, category 1 or equipment group I, category M1. This standard does not contain the requirements for equipment group I, category M2 where there exists a potential source of release. This standard does not contain the requirements for group II where there exists a potential hazard from combustible dusts.

NOTE It is not the intention of this European Standard to cover stationary analyzer houses according to EN 61285.

1.2 This European Standard includes the requirements for the construction of the TVR and its associated components including, the inlet and outlet apertures for the ventilation gas supply and for the safety provisions and devices necessary for the type of protection 'v'.

1.3 This European Standard specifies the requirements for TVR's with or without an internal source of release of potentially flammable or toxic, gas, liquid or vapour (for example analyzers placed within the TVR).

1.4 Due to the safety factors incorporated in the type of protection, the uncertainty of measurement inherent in good quality, regularly calibrated measurement equipment is considered to have no significant detrimental effect and need not be taken into account when making the measurements necessary to verify compliance of the apparatus with the requirements of this standard.

2 Normative references

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

EN 954-1	Safety of machinery - Safety related parts of control systems
EN 50014	Electrical apparatus for potentially explosive atmospheres – General requirements
EN 50015	Electrical apparatus for potentially explosive atmospheres – Oil immersion 'o'
EN 50016	Electrical apparatus for potentially explosive atmospheres – Pressurized apparatus 'p'
EN 50017	Electrical apparatus for potentially explosive atmospheres – Powder filling 'q'
EN 50018	Electrical apparatus for potentially explosive atmospheres – Flame proof enclosures 'd'
EN 50019	Electrical apparatus for potentially explosive atmospheres – Increased safety 'e'
EN 50020	Electrical apparatus for potentially explosive atmospheres – Intrinsic safety 'i'

EN 50021		Electrical apparatus for potentially explosive atmospheres – Type of protection ‘n’
EN 50028		Electrical apparatus for potentially explosive atmospheres – Encapsulation 'm'
EN 50039		Electrical apparatus for potentially explosive atmospheres – Intrinsically safe electrical systems ‘i’
EN 60034-5		Rotating electrical machines -- Part 5: Degrees of protection provided bythe integral design of rotating electrical machines (IP code) – Classification (IEC 60034-5)
EN 60079-10	1996	Electrical apparatus for explosive gas atmospheres – Part 10: Classification of hazardous areas (IEC 60079-10:1995)
EN 60079-15	2003	Electrical apparatus for explosive gas atmospheres – Part 15: Type of protection “n” (IEC 60079-15:2001, modified)
EN 60529		Degrees of protection provided by enclosures (IP Code) (IEC 60529)
EN 61285		Industrial-process control – Safety of analyser houses (IEC 61285)
EN 61779-1		Electrical apparatus for the detection and measurement of flammable gases – Part 1: General requirements and test methods (IEC 61779-1:1998, modified)
EN 61779-2		Electrical apparatus for the detection and measurement of combustible gases – Part 2: Performance requirements for Group I apparatus indicating a volume fraction up to 5 % methane in air (IEC 61779-2:1998, modified)
EN 61779-3		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 (IEC 61779-3:1998, modified)
EN 61779-4		Electrical apparatus for the detection and measurement of combustible gases – Part 4: Performance requirements for Group II apparatus indicating a volume fraction up to 100 % lower explosive limit (IEC 61779-4:1998, modified)
EN 61779-5		Electrical apparatus for the detection and measurement of combustible gases – Part 5: Performance requirements for Group II apparatus indicating a volume fraction up to 100 % gas (IEC 61779-5:1998, modified)

3 Definitions

For the purpose of this standard, the following definitions apply:

3.1
purging

– the operation of passing a specified quantity of air through the TVR, or apparatus as defined in Annex A, and its associated ducts, so that any explosive gas or vapour is reduced to a safe concentration; or

– the operation of passing a quantity of inert gas through apparatus as defined in Annex B, and its associated ducts, so that any oxygen, as a component of air that may be present is reduced to a safe concentration

NOTE Purging may also be used for other purposes such as:
– to ensure that the air quality of the atmosphere within the TVR is acceptable; or
– to ensure that any toxic gas or vapour that may be present is reduced to a safe concentration; or
– to account for the potential depletion of oxygen, accumulation of carbon dioxide or potential release of any asphyxiant gas.

These and other like issues are the responsibility of the user and the test house is not required to verify compliance.

3.2
internal source of flammable release
a point or location from which a flammable substance in the form of a flammable gas or vapour or liquid may be released into the TVR such that an explosive gas atmosphere could be formed

3.3
ignition capable apparatus
apparatus which in normal or abnormal operation constitutes a source of ignition for a specified explosive atmosphere by being capable of producing sparks or generating ignition capable hot surfaces. Apparatus which meets the requirements of one or more of the types of protection listed in EN 50014 for the specified atmosphere is considered not ignition capable

3.4
non-incendive apparatus
apparatus which in normal operation does not produce sparks or generate hot surfaces capable of igniting a specified explosive atmosphere. Apparatus which meets the requirements of one or more of the types of protection in EN 50021 or EN 60079-15 and/or by the methods outlined in Annex A or Annex B is considered non-incendive

3.5
limited toxic release
a release of toxic gas, vapour or liquid, the maximum flow rate of which can be predicted by the use of limiting devices and/or by calculation

NOTE This standard does not specify the necessary safety criteria for dealing with toxic release. Some guidance is given in EN 61285.

3.6
limiting value
the limiting value is the lowest concentration value of the lower explosive limit (LEL) of each component involved, taking account of the most onerous conditions of concentration that may occur from every potential source of release within the TVR

3.7
protective gas
– air used for purging and maintaining a pressure differential and, if required, dilution within the TVR or an enclosure meeting the requirements of Annex A; or
– an inert gas used for maintaining a pressure differential within an enclosure meeting the requirements of Annex B

3.8
ventilation
the maintenance of a pressure differential between the external atmosphere and that within the TVR with continuous flow of the protective gas. The purpose is to dilute any potential limited release to a safe level within the TVR. This concept is only applicable to type of protection v2, v3 and v4

NOTE The term 'ventilation' is used in this text as a means of explosion protection. It is recognised that ventilation may also be used to ensure adequate air quality for personnel and also to maintain a specific temperature regime within the TVR; these latter requirements are out with the scope of this document.

3.9
Leakage Compensation of a Breathable Atmosphere (LCBA)
the maintenance of a pressure differential between the external atmosphere and that within the TVR with a supply of air which, after purging, when the outlet apertures are closed, is sufficient to maintain the required positive pressure differential whilst compensating for any loss due to leakage and maintaining an internal atmosphere of breathable quality. This concept is only applicable to type of protection vM2

NOTE Additional measures, such as the use of oxygen deficiency detectors may be required to ensure an equable environment within the TVR. Such measures are not within the scope of this standard.

3.10
containment system
those parts of the apparatus associated with the TVR containing the flammable gas, vapour or liquid that may constitute an internal source of release

NOTE The containment system may extend out with the enclosure walls of the TVR.

3.11
dilution
the continuous supply of a protective gas, after purging, at such a rate that the concentration of a flammable mixture inside the TVR is maintained at a value below the explosive limits except in a dilution area

NOTE For safety reasons dilution to a level lower than the LEL may be required if associated with the potential release there is an additional toxic or asphyxiant risk. Further guidance can be found in EN 61285.

3.12
dilution area
an area in the vicinity of a source of release where it cannot be demonstrated that, the concentration of flammable gas or vapour is diluted to a safe concentration

NOTE A dilution area may be extended to include locations where it is not necessary for the test house to carry out assessments, for example where no apparatus is located.

3.13
limited release
a release of flammable gas or vapour the maximum flow rate of which, can be predicted by the use of limiting devices and/or by calculation

3.14
unlimited release
a release of flammable gas or vapour the maximum flow rate of which cannot be predicted arising from the release of a flammable liquid

3.15
Lower Explosive Limit (LEL)
the volume ratio of flammable gas or vapour in air below which an explosive gas atmosphere will not be formed

3.16
Upper Explosive Limit (UEL)
volume ratio of flammable gas or vapour in air above which an explosive gas atmosphere will not be formed

3.17
volume ratio (v/v)
ratio of the volume of a component to the volume of the gas mixture under specified conditions of temperature and pressure

3.18
type of protection v
a type of protection intended to reduce the risk of explosion to an appropriate level by the prevention of the formation of an explosive atmosphere in the vicinity of a source of ignition

3.18.1
type of protection vM2
suitable for use in underground parts of mines and to those parts of surface installations of such mines, liable to be endangered by firedamp and/or combustible dust. Type of protection vM2 ensures the requisite level of protection, even in the event of frequently occurring disturbances or equipment faults which normally have to be taken into account by maintaining a positive pressure differential between the atmosphere within the TVR and that external

3.18.2
type of protection v2
suitable for areas in which explosive atmospheres caused by gases, vapours or mists are likely to occur Type of protection v2 ensures the requisite level of protection, even in the event of frequently occurring disturbances or equipment faults which normally have to be taken into account by maintaining a positive pressure differential between the atmosphere within the TVR and that external, and where appropriate adequate ventilation

3.18.3
type of protection v3
suitable for areas in which explosive atmospheres caused by gases, vapours or mists are unlikely to occur or if they do occur, are likely to do so infrequently and for a short period only. Type of protection v3 ensures the requisite level of protection during normal operation by maintaining a positive pressure differential between the atmosphere within the TVR and that external, and where appropriate adequate ventilation

3.18.4
type of protection v4
suitable for areas normally considered safe but in which a risk of an explosive atmosphere caused by gases, vapours or mists might occur due to the operation of equipment within the TVR and if they do occur, are likely to do so infrequently and for a short period only. Type of protection v4 ensures the requisite level of protection during normal operation by maintaining a negative pressure differential between the atmosphere within the TVR and that external, and where appropriate adequate ventilation

4 Construction requirements for TVR's and ducting

4.1 General

The size of the TVR depends on the number, size and access requirements of the equipment to be housed. Except for type of protection vM2 the absolute minimum unobstructed headroom shall be 2,0 m. Suspended ceilings, cable trenches and other dead air spaces shall be avoided.

