IS/IEC 60079-1 (2007): Explosive Atmospheres, Part 1: Equipment Protection by Flameproof Enclosures 'd' [ETD 22: Electrical Apparatus for Explosive Atmosphere]

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IS/IEC 60079-1 : 2007
(Superseding IS 2148 : 2004)

भारतीय मानक

विस्फोटी पर्यावरण

भाग 1 ज्वालासह आवरण "d" द्वारा उपकरण संरक्षण

Indian Standard

EXPLOSIVE ATMOSPHERES

PART 1 EQUIPMENT PROTECTION BY FLAMEPROOF ENCLOSURES "d"

ICS 29.260.20

BUREAU OF INDIAN STANDARDS
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NEW DELHI 110002

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Price Group 15

CONTENTS

Electrical Apparatus for Explosive Atmospheres Sectional Committee, ETD 22

NATIONAL FOREWORD

This Indian Standard (Part 1) which is identical with IEC 60079-1 : 2007 Explosive atmospheres — Part 1 : Equipment protection by flameproof enclosures "d" issued by the International Electrotechnical Commission (IEC) was adopted by the Bureau of Indian Standards on the recommendation of the Electrical Apparatus for Explosive Atmospheres Sectional Committee and approval of the Electrotechnical Division Council.

IS 2148 Electrical apparatus for explosive gas atmospheres — Flameproof enclosures "d" was first published in 1962 and revised in 1968 and 1981. It was once again revised in 2004 in order to align it with IEC 60079-1 : 2001 and published as a dual numbered standard IS 2148 : 2004/IEC 60079-1 : 2001. Subsequently IEC 60079-1 : 2001 was revised in 2003 and in 2007. IEC 60079-1 : 2007 is now being adopted as IS/IEC 60079-1 : 2007 and will supersede IS 2148 : 2004. IS 2148 : 2004 shall continue for certification till such a time IS/IEC 60079-1 : 2007 is implemented.

Attention is invited to the fact that the manufacture and use of flameproof equipment in the country is controlled by the concerned statutory authorities for the area of their jurisdiction. This standard is not intended to take the place of the various statutes and regulations in force in the country applicable to the installation and use of electrical apparatus in places where there is an explosion hazard; it has been drawn up to assist the concerned authorities to have a common basis for construction and testing of apparatus required to have a flameproof enclosure.

The text of IEC Standard has been approved as suitable for publication as an Indian Standard without deviations. Certain conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

a) Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'.

b) Comma (,) has been used as a decimal marker, while in Indian Standards, the current practice is to use a point (.) as the decimal marker.

In this adopted standard, reference appears to certain International Standards for which Indian Standards also exist. The corresponding Indian Standards, which are to be substituted in their respective places are listed below along with their degree of equivalence for the editions indicated:

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
IEC 60061 Lamp caps and holders together with gauges for control of interchangeability and safety	IS 9206 : 1979 Dimensions of caps for tungsten filament general service electric lamps	Technically Equivalent
IEC 60079-0 : 2004 Electrical apparatus for explosive gas atmospheres — Part 0: General requirements	IS/IEC 60079-0 : 2004 Electrical apparatus for explosive gas atmospheres: Part 0 General requirements	Identical
IEC 60079-1-1 : 2002 Electrical apparatus for explosive gas atmospheres — Part 1-1: Flameproof enclosures "d" — Method of test for ascertainment of maximum experimental safe gap	IS 9735 : 2003 Electrical apparatus for explosive gas atmospheres — Flameproof enclosures "d" — Method of test for ascertainment of maximum experimental safe gap (*first revision*)	do

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
IEC 60079-7 : 2006 Explosive atmospheres — Part 7: Equipment protection by increased safety "e"	IS/IEC 60079-7 : 2006 Explosive atmospheres: Part 7 Equipment protection by increased safety "e"	Identical
IEC 60079-11 : 2006 Explosive atmospheres — Part 11: Equipment protection by intrinsic safety "i"	IS/IEC 60079-11 : 2006 Explosive atmospheres: Part 11 Equipment protection by intrinsic safety "i"	do
IEC 60079-14 : 2002 Electrical apparatus for explosive gas atmospheres — Part 14: Electrical installations in hazardous areas (other than mines)	IS 5571 : 2000 Guide for selection of electrical equipment for hazardous areas (*second revision*)	Technically Equivalent
IEC 60086-1 : 2000 Primary batteries — Part 1: General	IS 8144 : 1997 Multipurpose dry batteries (*first revision*)	do
IEC 60112 Method for the determination of the proof and the comparative tracking indices of solid insulating materials	IS 2824 : 1975 Method for determining the comparative tracking index of solid insulating materials under moist conditions (*first revision*)	do
IEC 60127-1 : 1988 Miniature fuses — Part 1: Definition for miniature fuses and general requirements for miniature fuse links — Specification	IS/IEC 127-1 : 1988 Miniature fuses: Part 1 Definition for miniature fuses and general requirements for miniature fuse links — Specification	Identical
IEC 60127-2 : 1989 Miniature fuses — Part 2: Cartridge fuse links — Specification	IS/IEC 127-2 : 1989 Miniature fuses: Part 2 Cartridge fuse links — Specification	do
IEC 60127-6 : 1994 Miniature fuses — Part 6: Fuse holders for miniature cartridge fuse links — Specification	IS/IEC 127-6 : 1994 Miniature fuses: Part 6 Fuse holders for miniature cartridge fuse links — Specification	do
IEC 60529 : 1989 Degrees of protection provided by enclosures (IP Code)	IS 12063 : 1987 Classification of degrees of protection provided by enclosures of electrical equipment	Technically Equivalent
IEC 60623 : 2001 Secondary cells and batteries containing alkaline or other non-acid electrolytes — Vented nickel-cadmium prismatic rechargeable single cells	IS 10918 : 1984 Vented type nickel cadmium batteries	do
IEC 60662 : 1980 High-pressure sodium vapour lamps	IS 9974 (Part 1) : 1981 High-pressure sodium vapour lamps: Part 1 General requirements and tests	do
	IS 9974 (Part 2) : 1981 High-pressure sodium vapour lamps: Part 2 Standard lamp data sheets	do
ISO 185 : 1988 Grey cast iron — Classification	IS 210 : 1993 Grey iron castings — Specification (*fourth revision*)	do
ISO 965-1 : 1998 ISO general purpose metric screw threads — Tolerances — Part 1: Principles and basic data	IS 14962 (Part 1) : 2001 ISO general purpose metric screw threads — Tolerances: Part 1 Principles and basic data	Identical

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
ISO 965-3 : 1998 ISO general-purpose metric screw threads — Tolerances — Part 3: Deviations for constructional threads	IS 14962 (Part 3) : 2001 ISO general purpose metric screw threads — Tolerances: Part 3 Deviations for constructional screw threads	Identical
ISO 2738 : 1999[1)] Sintered metal materials excluding hard metals — Permeable sintered metal materials — Determination of density, oil content and open porosity	IS 5642 : 1991 Permeable sintered metal materials — Determination of density, oil content, and open porosity (*second revision*)	Technically Equivalent
ISO 3864 : 1984 Safety colours and safety signs	IS 9457 : 2005 Safety colours and safety signs — Code of practice (*first revision*)	do
ISO 4003 : 1977 Permeable sintered metal materials — Determination of bubble test pore size	IS 13781 : 1993 Permeable sintered metal materials — Determination of bubble test pore size	Identical
ISO 4022 : 1987 Permeable sintered metal materials — Determination of fluid permeability	IS 13782 : 1993 Permeable sintered metal materials — Determination of fluid permeability	do

The technical committee has reviewed the provisions of the following International Standards referred in this adopted standard and has decided that they are acceptable for use in conjunction with this standard:

International Standard	*Title*
IEC 60695-11-10	Fire hazard testing — Part 11-10: Test flames — 50 W horizontal and vertical flame test methods
IEC 61951-1 : 2003	Secondary cells and batteries containing alkaline or other non-acid electrolytes — Portable sealed rechargeable single cells — Part 1 : Nickel-cadmium
IEC 61951-2 : 2003	Secondary cells and batteries containing alkaline or other non-acid electrolytes — Portable sealed rechargeable single cells — Part 2 : Nickel-metal hydride
ANSI/ASME B1.20.1-1983 : (R 2001)	Pipe threads, general purpose (inch)

Only the English language text of the International Standard has been retained while adopting it as an Indian Standard, and as such the page numbers given here are not the same as in the IEC Standard.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

[1)] ISO 2738 : 1987 was adopted as IS 5642 : 1991.