NOTE 1 An additional allowance of 30 % should be made for the addition of further equipment. Recommended minimum dimensions are 2,5 m length and width and 2,3 m headroom.

NOTE 2 If the electrical apparatus has to withstand particularly adverse service conditions (e.g. rough handling, humidity, effects of ambient temperature variations, effects of chemical agents, corrosion) these should be specified by the user to the manufacturer and are not the responsibility of the testing house.

4.2 Degree of ingress protection

The TVR, including any apertures for moving parts but excluding apertures for the inlet and outlet of the protective gas, shall have a degree of protection in accordance with at least IP40 of EN 60529.

In the case of equipment group I, type of protection vM2 the TVR shall have a degree of protection in accordance with at least IP44 of EN 60529.

4.3 Design and construction

The exterior of the TVR shall be designed and constructed to minimize the accumulation of dust and provide easy facility for cleaning, for example by the use of a pitched roof with extended eaves and the fitment of external pitched canopies.

4.4 Mechanical strength

The TVR, ducts, if any, and their connecting parts shall withstand a pressure equal to 1,5 times the maximum pressure differential specified by the manufacturer for normal service with a minimum of 200 Pa (2 mbar). In the case of type of protection v2 and v3 all outlets shall be closed and in the case of v4 all inlets shall be closed.

If a pressure differential can occur in service that can cause a deformation of the TVR, ducts, if any, or connecting parts, a safety device shall be fitted by the manufacturer to limit the maximum pressure differential to a level below that which could adversely affect the type of protection.

4.5 Penetrations

Penetrations shall be via devices such as bulkhead panels and gland plates with appropriate bulkhead fittings and/or glands or [1)] fire wall transit and shall maintain the required degree of ingress protection.

4.6 Floor drains

Where there is a source of internal release of liquid cleaning facilities such as a slight slope and drain to a common collecting point, shall be provided.

Where a floor drain is installed it shall, except for type of protection vM2, be free draining to the outside. Provision shall be made to prevent exchange of the atmosphere between the interior and exterior of the TVR.

4.7 Floors

Floors shall be non-slip. Non-slip finishes shall be resistant to any material likely to come into contact with the floor. Floors shall be non porous and impervious to hydrocarbon vapours. The test house is not required to verify compliance.

NOTE It is the user's responsibility to ensure that measures shall be taken to prevent ingress of extraneous liquids for example by raising the floor above ground and/or providing a step or ramp at the door entrance. Where the TVR is intended to be positioned on a concrete plinth this should be impervious to hydrocarbons and raised at least 0,1 m above the surrounding area.

4.8 Doors

A minimum of one door shall be provided. All doors shall open outwards. Except for vM2, doors shall be fitted with an automatic self closing mechanism to close and latch (regardless of the extent to which the door was initially open) even against the maximum overpressure specified in normal service.

4.8.1 Door(s) shall be fitted with lock(s) to control unauthorized access. Door(s) shall be capable of being opened from within, even when locked (for example by the use of a panic bar).

4.8.2 Doors shall be fitted with a position switch to operate when the door is closed.

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1) See Annex J of IEC/TR 61831.

4.9 Inspection window(s)

Where inspection window(s) are fitted in doors they shall be sealed, not be capable of being opened and shall be shatter resistant for example by wire reinforcing.

NOTE Recommendations for the requirements for inspection windows are given in EN 61285.

4.10 Apertures

The location, size and number of apertures shall be suitable for effective purging.

NOTE The number of apertures should be chosen in regard to the design and disposition of the apparatus particular consideration being given to the needs of sub-compartments into which the apparatus might be divided.

4.10.1 Apertures shall be designed to be self closing in the event of ventilation failure or failure of maintenance of pressure differential.

4.10.1.1 In the case of equipment group I, type of protection vM2, apertures shall be self closing and sealed to at least IP44 of EN 60529. in the event of failure of maintenance of pressure differential.

4.10.1.2 In the case of equipment group II apertures shall be self closing in the event of ventilation failure.

4.10.2 Aperture closures shall be fitted with a switch or device to operate when open.

4.10.3 Apertures shall be fitted with mesh or screen meeting IP20, to prevent foreign material such as rodents or leaves impairing the proper operation of the closure devices.

4.10.4 In the case of equipment group II, the distribution of inlet and outlet apertures shall be arranged so as to be unaffected by outside weather conditions such as wind, rain or snow. TVR's intended for use outdoors shall have several apertures distributed on opposite faces so that at least 50 % are effective even during adverse weather conditions.

4.11 Enclosures

Where within the TVR, there may exist enclosures, such as junction boxes or distribution panels which are protected by one or more of the methods listed in Clause 2, excluding EN 50016, the total volume of such enclosures shall not exceed 10 % of the internal volume of the room or chamber in which they are fitted.

NOTE The test house is not required to verify that the internals of such enclosures are purged during the TVR purge sequence.

5 Requirements for TVR's, equipment group I, type of protection vM2

5.1 The leakage compensation system shall ensure a positive pressure differential of 25 Pa (0,25 mbar) between the external atmosphere and that within the TVR (except within the immediate vicinity of the outlet aperture during purging).

The manufacturer shall specify the minimum and maximum over pressure differential in service.

NOTE It is essential for the safety of a TVR that the installation of the associated ducts and of the compressor or fan does not introduce a hazard.

5.2 The minimum flow rate of protective gas required for purging is the rate specified by the manufacturer. The minimum purging duration is the duration also specified by the manufacturer and verified by the type tests. The purging flow rate shall be monitored at the inlet to the TVR.

NOTE To determine the free space of the associated ducts and to set up the additional purging time for the given minimum flow rate is the responsibility of the user. The purge duration shall be increased by the time necessary to purge the free volume of those associated ducts which are not part of the certified apparatus by at least five times their volume at the minimum flow rate specified by the manufacturer.

5.2.1 The design and arrangement of inlet ducts and the outlet apertures shall be arranged to ensure even distribution of the purge air flow so as to avoid pockets where gases could accumulate.

5.2.2 If additional equipment is required to ensure adequate distribution of purge air it shall be incorporated as part of the essential safety system and shall be protected by one of the means listed in Clause 2.

NOTE The circulation fans may form part of a heating cooling system.

6 Ventilation requirements for TVR's, equipment group II

6.1 Ventilation shall provide a minimum of 5 air changes per hour.

NOTE Ventilation may also be used to ensure an equable environment for personnel and/or equipment. For that reason heating and/or cooling facilities may be incorporated in the ventilation system.

6.2 The ventilation system shall ensure a minimum pressure differential of 25 Pa (0,25 mbar) between the external atmosphere and that within the TVR except within the immediate vicinity of the outlet aperture in the case of v2 and v3 and the inlet apertures in the case of v4.

The manufacturer shall specify the minimum and maximum pressure differential in service.

NOTE 1 It is essential for the safety of a TVR that the installation of the associated ducts and of the compressor or fan does not introduce a hazard.

NOTE 2 Local wind conditions shall always be taken into consideration when overpressures are being set.

6.3 The minimum flow rate of protective gas required for purging is the rate specified by the manufacturer. The minimum purging duration is the duration also specified by the manufacturer and verified by test or calculation in the case of v2, v3 and v4. The purging flow rate shall be monitored at the inlet to the TVR in the case of v2 and v3 and at the outlet in the case of v4.

NOTE To determine the free space of the associated ducts and to set up the additional purging time for the given minimum flow rate is the responsibility of the user. The purge duration shall be increased by the time necessary to purge the free volume of those associated ducts which are not part of the certified apparatus by at least five times their volume at the minimum flow rate specified by the manufacturer.

6.3.1 The design and arrangement of ducts and the apertures shall be arranged to ensure even distribution of the ventilation air flow so as to avoid pockets where gases or vapours could accumulate.

NOTE 1 Guidance on the installation and location of ducts is given in Annex B and Annex C of IEC 60079-16.

If additional circulation fans or equipment are required to ensure adequate distribution of air they shall be incorporated as part of the essential safety system and shall, if fitted within the TVR and/or associated ducts, be protected by one of the means listed in Clause 2.

NOTE 2 The circulation fans may form part of a heating cooling system.

6.4 The ventilation flow rate shall be monitored at the inlet to the TVR in the case of v2 and v3 and at the outlet in the case of v4. The minimum ventilation flow rate specified by the manufacturer shall be achieved with 50 % of the flaps closed.

7 Additional ventilation requirements for TVR'S with an internal source of release

7.1 Ventilation shall provide that air flow necessary to dilute escaping vapours from the rupture or failure of the most hazardous sample or service line to less than 20 % of the limiting value except in a dilution area. Where one fault or rupture automatically precipitates another, they shall be treated together as a single fault.

NOTE For most fluids, the major constraint is that the concentration of vapours, which are hazardous for personnel, is lower than the LEL, and additional ventilation may be required. Additional safety measures for the safe handling and disposal of gases or vapours emerging from the ventilation system are the responsibility of the user.

7.2 A minimum of two gas detectors shall be fitted. They shall be positioned according to the nature of the gases expected either from the external atmosphere or potentially released within the TVR. Where a set of detectors is required to ensure adequate response to the range of flammable gases specified, a minimum of two sets of detectors shall be fitted.

8 Temperature limits

8.1 The TVR shall be classified in accordance with the temperature classification requirements of EN 50014 or EN 50021 or EN 60079-15. The maximum surface temperature shall be determined as follows:

a) in the case of v2 and v3 either by the temperature of the hottest point of the external surface of the TVR; or

b) by the T rating of the internal parts which are protected by any of the types of protection listed in EN 50014 or EN 50021 or EN 60079-15, and which remain energized even when the supply of protective gas is removed (e.g. electrical heaters) which ever is the hotter.