Indian Standard

EXPLOSIVE ATMOSPHERES

PART 1 EQUIPMENT PROTECTION BY FLAMEPROOF ENCLOSURES "d"

1 Scope

This part of IEC 60079 contains specific requirements for the construction and testing of electrical equipment with the type of protection flameproof enclosure "d", intended for use in explosive gas atmospheres.

This standard supplements and modifies the general requirements of IEC 60079-0. Where a requirement of this standard conflicts with a requirement of IEC 60079-0, the requirement of this standard will take precedence.

NOTE Equipment protection by flameproof enclosures "d" provides Equipment Protection Level (EPL) Gb. For further information, see Annex G.

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.

IEC 60061 (all parts), *Lamp caps and holders together with gauges for the control of interchangeability and safety*

IEC 60079-0:2004, *Electrical apparatus for explosive gas atmospheres – Part 0: General requirements*

IEC 60079-1-1, *Electrical apparatus for explosive gas atmospheres – Part 1-1: Flameproof enclosures "d" – Method of test for ascertainment of maximum experimental safe gap*

IEC 60079-7, *Explosive atmospheres – Part 7: Equipment protection by increased safety "e"*

IEC 60079-11, *Explosive atmospheres – Part 11: Equipment protection by intrinsic safety "i"*

IEC 60079-14:2002, *Electrical apparatus for explosive gas atmospheres – Part 14: Electrical installations in hazardous areas (other than mines)*

IEC 60086-1:2000, *Primary batteries – Part 1: General*

IEC 60112, *Method for the determination of the proof and the comparative tracking indices of solid insulating materials*

IEC 60127 (all parts), *Miniature fuses*

IEC 60529:1989, *Degrees of protection provided by enclosures (IP Code)*

IEC 60623:2001, *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Vented nickel-cadmium prismatic rechargeable single cells*

IEC 60662:1980, *High-pressure sodium vapour lamps*

IEC 60695-11-10, *Fire hazard testing – Part 11-10: Test flames – 50 W horizontal and vertical flame test methods*

IEC 61951-1:2003, *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Portable sealed rechargeable single cells – Part 1: Nickel-cadmium*

IEC 61951-2:2003, *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Portable sealed rechargeable single cells – Part 2:Nickel-metal hydride*

ISO 185:1988, *Grey cast iron – Classification*

ISO 965-1:1998, *ISO general-purpose metric screw threads – Tolerances – Part 1: Principles and basic data*

ISO 965-3:1998, *ISO general-purpose metric screw threads – Tolerances – Part 3: Deviations for constructional threads*

ISO 2738:1999, *Sintered metal materials, excluding hard metals – Permeable sintered metal materials – Determination of density, oil content and open porosity*

ISO 3864: 1984, *Safety colours and safety signs*

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

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

ANSI/ASME B1.20.1-1983 (R2001), *Pipe threads, general purpose (inch)*

3 Terms and definitions

For the purposes of this document, the following terms and definitions, in addition to those given in IEC 60079-0, apply.

NOTE Additional definitions applicable to explosive atmospheres can be found in IEC 60050-426.

3.1
flameproof enclosure "d"
enclosure in which the parts which can ignite an explosive gas atmosphere are placed and which can withstand the pressure developed during an internal explosion of an explosive mixture, and which prevents the transmission of the explosion to the explosive gas atmosphere surrounding the enclosure

3.2
volume
total internal volume of the enclosure. However, for enclosures in which the contents are essential in service, the volume to be considered is the remaining free volume

NOTE For luminaries, the volume is determined without lamps fitted.

3.3
flameproof joint or flamepath
place where the corresponding surfaces of two parts of an enclosure, or the conjunction of enclosures, come together and which prevents the transmission of an internal explosion to the explosive gas atmosphere surrounding the enclosure

3.4
width of flameproof joint
L
shortest path through a flameproof joint from the inside to the outside of an enclosure

NOTE This definition does not apply to threaded joints.

3.5
distance

shortest path through a flameproof joint, when the width of the flameproof joint *L* is interrupted by holes intended for the passage of fasteners for assembling the parts of the flameproof enclosure

3.6
gap of flameproof joint
i
distance between the corresponding surfaces of a flameproof joint when the electrical apparatus enclosure has been assembled

NOTE For cylindrical surfaces, forming cylindrical joints, the gap is the difference between the diameters of the bore and the cylindrical component.

3.7
maximum experimental safe gap (for an explosive mixture)
MESG
maximum gap of a joint of 25 mm in width which prevents any transmission of an explosion during 10 tests made under the conditions specified in IEC 60079-1-1

3.8
shaft
part of circular cross-section used for the transmission of rotary movement

3.9
operating rod
part used for the transmission of control movements which may be rotary or linear or a combination of the two

3.10
pressure-piling
results of an ignition, in a compartment or subdivision of an enclosure, of a gas mixture pre-compressed, for example, due to a primary ignition in another compartment or subdivision

3.11
quick-acting door or cover
door or cover provided with a device which permits opening or closing by a simple operation, such as the movement of a lever or the rotation of a wheel. The device is arranged so that the operation has two stages:

- one for locking or unlocking,
- another for opening or closing

3.12
door or cover fixed by threaded fasteners
door or cover, the opening or closing of which requires the manipulation of one or more threaded fasteners (screws, studs, bolts or nuts)

3.13
threaded door or cover
door or cover which is assembled to a flameproof enclosure by a threaded flameproof joint

3.14
breathing device
device which permits an exchange between the atmosphere within an enclosure and the surrounding atmosphere and which maintains the integrity of the type of protection

3.15
draining device
device which permits liquids to flow out from an enclosure and which maintains the integrity of the type of protection

3.16
Ex blanking element
threaded blanking element tested separately from the equipment enclosure but having an equipment certificate and which is intended to be fitted to the equipment enclosure without further consideration

NOTE 1 This does not preclude a component certificate for blanking elements in accordance with IEC 60079-0. Examples of blanking elements are shown in Figure 22.

NOTE 2 Non-threaded blanking elements are not equipment.

3.17
Ex thread adapter
thread adapter tested separately from the enclosure but having an equipment certificate and which is intended to be fitted to the equipment enclosure without further consideration

NOTE This does not preclude a component certificate for thread adapters in accordance with IEC 60079-0. Examples of thread adapters are shown in Figure C.2.

3.18
Ex component enclosure
empty flameproof enclosure provided with an Ex component certificate, without the internal equipment being defined, so as to enable the empty enclosure to be made available for incorporation into an equipment certificate without the need for repetition of type testing

4 Equipment grouping and temperature classification

The equipment grouping and temperature classification defined in IEC 60079-0 for the use of electrical equipment in explosive gas atmospheres apply to flameproof enclosures. The subdivisions A, B and C for electrical equipment of Group II also apply.

5 Flameproof joints

5.1 General requirements

All flameproof joints, whether permanently closed or designed to be opened from time to time, shall comply, in the absence of pressure, with the appropriate requirements of Clause 5.

The design of joints shall be appropriate to the mechanical constraints applied to them.

The dimensions given in 5.2 to 5.5 inclusive specify the minimum or maximum values that may be applied to the essential parameters of flamepaths. In instances where a dimension of a flameproof joint is other than the relevant minimum or maximum (for example, in order to comply with the test for non-transmission of an internal ignition), the equipment shall be marked "X" according to 29.2 item i) of IEC 60079-0 and the specific conditions of use on the certificate shall be in accordance with one of the following:

a) dimensions of the flameproof joints shall be detailed; or
b) specific drawing referenced that details the dimensions of the flameproof joints; or
c) specific guidance noted to contact the original manufacturer for information on the dimensions of the flameproof joints.

The surface of joints may be protected against corrosion.

Coating with paint or powder-coat finish is not permitted. Other coating material may be used if the material and application procedure have been shown not to adversely affect the flameproof properties of the joint.

A corrosion inhibiting grease may be applied to joint surfaces before assembly. The grease, if applied, shall be of a type that does not harden because of ageing, does not contain an evaporating solvent, and does not cause corrosion of the joint surfaces. Verification of suitability shall be in accordance with the grease manufacturer's specifications.

Joint surfaces may be electroplated. The metal plating, if applied, shall not be more than 0,008 mm thick.

5.2 Non-threaded joints

5.2.1 Width of joints (*L*)

The width of joints shall not be less than the minimum values given in Tables 1 and 2. The width of joints for cylindrical metallic parts press-fitted into the walls of a metallic flameproof enclosure of a volume not greater than 2 000 cm^3 may be reduced to 5 mm, if

- the design does not rely only on an interference fit to prevent the part being displaced during the type tests of Clause 15, and
- the assembly meets the impact test requirements of IEC 60079-0, taking the worst-case interference fit tolerances into account, and
- the external diameter of the press-fitted part, where the width of the joint is measured, does not exceed 60 mm.

5.2.2 Gap (*i*)

The gap, if one exists, between the surfaces of a joint shall nowhere exceed the maximum values given in Tables 1 and 2.

The surfaces of joints shall be such that their average roughness R_a (derived from ISO 468) does not exceed 6,3 µm.

For flanged joints, there shall be no intentional gap between the surfaces, except for quick-acting doors or covers.

For electrical equipment of group I, it shall be possible to check, directly or indirectly, the gaps of flanged joints of covers and doors designed to be opened from time to time. Figure 1 shows an example of construction for indirect checking of a flameproof joint.

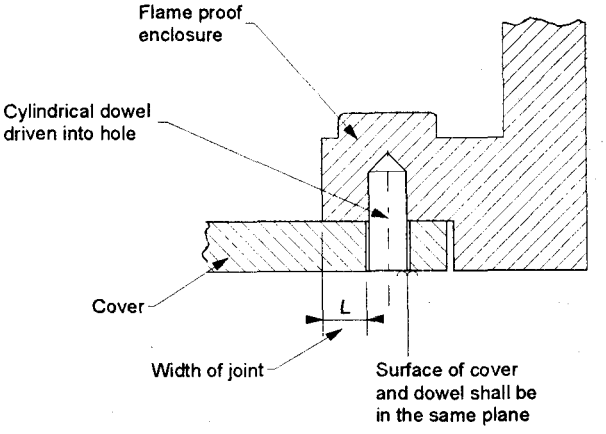


Figure 1 – Example of construction for indirect checking of a flanged group I flameproof joint

5.2.3 Spigot joints

For the determination of the width L of spigot joints, one of the following shall be taken into account:

- the cylindrical part and the plane part (see Figure 2a). In this case, the gap shall nowhere exceed the maximum values given in Tables 1 and 2;
- the cylindrical part only (see Figure 2b). In this case, the plane part need not comply with the requirements of Tables 1 and 2.

NOTE For gaskets, see also 5.4.

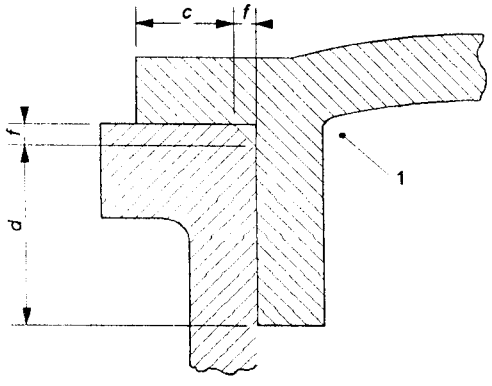


Figure 2a – Cylindrical part and plane part

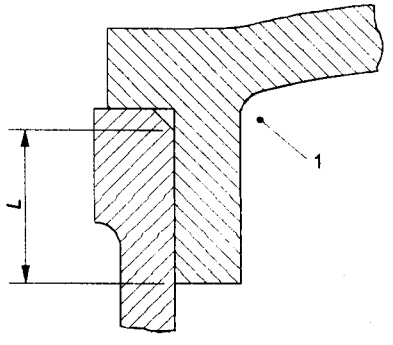


Figure 2b – Cylindrical part only

Key

L = c + d (I, IIA, IIB, IIC)

c ≥ 6,0 mm (IIC)

≥ 3,0 mm (I, IIA, IIB)

d ≥ 0,50 L (IIC)

f ≤ 1,0 mm (I, IIA, IIB, IIC)

1 interior of enclosure

Figure 2 – Spigot joints

5.2.4 Holes in joint surfaces

Where a plane joint or the plane part or partial cylindrical surface (see 5.2.6) of a joint is interrupted by holes intended for the passage of threaded fasteners for assembling the parts of a flameproof enclosure, the distance l to the edge of the hole shall be equal to or greater than

- 6 mm when the width of joint L is less than 12,5 mm,
- 8 mm when the width of joint L is equal to or greater than 12,5 mm but less than 25 mm,
- 9 mm when the width of joint L is equal to or greater than 25 mm.

NOTE The requirements for clearance holes of fasteners are specified in IEC 60079-0.

The distance l is determined as follows.

5.2.4.1 Flanged joints with holes outside the enclosure (see Figures 3 and 5)

The distance l is measured between each hole and the inside of the enclosure.

5.2.4.2 Flanged joints with holes inside the enclosure (see Figure 4)

The distance l is measured between each hole and the outside of the enclosure.

5.2.4.3 Spigot joints where, to the edges of the holes, the joint consists of a cylindrical part and a plane part (see Figure 6)

The distance *l* is defined as follows:

- the sum of the width *a* of the cylindrical part and the width *b* of the plane part, if *f* is less than or equal to 1 mm and if the gap of the cylindrical part is less than or equal to 0,2 mm for electrical equipment of groups I and IIA, 0,15 mm for electrical equipment of group IIB, or 0,1 mm for electrical equipment of group IIC (reduced gap); or
- the width *b* of the plane part alone, if either of the above-mentioned conditions is not met.

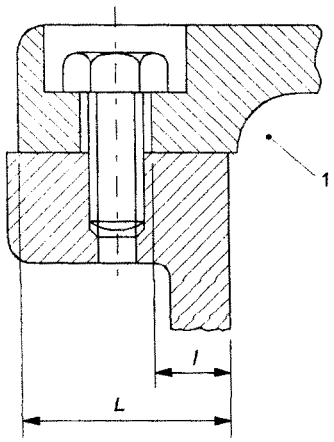


Figure 3

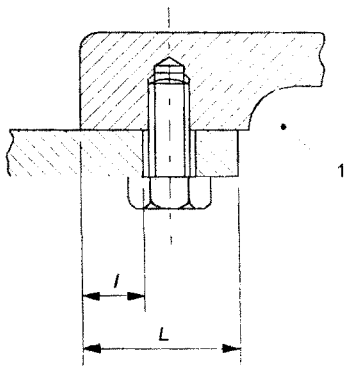


Figure 4

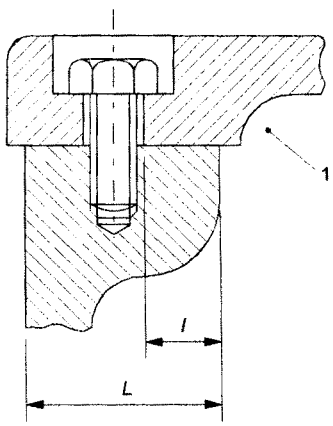


Figure 5

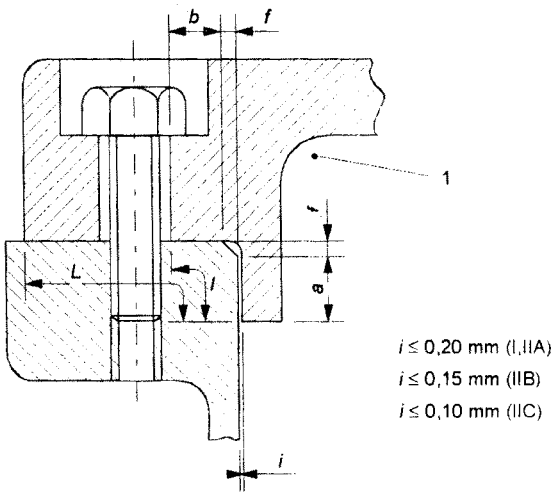


Figure 6

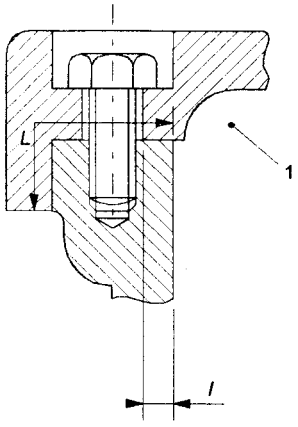


Figure 7

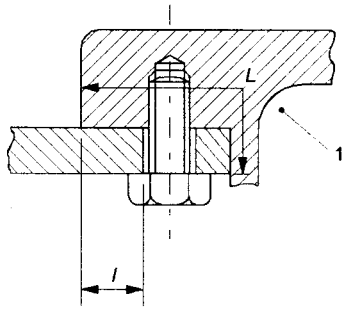


Figure 8

Key

1 interior of enclosure

Figures 3, 4, 5 – Holes in surfaces of flanged joints

Figures 6, 7, 8 – Holes in surfaces of spigot joints

5.2.4.4 Spigot joints where, to the edges of the holes, the joint consists only of the plane part (see Figures 7 and 8), in so far as plane joints are permitted (see 5.2.7)

The distance *l* is the width of the plane part between the inside of the enclosure and a hole, where the hole is outside the enclosure (see Figure 7), or between a hole and the outside of the enclosure where the hole is inside the enclosure (see Figure 8).