8.1.1 Normally the temperature of the protective gas to be taken into consideration is 40 K at the inlet to the TVR. In special circumstances a higher temperature may be permitted or a lower temperature may be required, for example for cooling purposes, in which case the maximum inlet temperature of the protective gas shall be marked on the TVR and stated in the manufacturer's documentation.

8.2 If during normal service the temperature of any surface within the TVR exceeds the value determined in 8.1 b for the temperature class, appropriate measures shall be taken to prevent if ventilation ceases, any explosive atmosphere coming into contact with the hot surface.

NOTE This may be achieved either by the design and construction of the TVR, e.g. air locks or by bringing auxiliary ventilation systems into operation or by arranging that the hot surface within the TVR is in a gas tight or encapsulated housing.

9 Minimum safety provisions and devices

9.1 All safety devices used to prevent electrical apparatus protected by type of protection 'v' from causing an explosion shall themselves not be capable of causing an explosion or shall be mounted outside the hazardous area.

9.2 The safety devices required by this standard form safety related parts of a control system. It is the responsibility of the manufacturer to assess that the safety and integrity of the control system is consistent with the level of safety required by this standard.

NOTE See EN 954-1, Safety of machinery - Safety related parts of a control system.

9.3 The safety devices shall be provided by the manufacturer of the TVR or by the user. In the latter case the apparatus shall be marked "X" and the description documents shall contain all necessary information required by the user to ensure conformity with the requirements of this standard.

9.4 Where the safety related control system forms part of the apparatus, a functional sequence diagram shall be provided by the manufacturer, for example truth table, state diagram, flow chart, etc., to define the action of the control system. The sequence diagram shall clearly identify and show the operational states of the safety devices and ensuing actions. Functional tests shall be required to verify conformity to the diagram. These tests need only be carried out under normal conditions of atmospheric temperature and pressure (NTP) unless otherwise specified by the manufacturer.

9.5 The manufacturer shall specify the maximum and minimum action levels and tolerances of the safety devices. The safety devices shall be used within the normal operational limits as specified by the manufacturer (of those devices) taking due account of the most onerous conditions specified for normal service.

9.6 Safety devices, such as time delay relays and devices for monitoring the pressure differential and the flow of protective gas, shall be provided to prevent ignition capable apparatus, in the case of category 2 and equipment not meeting the requirements for non-incendive apparatus in the case of category 3 , within the TVR, becoming energized until purging has been completed.

The sequence of operations of the safety devices shall be as follows:

– following the initiation of the sequence, the purging flow through and the pressure differential between the internals of the TVR and the external atmosphere shall be monitored in accordance with this standard;

– in the case of v4 the inlet apertures shall indicate closure prior to commencement of purge in all other cases the outlet apertures shall indicate closure prior to commencement of purge when:

  a) in the case of vM2, the minimum specified purge rate or in the case of v2, v3 or v4 the minimum specified ventilation flow rate of protective gas through the TVR is achieved;

     and

  b) the pressure differential is within the specified limits;

     and

  c) in the case of category M2 all of the outlet apertures are open or in the case of v2, v3 and v4 $\geq$ 50 % of the apertures are open;

     and

  d) the minimum prescribed purge flow rate for equipment protected by the methods described in Annex A or Annex B, if fitted, has been achieved,

  the purge timer can be started.

– when the purge time has elapsed, the purge flow rate may be reduced to a level not lower than the minimum ventilation flow rate, when specified in the case of v2, v3 or v4;

– after the expiry of the purging time, and whilst maintaining the minimum pressure differential and ventilation flow rate, when specified in the case of v2, v3 or v4, the main apparatus is then available to be energized.

In the event of failure of any step in the sequence, the circuit shall be arranged to reset to the beginning except if during the initial purge cycle, the minimum specified pressure differential is not maintained but the door switch indicates that the door is not closed, the timer shall be halted. If the loss of pressure differential persists for longer than 60 s the circuit shall be arranged to reset to the beginning regardless of the status of the door switch.

9.7 The concentration of flammable gas after purging shall not exceed 20 % of the limiting value.

9.8 An automatic device or devices shall be provided to operate when the pressure differential falls below the minimum value specified by the manufacturer. It shall be possible to check the correct operation of the devices.

9.8.1 All ignition capable apparatus shall be isolated immediately upon operation of the pressure differential device. Exceptions are:

9.8.1.1 in the case of v3, electrical apparatus within the TVR that may be energized when type of protection pressurization v3 is not in operation, shall as a minimum, meet the requirements for non-incendive apparatus as defined in 3.4;

9.8.1.2 in the case of v3, where there is no internal source of release and when gas detectors are fitted and indicate less than 20 % of the limiting value a delay up to a maximum of 24 h is permitted before isolation of apparatus, not meeting the requirements of 3.4, upon operation of the pressure differential device;

9.8.1.3 when the door switch indicates that the door is not closed, a delay up to a maximum of 60 s is permitted before isolation upon operation of the pressure differential device.

10 Additional safety provisions and devices for TVR's meeting the requirements of type of protection v2 and vM2

10.1 All of the provisions of Clause 8 this standard shall apply.

10.2 Doors and access ways, except for emergency escape panels which are not intended to be opened in normal use, into TVR's meeting the requirements of type of protection v2 or vM2 shall be via an airlock.

10.2.1 Electrical apparatus within the confines of the airlock shall meet the requirements of one or more of the protection concepts listed in EN 50014.

10.2.2 The free volume of the airlock shall not exceed 20 % of the free internal volume of the TVR; or provision shall be made to ensure that upon entering and closing the outer door of the airlock that the airlock is purged by a quantity of protective gas, equivalent to 5 volumes (of the air lock) before the inner door is opened. This may be achieved, for example, by a flow measuring device and a notice indicating the minimum time to be observed before the inner door may be opened; unless a minimum of two gas detectors, meeting the requirements of one or more of EN 61779-2, EN 61779-3, EN 61779-4 or EN 61779-5, is fitted within the airlock and the gas detectors are set to operate at not greater than 20 % of the limiting value; in which case the inner door may be opened when the gas detectors indicate less than 20 % of the limiting value.

NOTE It is the user's responsibility to provide prompt restorative action if the gas detectors within the airlock indicate a level in excess of 20 % of the limiting value for a period of time.

10.2.3 Each door of the airlock shall be fitted with a device to indicate when the doors are closed. There shall be a local indication when a door is not closed.

10.2.4 A warning sign shall be placed upon each door, in a prominent location, to indicate that one door must be closed before the other is open.

10.2.5 In the case of vM2, the power to all ignition capable apparatus shall be disconnected immediately if both doors are not closed.

10.3 Electrical apparatus within the TVR that may be energized when type of protection pressurization v2 or vM2 is not in operation, shall be protected by a type of protection listed in Clause 2.

11 Additional requirements for TVR's with an internal source of release

11.1 Assessment of containment systems

Where within the TVR there is more than one containment system, with no shared connection, each shall be assessed separately.

11.2 Release conditions

11.2.1 No release

11.2.1.1 There is no internal release when all parts of the containment system meet the requirements for infallible parts of the containment system.

11.2.1.2 No release is deemed to exist when the flammable substances inside the containment system are in the gas or vapour phase when operating between the specified temperature limits and

– either the gas mixture within the containment system is always below LEL. The conditions to be met in this subclause require the apparatus to marked "X",

– or, in the case of v2 and v3, the minimum pressure specified for the TVR is at least 25 Pa higher than the maximum pressure specified for the containment system and an automatic device is provided to isolate and discharge the contents of the containment system, to a location out with the TVR, at atmospheric pressure, within 60 s, if the pressure difference falls below 25 Pa,

– or, in the case of v4, an automatic device is provided to isolate and discharge the contents of the containment system, to a location out with the TVR, at atmospheric pressure, within 60 s, if the pressure difference falls below 25 Pa.

NOTE Consideration should be given by the user to the possible formation of flammable mixture due to the possibility of air penetration into the containment system and the resulting additional precautions that may be necessary.

11.2.2 Release of a flammable liquid

The liquid flow rate shall be limited. This condition applies to liquids which can evolve flammable gas or vapour. If there may be, together with the liquid, entrained oxygen, the maximum flow rate of oxygen shall be predictable.

11.3 Design requirements for the containment system

The design and construction of the containment system, which will determine whether leakage is likely to occur or not, should be based on the most onerous conditions of service specified by the manufacturer.

The manufacturer shall specify the maximum operating pressure and the flow rate into the containment system in normal service. Where the containment system comprises several components, the rated design pressure of the containment system shall not exceed the manufacturer's rated pressure of any component of the containment system with a safety factor of 1,5.

Details of the constructional design of the containment system, the types and operating conditions of flammable substances it may contain and the expected release rate or rates at given locations, shall be provided by the manufacturer. In practice the containment system may be classified as comprising several parts or components which may be assessed in one or more of the following categories:

11.3.1 Infallible parts of the containment system

Infallible parts of the containment system shall not have any intentional leakage into the TVR. This condition is satisfied when the containment system comprises metallic, ceramic or glass, pipes, tubes or vessels which have no moving joints. Joints shall be made by welding, brazing, glass to metal sealing or eutectic [2)] methods.

Low temperature solder alloys such as lead/tin composites are not acceptable.

11.3.2 Containment system with limited release

The design of a containment system with limited release shall be such that the rate of release of the flammable substance is predictable in all conditions of containment system failure. The quantity of flammable substance released into the TVR includes the quantity of flammable substance in the containment system and the flow of the flammable substance entering the containment system from the process. The latter flow shall be limited to a predictable rate by appropriate devices, fitted outside the TVR.