5.2.5 Conical joints

Where joints include conical surfaces, the width of the joint and the gap normal to the joint surfaces shall comply with the relevant values in Tables 1 and 2. The gap shall be uniform through the conical part. For electrical equipment of Group IIC, the cone angle shall not exceed 5°.

NOTE The cone angle is taken to be the angle between the major axis of the cone and the surface of the cone.

5.2.6 Joints with partial cylindrical surfaces (not permitted for group IIC)

There shall be no intentional gap between the two parts (see Figure 9a).

The width of the joint shall comply with the requirements of Table 1.

The diameters of the cylindrical surfaces of the two parts forming the flameproof joint, and their tolerances, shall ensure compliance with the relevant requirements for the gap of a cylindrical joint as given in Table 1.

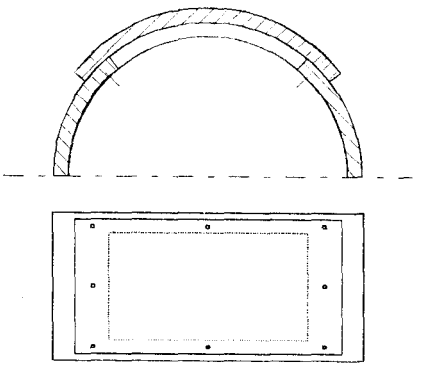


Figure 9a – Example of a joint with partial cylindrical surfaces

5.2.7 Flanged joints for acetylene atmospheres

Flanged joints are only permitted for electrical equipment of group IIC intended for use in explosive gas atmospheres containing acetylene provided all of the following conditions are met:

a) gap $i \leq 0{,}04$ mm;

b) width $L \geq 9{,}5$ mm; and

c) volume ≤ 500 cm^3.

5.2.8 Serrated joints

Serrated joints need not comply with the requirements of Tables 1 and 2 but shall have

a) at least five fully engaged serrations,

b) a pitch greater than or equal to 1,25 mm, and

c) an included angle of 60° (±5°).

Serrated joints shall not be used for moving parts.

Serrated joints shall satisfy the test requirements of 15.2, with the test gap, i_E, between the mating serrations as specified in 15.2, based on the manufacturer's maximum constructional gap, i_C.

If the manufacturer's maximum constructional gap is different to that shown in Tables 1 or 2 for a flanged joint of the same length (determined by multiplying the pitch by the number of serrations), the "conditions of use" requirements of 5.1 apply.

See Figure 9b.

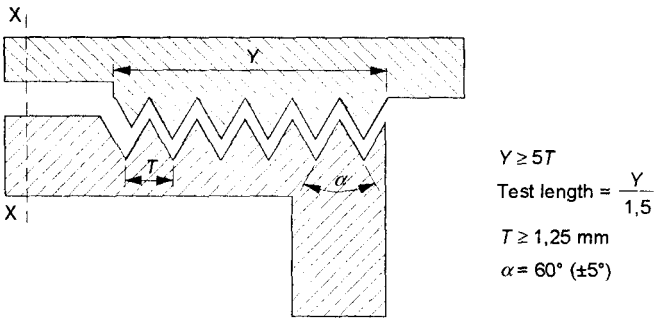


Figure 9b – Example of serrated joint

Table 1 – Minimum width of joint and maximum gap for enclosures of groups I, IIA and IIB

Type of joint		Minimum width of joint L mm	Maximum gap mm											
			For a volume cm^3 $V \leq 100$			For a volume cm^3 $100 < V \leq 500$			For a volume cm^3 $500 < V \leq 2\,000$			For a volume cm^3 $V > 2\,000$		
			I	IIA	IIB	I	IIA	IIB	I	IIA	IIB	I	IIA	IIB
Flanged, cylindrical or spigot joints		6	0,30	0,30	0,20	–	–	–	–	–	–	–	–	–
		9,5	0,35	0,30	0,20	0,35	0,30	0,20	0,08	0,08	0,08	–	–	–
		12,5	0,40	0,30	0,20	0,40	0,30	0,20	0,40	0,30	0,20	0,40	0,20	0,15
		25	0,50	0,40	0,20	0,50	0,40	0,20	0,50	0,40	0,20	0,50	0,40	0,20
Cylindrical joints for shaft glands of rotating electrical machines with:	Sleeve bearings	6	0,30	0,30	0,20	–	–	–	–	–	–	–	–	–
		9,5	0,35	0,30	0,20	0,35	0,30	0,20	–	–	–	–	–	–
		12,5	0,40	0,35	0,25	0,40	0,30	0,20	0,40	0,30	0,20	0,40	0,20	–
		25	0,50	0,40	0,30	0,50	0,40	0,25	0,50	0,40	0,25	0,50	0,40	0,20
		40	0,60	0,50	0,40	0,60	0,50	0,30	0,60	0,50	0,30	0,60	0,50	0,25
	Rolling-element bearings	6	0,45	0,45	0,30	–	–	–	–	–	–	–	–	–
		9,5	0,50	0,45	0,35	0,50	0,40	0,25	–	–	–	–	–	–
		12,5	0,60	0,50	0,40	0,60	0,45	0,30	0,60	0,45	0,30	0,60	0,30	0,20
		25	0,75	0,60	0,45	0,75	0,60	0,40	0,75	0,60	0,40	0,75	0,60	0,30
		40	0,80	0,75	0,60	0,80	0,75	0,45	0,80	0,75	0,45	0,80	0,75	0,40

NOTE Constructional values rounded according to ISO 31-0 should be taken when determining the maximum gap.

Table 2 – Minimum width of joint and maximum gap for group IIC enclosures

Type of joint		Minimum width of joint L mm	Maximum gap mm			
			For a volume cm^3 $V \leq 100$	For a volume cm^3 $100 < V \leq 500$	For a volume cm^3 $500 < V \leq 2\,000$	For a volume cm^3 $V > 2\,000$
Flanged joints[a]		6	0,10	–	–	–
		9,5	0,10	0,10	–	–
		15,8	0,10	0,10	0,04	–
		25	0,10	0,10	0,04	0,04
Spigot joints (Figure 2a)	$c \geq 6$ mm	12,5	0,15	0,15	0,15	–
	$d \geq 0,5\ L$	25	0,18[b]	0,18[b]	0,18[b]	0,18[b]
	$L = c + d$	40	0,20[c]	0,20[c]	0,20[c]	0,20[c]
	$f \leq 1$ mm					
Cylindrical joints Spigot joints (Figure 2b)		6	0,10	–	–	–
		9,5	0,10	0,10	–	–
		12,5	0,15	0,15	0,15	–
		25	0,15	0,15	0,15	0,15
		40	0,20	0,20	0,20	0,20
Cylindrical joints for shaft glands of rotating electrical machines with rolling element bearings		6	0,15	–	–	–
		9,5	0,15	0,15	–	–
		12,5	0,25	0,25	0,25	–
		25	0,25	0,25	0,25	0,25
		40	0,30	0,30	0,30	0,30

[a] Flanged joints are permitted for explosive mixtures of acetylene and air only in accordance with 5.2.7.

[b] Maximum gap of cylindrical part increased to 0,20 mm if $f < 0,5$ mm.

[c] Maximum gap of cylindrical part increased to 0,25 mm if $f < 0,5$ mm.

NOTE The constructional values rounded according to ISO 31-0 should be taken when determining the maximum gap.

5.3 Threaded joints

Threaded joints shall comply with the requirements given in Tables 3 or 4.

Table 3 – Cylindrical threaded joints

Pitch	≥0,7 mm[a]
Thread form and quality of fit	Medium or fine tolerance quality according to ISO 965-1 and ISO 965-3[b]
Threads engaged	≥5
Depth of engagement	
Volume ≤100 cm^3	≥5 mm
Volume >100 cm^3	≥8 mm

[a] Where the pitch exceeds 2 mm, special manufacturing precautions may be necessary (for example, more threads engaged) to ensure that the electrical equipment can pass the test for non-transmission of an internal ignition which is prescribed in 15.2.

[b] Cylindrical threaded joints which do not conform with ISO 965-3 in respect of thread form or quality of fit, are permitted if the test for non-transmission of an internal ignition, prescribed in 15.2, is passed, when the width of the threaded joint specified by the manufacturer is reduced by the amount specified in Table 6.

Table 4 – Taper threaded joints[a]

Threads provided on each part	≥5[b]

[a] Internal and external thread shall have the same nominal size.

[b] Threads shall conform to the NPT requirements of ANSI/ASME B1.20.1, and shall be made-up wrench tight. Male threaded fittings with a shoulder or interruption shall be provided with:

1) an effective thread length not less than the "L2" dimension; and

2) a length not less than the "L4" dimension between the face of the shoulder and end of the fitting thread.

Female threads shall gauge at "flush" to "2 turns large" using an L1 plug-gauge.

5.4 Gaskets (including O-rings)

If a gasket of compressible or elastic material is used, for example, to protect against the ingress of moisture or dust or against leakage of a liquid, it shall be applied as a supplement, that is to say neither be taken into account in the determination of the width of the flameproof joint nor interrupt it.

The gasket shall then be mounted so that

- the permissible gap and width of flanged joints or the plane part of a spigot joint are maintained,
- the minimum width of joint of a cylindrical joint or the cylindrical part of a spigot joint are maintained before and after compression.

These requirements do not apply to cable glands (see 13.1) or to joints which contain a sealing gasket of metal or of a non-flammable compressible material with a metallic sheath. Such a sealing gasket contributes to the explosion protection, and in this case the gap between each surface of the plane part shall be measured after compression. The minimum width of the cylindrical part shall be maintained before and after compression.

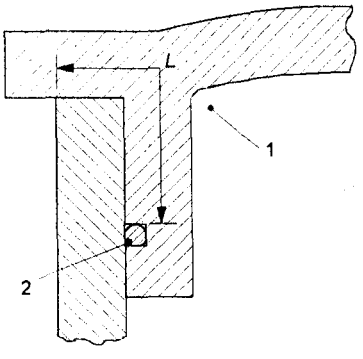


Figure 10

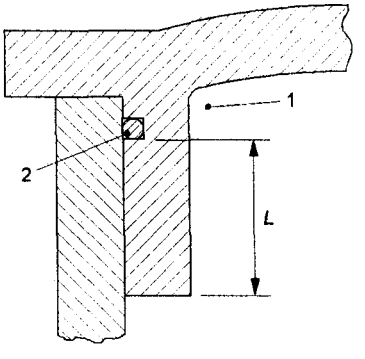


Figure 11

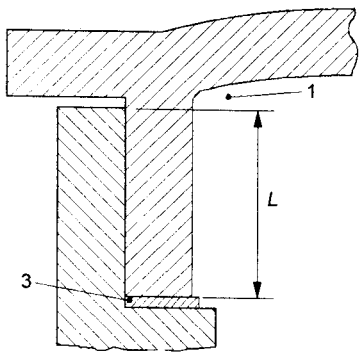


Figure 12

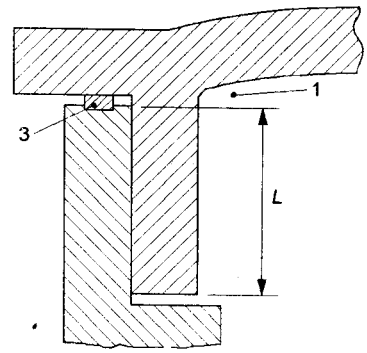


Figure 13

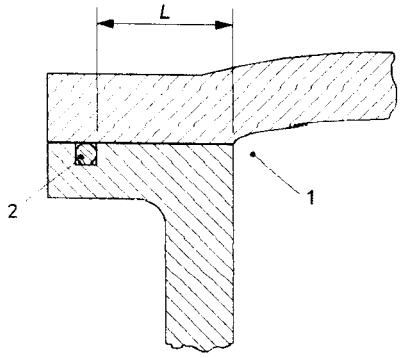


Figure 14

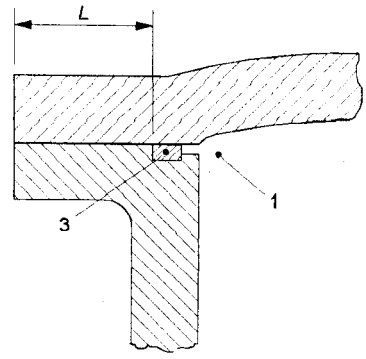
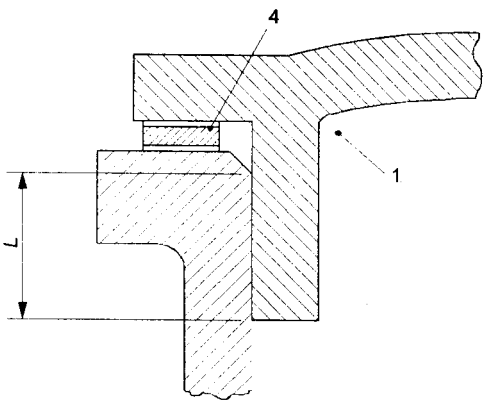


Figure 15



Key

1 interior of enclosure
2 O-ring
3 gasket
4 metallic or metal sheath gasket

Figure 16

Figures 10 to 16 – Illustration of the requirements concerning gaskets

5.5 Equipment using capillaries

The capillaries shall either comply with the gap dimensions given in Table 1 or Table 2 for cylindrical joints using 0 as the diameter of the inner part, or when the capillaries do not conform to the gaps given in these tables, the equipment shall be evaluated in accordance with the test for non-transmission of an internal ignition given in 15.2.

6 Cemented joints

6.1 General

Parts of a flameproof enclosure may be cemented either directly into the wall of the enclosure so as to form with the latter an inseparable assembly, or into a metallic frame such that the assembly can be replaced as a unit without damaging the cement.

If a joint which is cemented does not fulfil the requirements of Clause 5, in the absence of the cement it shall be subjected to the thermal endurance to heat and thermal endurance to cold of IEC 60079-0.

6.2 Mechanical strength

Cemented joints are only permitted to ensure the sealing of the flameproof enclosure of which they form a part. Arrangements shall be made in the construction so that the mechanical strength of the assembly does not depend upon the adhesion of the cement alone. Cemented joints shall comply with a test having overpressure and time in accordance with 15.1.3, with compliance criteria in accordance with C.3.1.1.

6.3 Width of cemented joints

The shortest path through a cemented joint from the inside to the outside of a flameproof enclosure of volume V shall be

≥3 mm if	$V \leq 10$ cm^3
≥6 mm if	10 cm^3 < $V \leq 100$ cm^3
≥10 mm if	$V > 100$ cm^3

7 Operating rods

Where an operating rod passes through the wall of a flameproof enclosure, the following requirements shall be met.

7.1 If the diameter of the operating rod exceeds the minimum width of the joint specified in Tables 1 and 2, the width of the joint shall be at least equal to this diameter but without, however, having to exceed 25 mm.

7.2 If the diametrical clearance is liable to be enlarged as a result of wear in normal service, appropriate arrangements shall be made to facilitate a return to the original state, for example, by means of a replaceable bush. Alternatively, gap enlargement due to wear may be prevented by the use of bearings complying with Clause 8.

8 Supplementary requirements for shafts and bearings

8.1 Joints of shafts

Flameproof joints of shafts of rotating electrical machines shall be arranged so as not to be subject to wear in normal service.

The flameproof joint may be

- a cylindrical joint (see Figure 17), or
- a labyrinth joint (see Figure 18), or
- a joint with a floating gland (see Figure 19).

8.1.1 Cylindrical joints

Where a cylindrical joint contains grooves for the retention of grease, the region containing the grooves shall neither be taken into account when determining the width of a flameproof joint nor interrupt it (see Figure 17).

The minimum radial clearance *k* (see Figure 20) of shafts of rotating electrical machines shall not be less than 0,05 mm.

8.1.2 Labyrinth joints

Labyrinth joints which do not comply with the requirements of Tables 1 and 2 may nevertheless be considered as complying with the requirements of this standard if the tests specified in Clauses 14 through 16 are satisfied.

The minimum radial clearance *k* (see Figure 20) of shafts of rotating electrical machines shall not be less than 0,05 mm.