If the flow limiting devices are not included as part of the apparatus, the TVR shall be marked with an "X".

TVR's containing apparatus with flames shall be assessed as though the flame had been extinguished. The maximum quantity of the fuel/air mixture which supplies the flame shall be added to the quantity of release from the containment system.

NOTE 1 Elastomeric seals, windows and other non metallic parts of the containment system are permissible. Pipe threads and flanged joints are also permissible.

NOTE 2 It is the responsibility of the user to ensure that the maximum pressure and flow of the flammable substance into the containment system do not exceed the ratings specified by the manufacturer.

11.4 Ignition capable apparatus in the case of type of protection v2

Ignition capable apparatus shall not be located in the dilution area. Electrical apparatus in the dilution area shall be protected by a type of protection defined in 3.3. Exceptions from this requirement are

a) flames, ignitors or other similar apparatus intended to ignite a flame. The dilution area emanating from this flame shall not overlap any other dilution area, or

b) apparatus conforming to the requirements of Annex A or Annex B.

11.5 Location of apparatus in the case of type of protection v3

– Apparatus that may be located in a dilution area shall meet the requirements of the definition of non-incendive apparatus defined in 3.4; or

– apparatus protected by one or more of the types of protection listed in 3.3; or

– apparatus meeting the requirements of Annex A or Annex B.

Exceptions from this requirement are: flames, ignitors or other similar apparatus intended to ignite a flame. The dilution area emanating from this flame shall not overlap any other dilution area.

[2)] A method of joining two or more components, normally metallic, employing a binary or ternary alloy system which solidifies at a constant temperature which is lower than the beginning of solidification of any of the components being joined.

11.6 Internal hot surfaces

If the TVR contains any surface having a temperature which exceeds the ignition temperature of the flammable substance released from the containment system and is not covered by the requirements of Annex A, the following actions shall be taken.

11.6.1 Loss of minimum pressure differential, type of protection v2

The flow of flammable sample into the containment system shall, upon loss of pressure differential, be cut off automatically and discharged to a pressure not greater than that within the TVR, within 60 s.

11.6.2 Loss of ventilation flow, type of protection v2

The flow of flammable sample into the containment system shall upon loss of ventilation flow, be cut off automatically and discharged to a pressure not greater than that within the TVR, within 60 s unless ventilation flow can be re-established.

If after 24 h the primary ventilation is not restored, the flow of flammable sample into the containment system shall be cut off automatically and discharged to a pressure not greater than that within the TVR, within 60 s.

NOTE The provision of a low pressure facility for the discharge of the contents of the containment system and the safe handling and disposal thereof are the responsibility of the user.

11.6.3 Loss of ventilation flow, type of protection v3

The flow of flammable sample into the containment system shall, upon loss of ventilation flow, be cut off automatically within 24 h and discharged to a pressure not greater than that within the TVR, within 60 s.

11.7 Potential source of internal release

Where there exists a potential source of internal release, the source of release shall, upon ventilation failure, be disconnected external to the TVR and discharged to a pressure, not greater than that within the TVR.

NOTE The provision of a low pressure facility for the discharge of the contents of the containment system and the safe handling and disposal thereof are the responsibility of the user.

12 Requirements for gas detectors

12.1 Gas detectors shall be fitted within the TVR in the case of type of protection v2, v3 or v4, where there exists a potential source of release within the TVR and/or within airlocks when required in type of protection v2 and type of protection vM2.

12.1.1 In the case of type of protection v2, all ignition capable apparatus shall be isolated immediately upon operation of the overpressure device unless the gas detectors indicate less than 20 % of the limiting value in which case a delay of up to 24 h is permitted for apparatus meeting the requirements of Annex A or Annex B or complying with the definition 3.4 non-incendive apparatus only.

12.1.2 In the case of type of protection vM2, all ignition capable apparatus shall be isolated immediately upon operation of the overpressure device unless the gas detectors indicate less than 20 % of the limiting value in which case a relaxation of 24 h is permitted.

12.2 Where gas detectors are required, a minimum of two gas detectors meeting the requirements of one or more of the standards defined in Clause 2 shall be fitted within the TVR. Gas detectors shall give two levels of alarm with trip functions as follows:

a) immediately isolate wall sockets (where fitted) on detection of 20 % of the limiting value;

b) immediately isolate all ignition capable equipment on detection of 20 % of the limiting value, except for equipment meeting the requirements of Annex A or Annex B or complying with the definition 3.4 non-incendive apparatus;

c) immediately isolate all equipment meeting the requirements of Annex A and/or Annex B or complying with the definition 3.4 non-incendive apparatus on detection of 60 % of the limiting value;

d) gas detection shall initiate a visible and audible alarm within the TVR, a visual alarm external to the TVR and make provision to alarm elsewhere at a manned location;

e) immediately, on detection of 20 % of the limiting value, cut of the flow of flammable material into the containment system and discharge the contents to a location out with the TVR at atmospheric pressure, within 60 s;

f) neither the power to circuits, nor the flow of flammable gas into the containment system, may be restored until

   (i) the alarm condition as indicated by the gas detection apparatus falls below 20 % of the limiting value, and

   (ii) an automatic device ensures that the TVR is purged, by the ventilation system, for a time not less than that determined by the methods described in 14.4.2 or 14.4.3, and

   (iii) a manual reset device, located local to the TVR, is operated.

NOTE 1 It is the user's responsibility to provide corrective action to the source of release prior to operation of the manual reset device.

NOTE 2 Consideration may be given to isolate non-ignition capable equipment if detection of 60 % of the limiting value is not acted upon within a pre-determined period e.g. 24 h to 72 h.

12.3 Trip functions shall operate independently of ventilation failure functions.

13 Supply of protective gas

13.1 Ventilation

In the case of ventilation the air source shall be from a non-hazardous area where corrosive or toxic gases do not occur.

NOTE The protective gas should not, by reason of the impurities that it may contain, reduce the effectiveness of the type of protection "v", or adversely affect the satisfactory operation and integrity of the enclosed apparatus.

13.1.1 Ventilation shall be by means of a fan mounted external to the TVR.

13.1.2 In the case of type of protection v2, motor(s) fitted within the duct shall be protected by one or more of the means defined in 3.3.

The requirements of 17.2, 17.3 and 17.4 of EN 50014 shall apply to the fan.

In the case of type of protection v3 or v4, motor(s) fitted within the duct shall be protected by one or more of the means defined in 3.4.

13.1.3 In the case of v3 with an internal source of release or v2, a minimum of two fans shall be provided. Each fan shall be capable of maintaining the minimum prescribe ventilation flow rate whilst maintaining the minimum overpressure. One fan shall be maintained as a standy by, upon failure of the primary fan, the auxiliary fan shall re-establish ventilation flow and minimum over pressure within 60 s.

NOTE 1 It is the responsibility of the user to ensure appropriate integrity and separation of electrical supplies to the fans.

NOTE 2 The fans should be fitted in parallel and provided with suitable electrical and mechanical isolation to facilitate maintenance.

NOTE 3 Filters should be installed in the ducting and should be easily accessible for cleaning or replacement.

NOTE 4 It is the manufacturer's responsibility to ensure that the fans have sufficient capacity to provide the required level of ventilation, between specified maintenance intervals, taking account of expected variations in normal service and potential deterioration between specified service intervals.

13.2 Leakage Compensation of a Breathable Atmosphere (LCBA)

In the case of LCBA, the air shall be delivered from a compressed air supply passing through one or more pressure reducing devices. In the event of failure of any one of the pressure reducing devices one or more pressure relieving devices shall be fitted to the TVR and/or air supply line to ensure that a dangerous over pressure cannot occur.

NOTE 1 It is the user's responsibility to ensure the necessary reliability of the pressure reduction and pressure relief device(s).

NOTE 2 In the case of compressed air supply, it is the user's responsibility, for example by the use of activated charcoal scrubbers, to ensure that the air is oil free and of "breathing quality". Some technologies for the supply of "air" may deliver a nominal level of oxygen. It is the user's responsibility to ensure, for example by the use of oxygen detectors in the air supply line, that the oxygen concentration cannot be greater than 20,95% v/v and not less than that specified by local regulations.

NOTE 3 Compressed air supplies commonly have low humidity with dewpoints between – 40 K and – 20 K. This standard does not cover the additional precautions that may need to be taken to minimize the dangers of sparks arising from the accumulation of electrostatic charge by the friction of dry air on dielectric surfaces.

13.2.1 Oxygen detectors shall be fitted to control the supply compressed air to ensure that oxygen deficiency does not exceed specified limits. It shall be possible to test the oxygen detectors whilst maintaining supply of leakage compensation gas to the TVR.

NOTE 1 The specification of limits of oxygen deficiency and any actions taken, are the responsibility of the user.

NOTE 2 It is the user's responsibility to routinely check the correct operation and function of the oxygen detectors.

13.3 Density limits

The manufacturer shall specify the density limits of the range of flammable gases for which the TVR is designed except where the TVR is designed for all flammable gases or a specific flammable gas.

14 Type verification and tests

14.1 Sequence of tests

The apparatus shall be subjected to the following tests applicable and in the following sequence:

- in the case of type of protection v2 & vM2, all relevant tests of EN 50014 and in the case of type of protection v3 or v4, all relevant tests of EN 50021 or EN 60079-15;
- thermal tests;
- overpressure test;
- purging test;
- verification of minimum overpressure;
- verification of minimum ventilation flow rate;

– overpressure test for containment systems with limited release;

– verification of sequence of operation of the safety devices.

All relevant tests of EN 50014 or, where appropriate, EN 50021 or EN 60079-15, shall be carried out.