8.1.3 Joints with floating glands

The determination of the maximum degree of float of the gland shall take account of the clearance in the bearing and the permissible wear of the bearing as specified by the manufacturer. The gland may move freely radially with the shaft and axially on the shaft but it shall remain concentric with it. A device shall prevent rotation of the gland (see Figure 19).

Floating glands are not permitted for electrical equipment of group IIC.

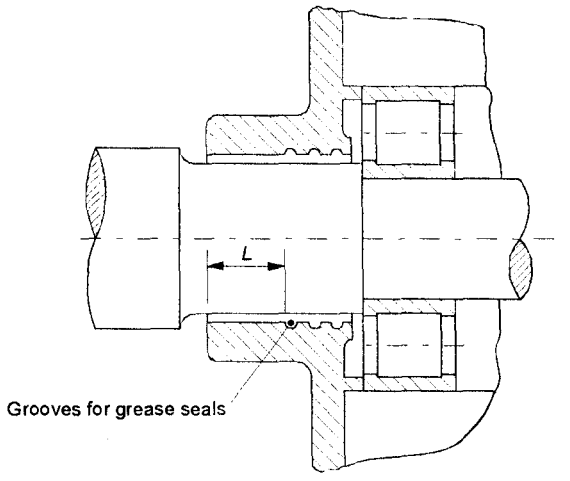


Figure 17 – Example of cylindrical joint for shaft of rotating electrical machine

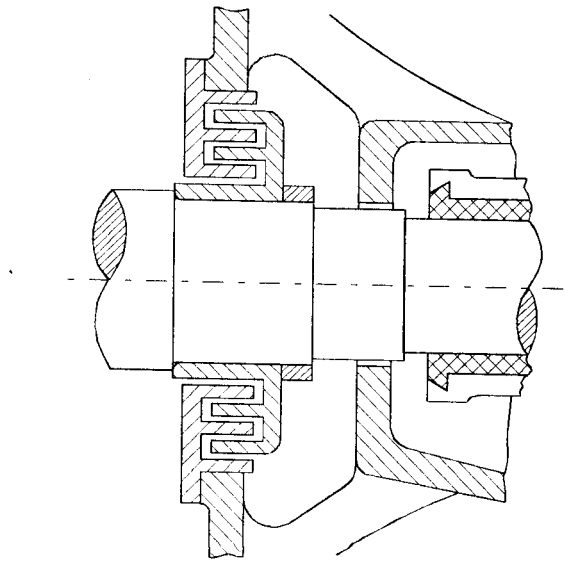
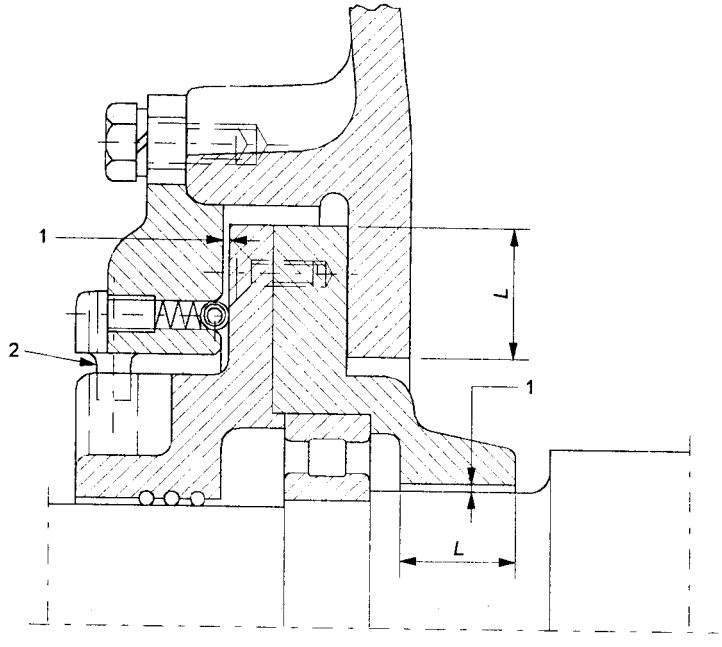


Figure 18 – Example of labyrinth joint for shaft of rotating electrical machine

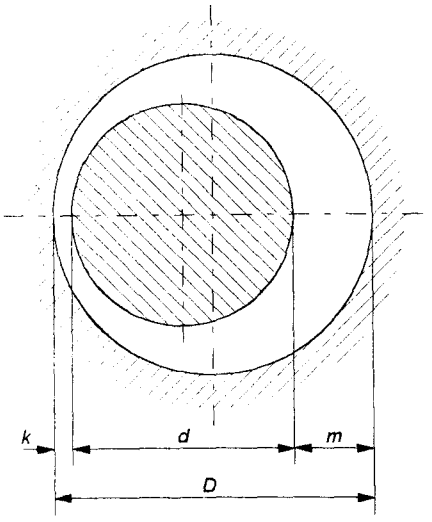


Key

1 gap

2 stop to prevent rotation of gland

Figure 19 – Example of joint with floating gland for shaft of rotating electrical machine



Key

k	minimum radial clearance permissible without rubbing
m	maximal radial clearance taking *k* into account
D-d	diametrical clearance

Figure 20 – Joints of shaft glands of rotating electrical machines

8.2 Bearings

8.2.1 Sleeve bearings

A flameproof joint of a shaft gland associated with a sleeve bearing shall be provided in addition to the joint of the sleeve bearing itself and shall have a width of joint at least equal to the diameter of the shaft but not exceeding 25 mm.

If a cylindrical or labyrinth flameproof joint is used in a rotating electrical machine with sleeve bearings, at least one face of the joint shall be of non-sparking metal (for example, leaded brass) whenever the air gap between stator and rotor is greater than the minimum radial clearance *k* (see Figure 20) specified by the manufacturer. The minimum thickness of the non-sparking metal shall be greater than the air gap.

Sleeve bearings are not permitted for rotating electrical machines of group IIC.

8.2.2 Rolling-element bearings

In shaft glands equipped with rolling-element bearings, the maximum radial clearance *m* (see Figure 20) shall not exceed two-thirds of the maximum gap permitted for such glands in Tables 1 and 2.

NOTE 1 It is acknowledged that, with assemblies, all parts will not exist in their worst case dimensions simultaneously. A statistical treatment of the tolerances, such as "RMS", may be required for *m* and *k* verification.

NOTE 2 It is not a requirement of this standard that the manufacturer's *m* and *k* calculations be verified. Also, it is not a requirement of this standard that *m* and *k* be verified by measurement.

9 Light-transmitting parts

For light-transmitting parts of other than glass, the requirements in Clause 19 of this standard apply.

NOTE Precautions should be taken so that the mountings of light-transmitting parts of any material do not produce internal mechanical stress in those parts.

10 Breathing and draining devices which form part of a flameproof enclosure

Breathing and draining devices shall incorporate permeable elements which can withstand the pressure created by an internal explosion in the enclosure to which they are fitted, and which shall prevent the transmission of the explosion to the explosive atmosphere surrounding the enclosure.

They shall also withstand the dynamic effects of explosions within the flameproof enclosure without permanent distortion or damage which would impair their flame-arresting properties. They are not intended to withstand continuous burning on their surfaces.

These requirements apply equally to devices for the transmission of sound but do not cover devices for

- relief of pressure in the event of internal explosion, or
- use with pressure lines containing gas which is capable of forming an explosive mixture with air and is at a pressure in excess of 1,1 times atmospheric pressure.

10.1 Openings for breathing or draining

The openings for breathing or draining shall not be produced by deliberate enlargement of gaps of flanged joints.

NOTE If, for technical reasons, breathing or draining devices have to be provided, they should be so constructed that they are not liable to become inoperative in service (for example, because of the accumulation of dust or paint).

10.2 Composition limits

The composition limits of the materials used in the device shall be specified either directly or by reference to an existing applicable specification.

The elements of breathing or draining devices for use in an explosive gas atmosphere containing acetylene shall comprise not more than 60 % of copper by mass to limit acetylide formation.

10.3 Dimensions

The dimensions of the breathing and draining devices and their component parts shall be specified.

10.4 Elements with measurable paths

Interstices and measurable lengths of path need not comply with the values given in Tables 1 and 2, provided that the elements pass the tests of Clauses 14 through 16.

Additional requirements for crimped ribbon elements and multiple screen elements are given in Annex A.

10.5 Elements with non-measurable paths

Where the paths through the elements are not measurable (for example, sintered metal elements), the element shall comply with the relevant requirements of Annex B.