NOTE 1 Test for resistance to impact and degree of IP protection need not be carried out on the completed TVR but may instead be applied to all parts such as inspection windows, gland plates, penetrations, doors or apertures of the TVR which are not made of steel or concrete but which are integral to the type of protection. In which case the tests may be carried out on the parts themselves, appropriately mounted for the test.

NOTE 2 Though TVR's are transportable they are not portable in the sense described in EN 50014.

NOTE 3 The thermal shock test described in 23.4.6.2 of EN 50014 need not apply to inspection windows.

14.2 Thermal tests

These tests shall be carried out in accordance with the methods described in EN 50014 (or where appropriate, in the case of type of protection v3 or v4, EN 50021 or EN 60079-15). Alternatively at the discretion of the test house, the apparatus shall be marked T4 or the higher rating of any apparatus, supplied as an integral part of the TVR, complying with one or more of the types of protection defined in 3.3, which is mounted externally to the TVR or is mounted internally and can remain energized when type of protection “v” is not in operation.

14.3 Overpressure test

A pressure equal to 1,5 times the maximum overpressure specified for normal service with a minimum of 200 Pa or at the maximum pressure that can be achieved by the pressurizing system, shall be applied to the TVR and associated ducts and their connecting parts where they are an integral part of the enclosure.

NOTE This test may be omitted, if in the opinion of the test house, the maximum pressure that can be generated by the pressurizing system is sufficiently low in which case the pressurizing system shall be specified and the apparatus shall be marked with an 'X'.

The test shall be applied for a period of 5 min $\pm$ 60 s.

The test is considered to be satisfactory if no permanent deformation occurs which would invalidate the type of protection.

14.4 Purging test

14.4.1 Composition of test gas

14.4.1.1 In the case of type of protection vM2 the test gas shall have a composition 50 % v/v He balance N_2.

14.4.1.2 In the case of type of protection v2, v3 and v4, the test gases shall be He to emulate lighter gases such as hydrogen and Ar or CO_2 to emulate gases and vapours which are heavier than air.

14.4.1.3 Impurities or contaminations of the test gas shall not exceed 0,5 % v/v.

14.4.2 The TVR shall be filled with the test gas to a concentration such that the oxygen concentration is not greater than 6,25 % v/v (equivalent to 70 % v/v residual concentration of flammable material), at any point. As soon as the TVR is filled the test gas supply shall be turned off and the protective gas supply turned on at the minimum purging rate specified by the manufacturer. The time taken until there is no sample point, where the residual oxygen concentration indicates that the remaining test gas is at a concentration less than 20 % of the limiting value for which the TVR is being tested.

The minimum purging duration specified by the manufacturer shall be not less than 1,5 times the longer of the two measured purging times.

14.4.3 Alternatively, where it is not practicable to conduct a purge test and at the discretion of the test house, the purging time shall be not less than the time, determined by calculation, to ensure that, in the case of type of protection v2 a minimum of 20 volume changes has occurred and in the case of type of protection v3 and v4 a minimum of 10 TVR volume changes has occurred and that in either case the purge time specified is not less than the value t_x defined in Annex E. The volume to be purged shall be determined by the test house from information supplied by the manufacturer and shall be based upon external dimensions of the TVR and associated ducts and should not be reduced on the basis of wall thickness, or internal parts or apparatus. The purging flow rate used for the calculation shall be the minimum specified by the manufacturer taking account of the most onerous conditions specified in normal service.

NOTE An additional factor of x2 is used in lieu of a purge test. Detailed analysis is described in Annex E. Where a purge test is undertaken as 14.4.2 and a shorter time demonstrated than that by calculation in 14.4.3 then clearly the time established in 14.4.2 may be used.

14.5 Verification of minimum pressure differential

NOTE The value of pressure differential at 30 Pa has been chosen as equivalent to 25 Pa + 20 % to allow for performance degradation and filter blockage in normal operation.

14.5.1 In the case of type of protection vM2

A test shall be made to verify that the pressurization system is capable of operating and maintaining a pressure differential of 30 Pa with the outlet apertures open at the minimum purging flow rate, specified by the manufacturer and with the outlet apertures closed using leakage compensation.

14.5.2 In the case of type of protection v2, v3 and v4

A test shall be made to verify that the pressurization system is capable of operating and maintaining a pressure differential of 30 Pa with 100 % of the outlet apertures open at the minimum ventilation flow rate, specified by the manufacturer.

14.6 Ventilation flow rate tests for TVR's with an internal source of release

A test shall be made to verify that the ventilation system is capable of maintaining the minimum ventilation flow rate specified by the manufacturer with 50 % of the outlet apertures closed.

14.7 Overpressure test for containment systems with limited release

A test pressure of at least 1,5 times the maximum internal overpressure specified for normal service, shall be applied to the containment system and maintained for a period of 2 min ± 10 s. The test pressure shall have a minimum value not less than 200 Pa, where the contents of the containment system are always wholly in the gas or vapour phase, or [3] 400 KPa otherwise.

The test is considered to be satisfactory if no permanent deformation occurs.

14.8 Verification of sequence of operation of the safety devices

The test house shall verify that the sequence of operation of the safety devices as specified by the manufacturer is in accordance with 8.4 of this standard. The test house shall witness the sequence of operation as specified by the manufacturer. The test shall be conducted once only at the specified supply voltage and frequency (± 2 %) and ambient temperature, within the range specified by the manufacturer.

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3) Liquid samples require a minimum static of at least 10 kPa to ensure flow. Normal values will lie in the range 100 kPa to 20 MPa or higher. Static head does not account for expected impulse conditions or resonance effects. The level of 400 kPa has been chosen as to verify a minimum level of integrity that might be expected of a liquid containment system without being unduly onerous.

14.9 Additional tests

Any additional tests required by Annex A or Annex B.

15 Routine tests

15.1 Test conditions

The tests shall be conducted at the nominal supply voltage specified by the manufacturer less 10 %.

Where the protective gas is supplied by a primary fan or fan system and a secondary or backup fan or fan system, the tests shall be conducted with the primary system only, operated at the nominal supply voltage specified by the manufacturer less 10 %:

– verification of minimum overpressure;

– verification of minimum ventilation flow rate;

– overpressure test for containment systems with limited release;

– verification of sequence of operation of the safety devices.

15.2 Verification of minimum pressure differential

15.2.1 In the case of type of protection vM2

A test shall be made to verify that the pressurization system is capable of operating and maintaining a pressure differential of 30 Pa with the flaps open at the minimum purging flow rate, specified by the manufacturer and with the outlet apertures closed using leakage compensation.

NOTE The value of pressure differential at 30 Pa has been chosen as equivalent to 25 Pa + 20 % to allow for performance degradation and filter blockage in normal operation.

15.2.2 In the case of type of protection v2, v3 and v4

A test shall be made to verify that the pressurization system is capable of operating and maintaining a pressure differential of 30 Pa with 100 % of the outlet apertures open at the minimum ventilation flow rate, specified by the manufacturer.

15.3 Ventilation flow rate tests for TVR's with an internal source of release

A test shall be made to verify that the ventilation system is capable of maintaining 120 % of the minimum specified ventilation flow rate specified by the manufacturer with 50 % of the exit flaps closed.

15.4 Overpressure test for containment systems with limited release

A test pressure of at least 1,5 times the maximum internal overpressure specified for normal service, shall be applied to the containment system and maintained for a period of 2 min ± 10 s. The test pressure shall have a minimum value not less than 200 Pa, where the contents of the containment system are always wholly in the gas or vapour phase, or 400 kPa otherwise.

The test is considered to be satisfactory if no permanent deformation occurs.

15.5 Verification of sequence of operation of the safety devices

The test shall verify the sequence of operation of the safety devices.

15.6 Additional tests

Any additional tests required by Annex A or Annex B.

16 Marking

TVR's shall be marked in accordance with the requirements of EN 50014 or where appropriate EN 50021 or EN 60079-15. The following supplementary information shall also be marked as appropriate.

16.1 TVR's all cases

a) The volume, defined by establishing a worst case envelope of the most extreme external dimensions of the TVR plus the volume of ducts where they are an integral part of the TVR.

b) Minimum quantity of protective gas required to purge the enclosure specified by

- minimum purging flow rate of protective gas,
- minimum purging duration,
- minimum additional purging duration per unit volume of additional ducting (where appropriate).

NOTE It is the responsibility of the user to increase the quantity of protective gas to ensure purging of the ducts.

c) The minimum and maximum overpressure.

d) A special temperature or range of temperatures for the protective gas at the inlet to the pressurized enclosure when specified by the manufacturer.

e) The point or points at which the pressure is to be monitored unless this is indicated in the relevant documentation.

16.2 TVR's with a containment system

In addition to the above marking TVR's with a containment system shall be marked with the following if specified:

a) the type of internal release;

b) the minimum ventilation flow rate;

c) the minimum flow rate of protective gas, (as specified in Annex A or B) if necessary;

d) the maximum inlet pressure to the containment system;

e) the maximum flow rate into the containment system;

f) the maximum oxygen concentration in the containment system.

16.3 Safety related control systems

If certified, the safety related control system and associated safety devices, shall be marked [EEx v2], [EEx v3], [EEx v4] or [EEx vM2].

16.4 Additional marking

Any other marking required.

17 Instructions

The manufacturer shall provide instructions for use in accordance with Clause 28 of EN 50014 and supplemented as appropriate by the requirements in this standard.

Annex A
(normative)

Method of protection of electrical apparatus containing a potential release of a flammable gas or vapour

A.1 Introduction

A dilution area exists around a potential source of release of flammable material. A hazard exists where apparatus may be located wholly or partially within a dilution area. Whilst it may be necessary to have a knowledge of the extent of the dilution area relative to the location electrical apparatus this may prove difficult in practice. Annex B (informative) of EN 60079-10 describes a method of estimating the hypothetical volume of a potentially explosive atmosphere that may exist around a source of release. This annex describes the application of a ventilation flow rate to such apparatus where the source of release is always in the gaseous or vapour state, such that the hazard arising from an overlapping dilution area is reduced to manageable methods. Additional protection methods are described where the dilution area lies within the apparatus (internal source of release).

A.2 Definitions

A.2.1
protection by continuous flow of diluent air
a method of protection, of electrical apparatus, by the supply of diluent air at such a rate as to ensure that a potential internal release of a flammable gas or vapour is diluted below the limiting value within the confines of the apparatus being protected. The level of integrity afforded by this type of protection is equivalent to that required for category 3

A.2.2
diluent air
air, used as a protective gas, which at a specified minimum flow rate will dilute any potential source of release to a safe level

A.2.3
apparatus envelope
the apparatus envelope is defined as the simplest geometric shape which wholly contains the apparatus. This shape will normally be a sphere, cylinder or a cuboid. The apparatus envelope may be defined as the sum of two or more shapes

The apparatus envelope need not enclose parts of the apparatus that meet the requirements of infallible parts of a containment system where these project beyond the apparatus. It is not permitted to reduce the calculated volume of the apparatus envelope by subtracting any part of the volume of infallible parts of a containment system

A.3 Requirements

A.3.1 The apparatus envelope shall define the dimensions of and the volume V_{ae} of the geometric shape.

A.3.2 It shall be possible, without recourse to testing, to establish that the hypothetical volume V_z as defined in Annex B of EN 60079-10, using a worst case quality factor f = 5, is such that $V_z \leq V_{ae}$.

A.3.3 It shall be possible, without recourse to testing, to establish that the persistence time t as defined in Annex B of EN 60079-10 and using V_{ae} as the volume to be purged with a worst case quality factor f = 5 is such that t ≤ the minimum time specified to purge the TVR as defined in 6.3 of this standard.

A.3.4 Where the apparatus comprises one or more components they shall be connected in series. They may not be connected in parallel.

NOTE The apparatus being protected should be effectively sealed. Where this is not possible the apparatus may be located within an enclosure meeting the sealing requirements of EN 60529 IP54 (but need not meet the impact requirements) in which case the apparatus being assessed shall comprise the enclosure with its contents.

A.3.5 The minimum diluent flow shall be monitored at the outlet. An automatic device shall operate if the diluent flow falls below the minimum specified level.

A.3.6 Ducts or conduits shall be provided, to conduct the diluent gas from the apparatus to location out with the TVR. The manufacturer shall provide information to the user to ensure that proper connection to the outlet ducts and conduit consistent with the maximum specified flow rate of diluent air.

NOTE It is the user's responsibility to ensure safe disposal of the diluent air and any explosive gas air mixture that might be formed.

A.3.7 Where the apparatus contains an internal source of release, one or more flammable gas detectors shall be fitted at the outlet The point of installation of the gas detectors shall be such as to ensure that the transit time for the diluent gas, from the apparatus being protected is less than ten seconds at the specified minimum dilution flow rate.

A.3.8 Spark and particle barriers shall be fitted to the outlet ducts as described in A.2 and Table A.1 of EN 50016.

A.3.9 The monitoring devices shall be protected by one or more of the means listed in EN 50014.

A.3.10 The actions to be taken upon operation of the automatic flow monitoring device depend upon the status of the status and category of protection afforded and are listed in Table A.1.

A.3.11 The actions to be taken upon operation of the gas detectors in the dilution flow outlet are listed in Table A.2.

Table A.1

<table>
<tr><th>Status</th><th colspan="2">Category 3</th><th colspan="2">Category 2</th></tr>
<tr><td></td><td colspan="4">Internal source of release</td></tr>
<tr><td></td><td>No</td><td>Yes</td><td>No</td><td>Yes</td></tr>
<tr><td>Loss of apparatus dilution flow during the purge phase of TVR</td><td colspan="4">Reset TVR purge timer to zero, timer may not restart until minimum purge flow established</td></tr>
<tr><td>Loss of apparatus dilution flow during normal operation</td><td colspan="4">Status indication to manned location</td></tr>
<tr><td></td><td>Alarm within 24 h</td><td colspan="2">Alarm within 30 min</td><td>Alarm</td></tr>
<tr><td></td><td></td><td colspan="2">Disconnect power to non Ex equipment within 24 h</td><td>Disconnect power to non Ex equipment within 2 min</td></tr>
</table>

Table A.2

Status	Category 3	Category 2
Detection of > 20 % LEL at the apparatus dilution flow outlet	Status indication to manned location	
	Disconnect automatically all sources of supply of flammable material to the apparatus being protected by dilution flow	
	Disconnect power to non ignition capable apparatus, within TVR	

A.3.12 The minimum flow rate of diluent gas depends upon the grade of release to be anticipated.

NOTE Guidance is given in Annex A of EN 60079-10 on the classification of grades of release.

For a primary source of release the minimum dilution flow rate shall be given by:

$$Q_0 \geq 20 \cdot \frac{L_{\max}}{LEL_{mass}} \cdot \frac{T}{293}$$

For a secondary source of release the minimum dilution flow rate shall be given by:

$$Q_0 \geq 10 \cdot \frac{L_{max}}{LEL_{mass}} \cdot \frac{T}{293}$$

where

Q_0 = the volumetric flow rate of diluent air in m^3/s

L_{max} = the maximum release rate of flammable material in kg/s

LEL_{mass} = the lower explosive limit, expressed as mass per volume, kg/m^3

LEL_{vol} = the lower explosive limit, expressed as % (v/v)

M = molecular mass (kg/kmol)

$$LEL_{mass} = 0{,}416 \cdot 10^{-3} \cdot M \cdot LEL_{vol} \quad ^{*)}$$

T = the maximum ambient temperature in K, specified for normal service with a minimum of 333 K.

*) See EN 60079-10.

Annex B
(normative)

Method of protection of electrical apparatus containing a potential release of a flammable liquid

B.1 Introduction

A hazard exists where at the source of internal release the flammable substance may be wholly or partially in the liquid phase. This annex describes the requirements to ensure that the risk arising from a release of a flammable liquid is reduced to manageable methods.

B.2 Definitions

B.2.1
sample
the contents of the containment system, normally assumed to be wholly or partially in the liquid phase

B.2.2
inert gas
for the purpose of this standard, inert gas means nitrogen, carbon dioxide, argon or any gas which, when mixed with oxygen in the ratio 4:1 as found in air, does not make the ignition and flammability properties such as explosive limits, more onerous

B.2.3
flashing liquids
flashing liquids occur when the temperature within the containment system exceeds the boiling point of any flammable liquid component of the sample, but that component is maintained in the liquid phase by the pressure within the containment system. Flashing liquids will rapidly evolve flammable vapour when the pressure within the containment system drops below the vapour pressure of the flammable liquid component

B.2.4
pool area
the maximum surface area of the pool formed as a result of a continuous spillage of a liquid sample onto a level surface, from which a flammable vapour can evolve

B.2.5
flow limiting device
a device, fitted external to the TVR, which in the event of a catastrophic failure of the containment system, will limit the maximum discharge rate of liquid into the TVR at the worst case design conditions specified for normal service

B.2.6
pool containment
a method by the use of barriers, partitions and enclosures to contain and drain a continuous liquid release without increasing the pool area

B.3 Requirements

B.3.1 All parts of the containment system which do not meet the requirements for infallible parts of the containment system shall be enclosed within an enclosure meeting IP55 of EN 60529.

B.3.2 The enclosure shall be fitted with a drain at the lowest point leading to the outside of the TVR. The drain shall be installed with a continuously falling gradient not less than 1:12. Provision shall be made to prevent external atmospheric ingress for example by the use of a liquid seal.

B.3.3 The enclosure shall be fitted with an inlet and an outlet purge connection leading to the outside of the TVR. The inlet and outlet purge connections shall be higher than the drain.

B.3.4 A non return valve shall be installed in the inlet purge supply line, unless the protective gas is fed from a dedicated supply in which case special conditions shall apply and the apparatus shall be marked 'X'.

No other device may be installed or connected between the non return valve and the apparatus being purged.

B.3.5 A flow monitoring device shall be installed in the purge outlet.

No other device may be installed or connected between the flow monitoring device and the apparatus being purged.

B.3.6 The enclosure shall be purged, via the inlet vent with an inert gas, at a flow rate sufficient, to exchange a minimum of five apparatus envelopes in a time less than required to purge the TVR as specified in 6.3. Power may not be connected to any ignition capable apparatus until after the time specified in 6.3.

NOTE The purpose of the purge is to reduce any residual oxygen that may be present to a safe level.

B.3.7 The flow rate after purging may be reduced but shall ensure a minimum flow rate equivalent to five apparatus envelope volumes per hour.

B.3.8 A closure device such as a flap shall be fitted to the outlet aperture and shall be suitable for effective purging. The closure device shall be designed to be self closing in the event of purge failure. The vent aperture closure shall be fitted with a switch or device to operate when closed.

B.3.9 The vent aperture shall be fitted with mesh or screen meeting IP20, to prevent foreign material such as rodents or leaves impairing the proper operation of the closure devices.

B.3.10 The closure device shall be arranged so as to be unaffected by outside weather conditions such as wind, rain or snow.

B.4 Flammable non-flashing liquids

The temperature of the containment system shall be lower than the boiling point of the most volatile, flammable component of the sample.

B.4.1 A device shall be fitted to monitor if the temperature of the sample can exceed the boiling point.