The elements are classified according to their density as well as their pore size in accordance with the standard methods for the particular material and the particular manufacturing methods (see Annex B).

NOTE For functional reasons, it may also be necessary to state the fluid permeability and the open porosity specified in accordance with the standard methods for the particular material and the particular manufacturing methods (see Annex B).

10.6 Removable devices

If a device can be dismantled, it shall be designed to avoid reduction or enlargement of the openings during re-assembly.

10.7 Mounting arrangements of the elements

The breathing and draining elements shall be sintered, or fixed by other suitable methods:

- either directly into the enclosure to form an integral part of the enclosure, or
- in a suitable mounting component, which is clamped or screwed into the enclosure so that it is replaceable as a unit.

Alternatively, the element can be mounted, for example press-fitted in accordance with 5.2.1, so as to form a flameproof joint. In this case, the appropriate requirements of Clause 5 shall be applied, with the exception that the surface roughness of the element need not comply with 5.2.2, if the element arrangement passes the type test in Clauses 14 through 16.

If necessary, a clamping ring or similar means can be used to maintain the integrity of the enclosure. The breathing or draining element can be mounted

- either from within, in which case the accessibility of screws and clamping ring shall be possible only from the inside, or
- from outside the enclosure, in which case the fasteners shall comply with Clause 11

10.8 Mechanical strength

The device and its guard, if any, shall, when mounted normally, pass the test for resistance to impact of IEC 60079-0.

10.9 Breathing devices and draining devices when used as Ex components

In addition to Clause 10 through 10.6 inclusive, the following requirements shall apply to breathing and draining devices which are evaluated as Ex components.

10.9.1 Mounting arrangements of the elements and components

The breathing and draining elements shall be sintered or cemented in accordance with Clause 6, or fixed by other methods into a suitable mounting part to form the mounting component.

The mounting component is secured by clamping or by fasteners or screwed into the enclosure as a replaceable unit complying with the relevant requirements of Clauses 5 and 6 and, where appropriate, Clause 11.

10.9.2 Type tests for breathing and draining devices used as Ex components

Attachment of the sample device under test shall be made on the end of the test rig enclosure in the same manner as it would normally be mounted on a flameproof enclosure. The test shall be performed on the sample after the impact test of 10.8 and in accordance with 10.9.2.1 to 10.9.2.3.

NOTE The impact test may be performed on the sample, separate from the test enclosure when it is mounted on a plate that forms the end part of the test rig enclosure.

For devices with non-measurable paths, the maximum bubble test pore size of the sample shall be not less than 85 % of the specified maximum bubble test pore size. See B.1.2.

10.9.2.1 Test of the ability of the breathing and draining device to withstand pressure

10.9.2.1.1 Test procedure

The reference test pressures in each gas group are

- Group I 1 200 kPa
- Group IIA 1 350 kPa
- Group IIB 2 500 kPa
- Group IIC 4 000 kPa

For the purpose of the test, a thin flexible membrane is fitted over the inner surfaces of the breathing and draining devices. The reference pressure shall be one of the relevant pressures given above for the gas group for which the component is intended.

One of the following overpressure tests shall be applied:

- 1,5 times the reference pressure for a period of at least 10 s. Then each component shall be submitted to a routine test; or
- 4 times the reference pressure for a period of at least 10 s. If this test is successful, the manufacturer is not required to apply the routine test to all future components of the tested type.

10.9.2.1.2 Acceptance criteria

After the overpressure tests, the device shall show no permanent deformation or damage affecting the type of protection.

It shall be used as the test sample for all subsequent type tests.

10.9.2.2 Thermal tests

Breathing and draining devices as Ex components shall be subjected to the thermal tests based on the maximum intended flameproof enclosure volume, but no less than the volume of the test rig in Figure 21.

NOTE When using the test rig in Figure 21, the maximum volume can be calculated to be approximately 2,5 l.

Breathing and draining devices intended for multiple use in any single flameproof enclosure shall be tested additionally with the enclosure.

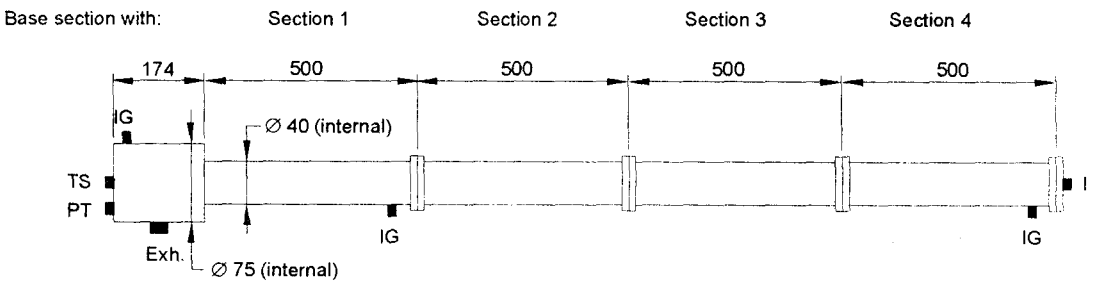
10.9.2.2.1 Test procedure

For enclosure volumes of less than or equal to 2,5 l, the test rig assembly with all four sections, as shown in Figure 21, shall be used, and the test procedure shall be carried out as follows:

- the position of the ignition source shall be at the enclosure inlet and 50 mm from the inside of the end-plate housing the device and the results observed;
- the test mixtures shall be as for 15.4.2.1, as appropriate;
- the temperature of the external surface of the device shall be monitored during tests;
- any device shall be operated as specified by the manufacturer's documentation. After each of five tests, the explosive mixture shall be maintained external to the device for a sufficient time to allow any continuous burning on the face of the device to become

evident, for at least 10 min, so as to increase the temperature of the external surface of the device or to make temperature transfer to the outer face possible;

- the tests shall be carried out five times for each gas mixture for the gas groups in which the device is intended for use.



Key

TS test sample position

I inlet

Exh. exhaust outlet

IG ignition source

PT pressure transducer

Figure 21 – Component test rig for breathing and draining devices

For enclosure volumes of greater than 2,5 l, a representative enclosure of the intended volume shall be used, and the test procedure shall be carried out as follows:

- the test mixtures shall be as for 15.4.2.1, as appropriate;
- the temperature of the external surface of the device shall be monitored during tests;
- any device shall be operated as specified by the manufacturer's documentation. After each of five tests, the explosive mixture shall be maintained external to the device for a sufficient time to allow any continuous burning on the face of the device to become evident, for at least 10 min, so as to increase the temperature of the external surface of the device or to make temperature transfer to the outer face possible;
- the tests shall be carried out five times for each gas mixture for the gas groups in which the device is intended for use.

10.9.2.2.2 Acceptance criteria

During the thermal tests, no flame transmission shall occur and no continuous burning shall be observed. The device shall show no evidence of thermal or mechanical damage or deformation which could affect its flame-arresting properties.

The measured external surface temperature rise of the device shall be multiplied by a safety factor of 1,2 for the determination of the temperature class of the electrical equipment.

NOTE Breathing and draining devices which fail any of the tests of 10.9 are excluded from evaluation as a component device. However, they may be used as an integral part of a flameproof enclosure, provided they are tested with the specific enclosure in accordance with 15.4.

10.9.2.3 Test for non-transmission of an internal ignition

This test shall be carried out on a standard test rig, as illustrated in Figure 21, and made in accordance with 15.4.3, with the following additions and modifications.

10.9.2.3.1 Test procedure

The position of the ignition source shall be as shown in Figure 21:

- at the inlet end, and

- at 50 mm from the inside of the end-plate housing the device.

For the purposes of the test, the test rig shall be assembled for each gas group, in accordance with Figure 21, and have the following number of sections:

- group I and group IIA: one section of test rig assembly;
- group IIB and group IIC: four sections of test rig assembly.

The gas mixture within the test rig enclosure shall be ignited and the tests shall be made five times at each ignition point.

For breathing and draining devices of groups I, IIA and IIB having either measurable paths or non-measurable paths, the non-transmission test of 15.2.1 shall be applied.

For breathing and draining devices of group IIC with measurable paths, the non-transmission test of 15.2.2 and either 15.4.3.2.1 or 15.4.3.2.2 shall be applied.

For breathing or draining devices of group IIC with non-measurable paths, 15.4.3.2.1 (method A) or 15.4.3.2.2 (method B) shall be applied.

10.9.2.3.2 Acceptance criteria

During the test, no ignition shall be transmitted to the surrounding test chamber.