B.4.1.1 The enclosure shall be purged, via the inlet vent with an inert gas, at a flow rate sufficient without recourse to testing, to establish that the persistence time t as defined in Annex B of EN 60079-10 and using the volume of the enclosure as the volume to be purged with a worst case quality factor f = 5 such that t ≤ the minimum time specified to purge the TVR. This condition is satisfied by the following inequalities:

$$t_{TVR} \geq t_{app} \geq \frac{-5 \cdot V_0}{Q_0} \cdot \ln \frac{LEL}{4 \cdot X_0}$$ for primary grade of release

$$t_{TVR} \geq t_{app} \geq \frac{-5 \cdot V_0}{Q_0} \cdot \ln \frac{LEL}{2 \cdot X_0}$$ for secondary grade of release

where

t_{TVR} = the time specified in 6.3

t_{app} = the time specified to purge the apparatus being protected

V_0 = the apparatus envelope defined in Annex A

Q_0 = the minimum specified flow rate to purge the apparatus

LEL = the lower explosive limit of the flammable release

X_0 = the maximum rate of release of the flammable substance in the same units of measure as LEL

B.4.1.2 The flow rate after purging may be reduce but shall ensure a minimum flow rate equivalent to five apparatus envelopes per hour.

NOTE 1 The use of inert gas within the TVR creates a risk of asphyxiation. It is the user's responsibility to apply appropriate measures, such as oxygen deficiency detectors, interlocks, warning signs and operational procedures to ensure adequate safety.

NOTE 2 The release or spillage of liquids will create a hazard at the outlet of the purging duct. It is the user's responsibility to ensure safe disposal of purge gas and any gas or liquid so entrained.

NOTE 3 It is highly probable that leaks will give rise to toxic hazards before an explosive atmosphere can be formed. The user should consider fitting detection devices to monitor whether any internal leakage has occurred, and any additional safety measures such as disconnection of sample lines to the TVR in the event of a leak detection.

B.5 Spark and particle barriers

B.5.1 Sparks and particle barriers shall be fitted to the outlet ducts as described in A.2 and Table A.1 of EN 50016. The monitoring devices shall be protected by one or more of the means listed in Clause 2.

B.5.2 The actions to be taken upon operation of the automatic flow monitoring device depend upon the status of the status and category of protection afforded and are listed in Table B.1

Table B.1

Status	Category 3	Category 2
Loss of apparatus purge flow during the purge phase of TVR	Reset TVR purge timer to zero, timer may not restart until minimum purge flow established	
Loss of apparatus flow during normal operation	Status indication to manned location	
	Alarm within 30 min	Alarm
	Disconnect power to non Ex equipment within 24 h	Disconnect power to ignition capable apparatus within 2 min

B.5.3 The following actions outlined in Table B.2 are advisory, but are not within the scope of this standard. The test house is not required to ensure compliance.

Table B.2

Status	Category 3	Category 2
Leak detection at the apparatus purge flow outlet	Status indication to manned location	
	Disconnect automatically all sources of supply of flammable material to the apparatus being protected	
	Disconnect power to non ignition capable apparatus, within TVR	

B.6 Flashing liquids

Additional measures are required if within the containment system there may be flashing liquids.

B.6.1 All parts of the containment system which do not meet the requirements for infallible parts of the containment system shall be enclosed within an enclosure meeting IP65 of EN 60529 except as outlined below.

B.6.2 A device, such as a pressure switch or excess flow valve, shall be fitted to disconnect the flow of sample in the event of sudden loss of pressure or excess flow resulting from a catastrophic failure of the containment system. The device shall require to be manually reset.

B.6.2.1 The enclosure shall be capable of withstanding an internal over pressure arising from the sudden release of the contents of the containment system. This may be achieved by the integrity of the enclosure, the design of the outlet aperture and/or by fitting one or more pressure relieving device(s) venting to the exterior of the TVR.

Compliance shall be verified by a test releasing a volume of gas, equivalent to the volume of the vaporized contents of the containment system into the enclosure within 5 s but not more rapidly than 2 s. The test shall be repeated.

NOTE A method of determining the volume of gas released and the maximum peak pressure arising from the release of a flashing liquid is given in Annex C.

The test is satisfactory if no permanent deformation of the enclosure occurs.

Annex C
(informative)

Determination of peak rise in enclosure pressure, resulting from an internal release of a flashing liquid

C.1 Introduction

An internal release of a superheated fluid, or a fluid containing a superheated component will result in the very rapid evolution of a large quantity of vapour. the design of the apparatus enclosure, its exit aperture and pressure relieving system (if fitted) must be capable of handling such a release, without suffering catastrophic failure. The method outlined below will determine a worst case upper limit for the volume of gas that can be evolved in order to define parameters for a routine test. The assumption is made that the containment system boundaries are defined by a device or devices which will automatically isolate the containment system upon detection of loss of pressure and that only the contents of the containment system need be taken into account in determining the volume of vapour evolved.

C.2 Definitions

V_{cs} = the free internal volume of the containment system up to and including the isolation devices

V_{gas} = the maximum volume of vapour that can be released from the containment system following a catastrophic rupture and assuming that all the volatile liquid has flashed to vapour

$\rho_1(T,P)$ = the density of the liquid in the containment system at temperature T and pressure P

n = the mole fraction of the volatile component of the sample (moles per kg)

Φ_f = the mass fraction flashing to vapour

C_{pL} = the specific heat of the liquid (kJ/kg)

H_v = the latent heat of vaporisation (kJ/kg)

T_b = the temperature at which the liquid starts to boil (K)

T_l = the temperature of the liquid in the containment system (K)

Upon development of a leak, the reduction in pressure will cause any superheated component to boil, with rapid release of vapour. This release will ultimately be limited as the temperature of the released fluid drops below the boiling point. Consequently the release will be a mixture of spray, vapour and liquid, but only the vapour component will contribute significantly to pressurization of the apparatus.

The following relationships hold:

$$\Phi_f = \frac{C_{pL}}{H} \cdot (T_l - T_b)$$

$$V_{gas} = V_{cs} \cdot n \cdot \rho_l(T_l, P) \cdot \frac{T_l \cdot 22{,}4 \cdot 10^{-3}}{273{,}13} \cdot \Phi_f$$

In practice the sample may contain several components in the superheated state, in which case each volatile component will require heat of vaporisation, in proportion to its concentration. The calculation of the vaporisation of mixtures of liquids is very complicated, however it is possible to determine an upper limit by repeating the calculation in turn, assuming the maximum concentration for each component and neglecting the effect of the other components. the volume of gas evolved can then be assumed to be less than the sum of the components calculated.

$$V_{gas} \leq V_{cs} \cdot \frac{22{,}4 \cdot 10^{-3} \cdot (\delta T + T_l)}{273{,}13} \cdot \sum n_i \cdot \rho_l (T_l, P)_i \cdot (T_l - T_{b_i})$$

where δT is an incremental safety factor, for higher ambients such that $\delta T = 0$ for maximum ambients less than or equal to 40 K and $\delta T = T - 40$ K for higher ambients. The design of the apparatus enclosure, its exit aperture and relief vent (if fitted) must be capable of withstanding the overpressure (with a safety factor of x 1,5), resulting from the rapid release of such a quantity of gas from the containment system, without causing permanent deformation.

Annex D
(informative)

Method of protection of electrical apparatus containing a potential release of a flammable gas or vapour

The following analysis is based upon methods and calculations contained in Annex B of EN 60079-10. The interpretation given here will determine the minimum dilution flow rate for an enclosure with a limited internal source of release, such that no additional hazard will extend to other apparatus located nearby. This is achieved by ensuring that the dilution flow rate is sufficiently large that any potential source of release will be diluted below the limiting value, before it can come into contact with other apparatus, using adequate factors of safety such that specific dilution tests are not required. The minimum dilution flow rates determined by this method will undoubtedly be more conservative than actually required. Lesser flow rates may be used subject to specific dilution tests.

where

Q_0 = the volumetric flow rate of diluent air in m^3/s

L_{max} = the maximum release rate of flammable material in kg/s

LEL_{mass} = the lower explosive limit, expressed as mass per volume, kg/m^3

M = molecular mass (kg/kmol):

$$LEL_{mass} = 0{,}416 \cdot 10^{-3} \cdot M \cdot LEL_{vol}$$

k = a safety factor applied to the LEL; typically:

- k = 0,25 continuous and primary grade of release
- k = 0,5 secondary grade of release

T = the maximum ambient temperature in K, specified for normal service with a minimum of 333 K.

The theoretical minimum flow rate to dilute a given release of flammable material to a concentration below the lower explosive limit can be calculated by means of the formula:

$$Q_{\min} = \frac{L_{\max}}{k \cdot LEL_{mass}} \cdot \frac{T}{293}$$

With a given number of changes per unit time, C, related to the general purging and dilution of the enclosure a hypothetical volume V_z of potentially explosive atmosphere around the source of release can be estimated using the formula:

$$V_z = \frac{Q_{\min}}{C}$$

For an enclosed volume, C is given by $$C = \frac{Q_0}{V_0}$$

where

Q_0 = the dilution flow rate

V_0 = the free volume of the enclosure.

This would be true in the ideal case for instantaneous and homogeneous mixing with protective gas at the source of release. In practice, because of impediments to flow, resulting in poorly purged parts of the enclosure. In such cases the effective number of changes per unit time will be lower than that given above, leading to an increase in V_z thus:

$$V_z = f \cdot \frac{Q_{\min}}{C}$$

where f is an efficiency factor, ranging from $f = 1$ in the ideal situation to, typically $f = 5$ in a poorly ventilated case. Thus V_z can be constrained by the following inequality:

$$V_z \leq f \cdot \frac{Q_{\min}}{Q_0} \cdot V_0$$

Thus V_z can be shown to lie within the apparatus enclosure if :

$$f \cdot \frac{Q_{\min}}{Q_0} \leq 1$$

which condition is satisfied if:

$$Q_0 \geq f \cdot Q_{\min}$$

$$Q_0 \geq \frac{f}{k} \cdot \frac{L_{\max}}{LEL_{mass}} \cdot \frac{T}{293}$$

and

assuming that without recourse to testing $f \leq 5$

then

for a primary source of release the minimum dilution flow rate shall be given by:

$$Q_0 \geq 20 \cdot \frac{L_{\max}}{LEL_{mass}} \cdot \frac{T}{293}$$

for a secondary source of release the minimum dilution flow rate shall be given by:

$$Q_0 \geq 10 \cdot \frac{L_{\max}}{LEL_{mass}} \cdot \frac{T}{293}$$

Annex E
(informative)

Mathematical model of dilution of a source of release

Where

P = ventilation flow rate or purge rate of protective gas

R = maximum rate of release in the same volumetric units as *P*

Y = the volumetric fraction of the release that is flammable

C(t) = the time varying concentration of flammable material within the TVR or apparatus enclosure

V = the free internal volume of the apparatus being purged or ventilated

Assume initially that mixing within the volume is good and that the concentration *C(t)* at the exit is similar to the concentration within the enclosure; then *C(0)* is the initial concentration at time *t = 0* and R · Y · δ*t* is the addition of flammable gas to the enclosure in time interval δ*t* due to a release of flammable material of concentration *Y* and maximum release rate *R*.

Then *(P + R) · C(t) · δt* is the loss of flammable material from the apparatus (due to purging) at a flow rate *P*. The quantity of flammable material within the enclosure at time t is *V · C(t).*

Then $V \cdot \delta C(t) = R \cdot Y \cdot \delta t - (P + R) \cdot C(t) \cdot \delta t$ is the incremental change in concentration during time δ*t*, which can be rearranged as follows:

$$\frac{\delta C(t)}{\delta t} = \frac{R \cdot Y}{V} - \frac{P + R}{V} \cdot C(t)$$

and taking exact differentials and rearranging gives the following first order differential equation:

$$\frac{dC(t)}{dt} + \frac{P + R}{V} \cdot C(t) - \frac{R \cdot Y}{V} = 0$$

and taking Laplace transforms gives:

$$C(s) \cdot s - C(0) + \frac{P + R}{V} \cdot C(s) - \frac{R \cdot Y}{V \cdot s} = 0$$

which can be rearranged by partial fractions as follows:

$$C(s) = \frac{R \cdot Y}{V} \cdot \frac{1}{s \cdot \left(s + \frac{P + R}{V} \right)} + C(0) \cdot \frac{1}{s + \frac{P + R}{V}}$$

by setting $\theta = \frac{R \cdot Y}{P + R}$ $\tau = \frac{V}{P + R}$

and taking inverse transforms:

$$C(t) = \theta \cdot \left(1 - e^{\frac{-t}{\tau}}\right) + C(0) \cdot e^{\frac{-t}{\tau}} \qquad \text{As} \qquad t \to \infty \qquad \text{then} \qquad C(t) \to \theta$$

The following conditions must apply:

$$\theta \equiv \frac{R \cdot Y}{P + R} \text{ < 20\% LEL}$$

$$\tau \equiv \frac{V}{P + R} \leq \frac{1}{5}$$

$$C(0) \leq \frac{[V_{cs}]}{V}$$

where $[V_{CS}]$ is the volumetric contents of the containment system released before the flow is limited or shut off.

The time taken t_x for the dilution system to reduce the concentration to a specific value $C(t_x)$ is given by:

$$t_x = -\frac{V}{P + R} \cdot \ln \frac{\theta - C(t_x)}{\theta - C(0)}$$

It will be seen that this latter formula reduces to that given in Annex B of EN 60079-10 for estimation of persistence time on the assumption that the release has stopped and consequently;

As $\theta \to 0$ then $\frac{V}{P + R} \to \frac{V}{P} \equiv \frac{1}{c}$

where c is the number of air changes per unit time.

$\theta = a \cdot C(t_x)$ where $0 \leq a \leq 1$

and $C(t_x)$ = 20 % of the worst case LEL and $C(0)$ = 1

and consequently the required time t_x to purge an enclosure comprises the following factors:

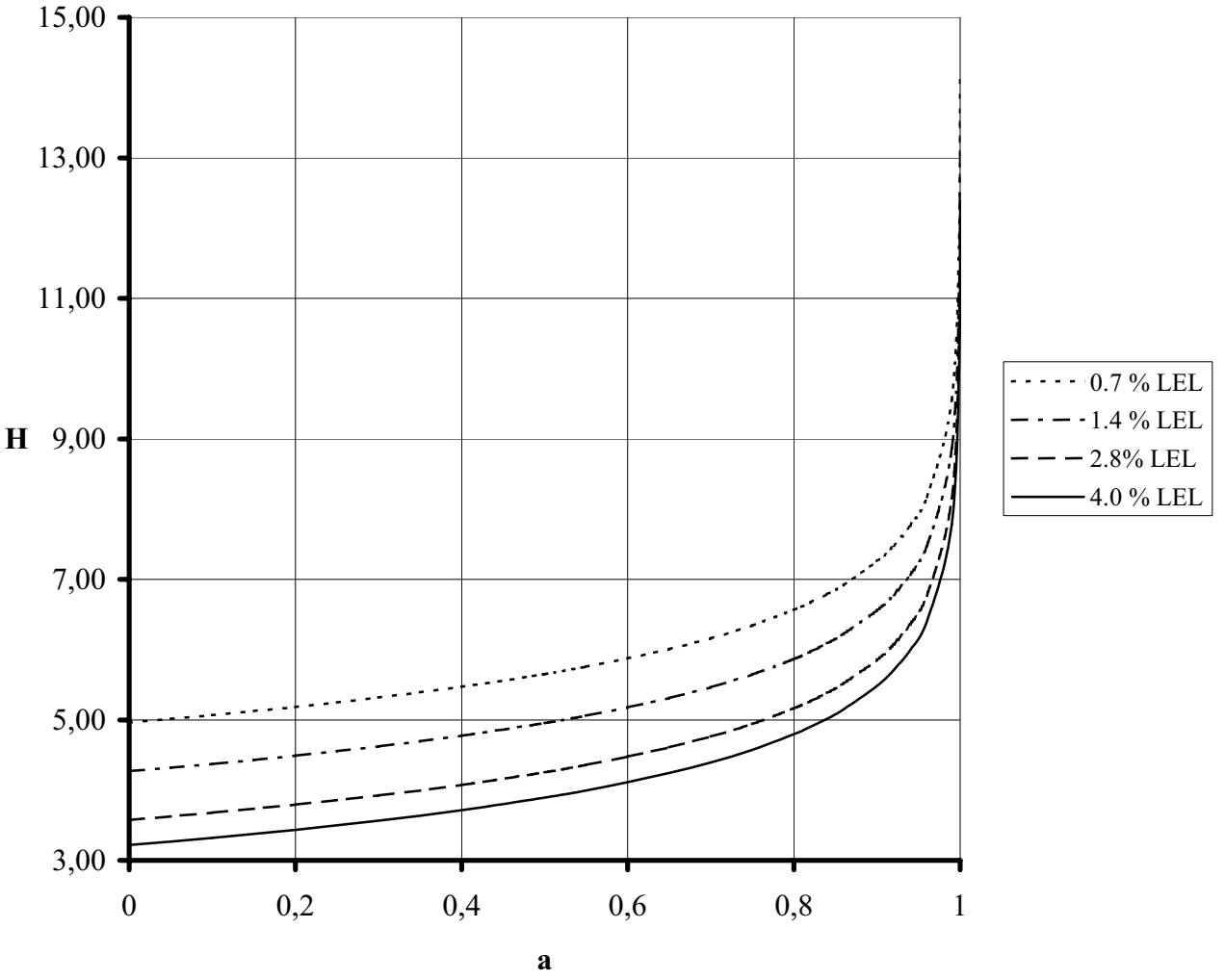
$$\tau = \frac{V}{P + R} \qquad H = -\ln \frac{\theta - C(t_x)}{\theta - C(0)}$$

This latter factor can be expressed in terms of *a*, the initial concentration *C(0)* and the target value $C(t_x)$ (taken to be ≤ 20 % LEL) thus:

$$H = -\ln \frac{1 - \frac{1}{a}}{1 - \frac{C(0)}{C(t_x)} \cdot \frac{1}{a}}$$

therefore the required purging time can be expressed as: $t_x = f \cdot \tau \cdot H$

where *f* is a safety factor taken to be *f = 5* except when validated by experiment.



Values of *H* are tabulated for values of $C(t_x)$ between 0,7 % v/v and 4 % v/v assuming a worst case initial condition of *C*(0) = 100 % v/v.

Annex ZZ
(informative)

Coverage of Essential Requirements of EC Directives

This European Standard has been prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association and within its scope the standard covers only the following essential safety requirements out of those given in Annex II of the EC Directive 94/9/EC:

- ER 1.0, ER 1.0.1 to ER 1.0.6
- ER 1.2 (partly), ER 1.2.1, ER 1.2.2 (partly), ER 1.2.3, ER 1.2.5 to ER 1.2.8
- ER 1.3.1, ER 1.3.5
- ER 1.4.1 (partly)
- ER 1.5, ER 1.5.1 to ER 1.5.8
- ER 1.6.2 (partly), ER 1.6.3 to ER 1.6.5
- ER 2.0.2.1, ER 2.0.2.2
- ER 2.2.1, ER 2.2.1.1 to ER 2.2.1.3
- ER 2.3.1, ER 2.3.1.1, ER 2.3.1.2

Compliance with this standard provides one means of conformity with the specified essential requirements of the Directive concerned.

WARNING: Other requirements and other EC Directives may be applicable to the products falling within the scope of this standard.

Bibliography

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

IEC 60079-16 Electrical apparatus for explosive atmospheres – Part 16: Artificial ventilation for the protection of analyser(s) houses

IEC/TR 61831 On-line analyser systems – Guide to design and installation

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