10.9.3 Ex component certificate

The Ex component certificate shall record all details necessary to properly select a breathing or draining device for attachment to a type tested flameproof enclosure. The Ex component certificate shall show

a) the manufacturer's name and identifying drawings and specifications;

b) the limiting reference pressure;

NOTE The selection of the device used as a component is made such that the limiting reference pressure of the device is not less than the reference pressure of the flameproof enclosure (tested with breathing and draining device entries plugged) to which the device is to be attached.

c) the maximum recorded surface temperature obtained during the type test corrected to 40 °C, or to the higher marked ambient;

d) the group, i.e. I, IIA, IIB, or IIC;

e) the maximum permitted enclosure volume (based on the thermal test) if greater than 2,5 l.

In addition, the Ex component certificate shall require that each Ex component or package of Ex components be accompanied by a copy of the certificate, together with the manufacturer's declaration stating

- compliance with the certificate conditions,
- confirmation of the material, maximum bubble test pore size and minimum density, where applicable;
- special mounting instructions, if any.

11 Fasteners, associated holes and blanking elements

11.1 Fasteners accessible from the outside and necessary for the assembly of the parts of a flameproof enclosure shall

- for group I, be special fasteners complying with the requirements of IEC 60079-0, with the head shrouded or provided in counter-bored holes or inherently protected by the equipment construction;

for group II, be special fasteners complying with the requirements of IEC 60079-0.

NOTE For group I applications, the intent behind requiring shrouding or counter-boring is to provide some basic protection of the fastener head from impact.

11.2 Fasteners of plastic material or light alloys are not permitted.

11.3 In carrying out the type tests specified in Clause 15, the screws and nuts specified by the manufacturer shall be used.

The property class of the screw or nut, or yield stress and type of the screw or nut, used during testing shall be either

a) marked on the equipment per 20.2(a), Table 9, or

b) specified in the relevant certificate.

NOTE See Annex F for additional informative details on mechanical properties for screws and nuts.

11.4 Studs shall comply with 11.3 and shall be securely fixed, i.e. they shall be welded or riveted or permanently attached to the enclosure by another equally effective method.

11.5 Fasteners shall not pass through the walls of a flameproof enclosure, unless they form a flameproof joint with the wall and are non-detachable from the enclosure, for example by welding, riveting or an equally effective method.

11.6 In the case of holes for screws or studs which do not pass through the walls of flameproof enclosures, the remaining thickness of the wall of the flameproof enclosure shall be at least one-third of the nominal diameter of the screw or stud with a minimum of 3 mm.

11.7 When screws are fully tightened into blind holes in enclosure walls, with no washer fitted, at least one full thread shall remain free at the base of the hole.

11.8 If, for ease of manufacture, a wall of a flameproof enclosure has to be drilled through, the resulting hole shall subsequently be closed by a device so that the flameproof properties of the enclosure are maintained. This device shall be securely fixed in accordance with the requirements of 11.4 for studs.

11.9 If apertures provided in a flameproof enclosure (for example, for cable gland or conduit entry) are not used, they shall be closed by blanking elements so that the flameproof properties of the enclosure are maintained (see Figure 22 for examples).

Blanking elements shall comply with Annex C.

The blanking element may be made so that it can be fitted or removed from either the outside or the inside of the wall of the flameproof enclosure.

The mechanically or frictionally locked blanking element shall comply with one or more of the requirements of 11.9.1 to 11.9.3.

11.9.1 If it is removable from the outside, this shall be possible only after disengagement of a retaining device inside the enclosure (see Figure 22a).

11.9.2 It may be so designed that it can be fitted or removed only by the use of a tool (see Figure 22b).

11.9.3 It may be of a special construction in which insertion is carried out by a method other than that used for removal. Removal shall only be by one of the methods specified in 11.9.1 or 11.9.2 or by a special technique (see Figure 22c).

11.9.4 A blanking element shall not be used with an adapter.

11.10 Threaded doors or covers shall be additionally secured by means of a hexagon socket set screw, or some equally effective method.

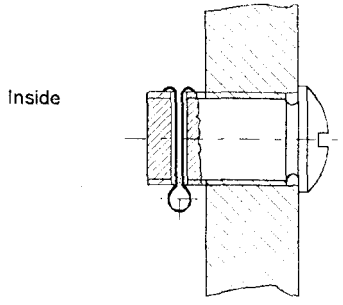


Figure 22a

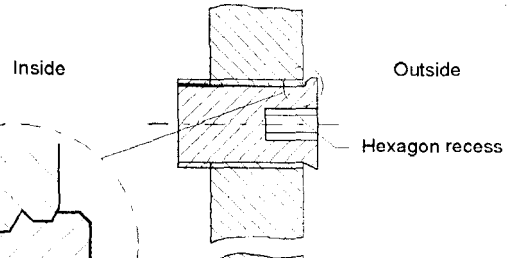


Figure 22b

Figure 22c

Figure 22 – Examples of blanking elements for unused apertures

12 Materials and mechanical strength of enclosures – Materials inside the enclosures

12.1 Flameproof enclosures shall withstand the relevant tests prescribed in Clauses 14 through 16.

12.2 When several flameproof enclosures are assembled together, the requirements of this standard apply to each of them separately, and in particular to the partitions separating them and to all the bushings and operating rods which pass through the partitions.

12.3 When an enclosure contains several intercommunicating compartments, or when it is subdivided because of the disposition of the internal parts, pressures and rates of rise of pressure greater than normal may be produced.

Such phenomena shall be precluded as far as possible by the construction. If it is impossible to avoid these phenomena, the resulting higher stresses shall be taken into account in the construction of the enclosure.

12.4 When cast iron is used, the material shall be not less than the quality 150 (ISO 185).

12.5 Liquids shall not be used in flameproof enclosures when there is a risk of producing oxygen, or an explosive mixture, more hazardous than that for which the enclosure was designed, by the decomposition of these liquids. They may, however, be used if the enclosure passes the tests prescribed in Clauses 14 through 16 for the type of explosive mixture produced; however, the surrounding explosive atmosphere shall be appropriate to the group for which the electrical equipment is constructed.

12.6 In flameproof enclosures of group I, insulating materials subjected to electrical stresses capable of causing arcs in air and which result from rated currents of more than 16 A (in switching equipment such as circuit-breakers, contactors, isolators) shall have a comparative tracking index equal to or greater than CTI 400 M, according to IEC 60112.

However, if the above-mentioned insulating materials do not pass this test, they may be used if their volume is limited to 1 % of the total volume of the empty enclosure or if a suitable detection device enables the power supply to the enclosure to be disconnected, on the supply side, before possible decomposition of the insulating material leads to dangerous conditions. The presence and effectiveness of such a device shall be verified.

12.7 Flameproof enclosures shall not be made of zinc, or made of zinc alloy of 80 % zinc or greater.

NOTE Zinc and zinc alloys tend to deteriorate rapidly (particularly tensile strength), especially in warm, moist air. It is also considered more reactive than most other metals. As such, the restriction above was implemented.

13 Entries for flameproof enclosures

The flameproof properties of the enclosure are not altered if all entries meet the relevant requirements given in this clause. In addition, metric threaded holes in the enclosure shall have a tolerance class of 6H or better according to ISO 965-1 and ISO 965-3, and any chamfer or undercut is limited to a maximum depth of 2 mm from the external wall surface.

Threaded holes in enclosures to facilitate cable glands or conduit entries shall have the thread type and size identified, for example M25 or 1/2NPT. This may be accomplished by

- marking of the specific thread type and size adjacent to the hole per 20.3(a), Table 10, or
- marking of the specific thread type and size on the nameplate per 20.3(a), Table 10, or
- identification of the specific thread type and size as part of the installation instruction document, with a reference marking on the nameplate (via text or ISO symbol B.3.1 from ISO 3864) per 20.3(b), Table 10.

The manufacturer shall state the following in the documents defining the electrical equipment:

a) the places where entries can be fitted; and

b) the maximum permitted number of these entries.

Each entry shall have no more than one thread adapter when an adapter is used. A blanking element shall not be used with an adapter.

13.1 Cable glands

Cable glands, whether integral or separate, shall meet the requirements of this standard, the relevant requirements of Annex C and create, on the enclosure, the joint widths and gaps prescribed in Clause 5.

Where cable glands are integral with the enclosure or specific to the enclosure they shall be tested as part of the enclosure concerned.

Where cable glands are separate:

- threaded Ex cable glands can be evaluated as equipment. Such cable glands do not have to be submitted to the tests of 15.1, nor to the routine test of Clause 16;
- other cable glands can only be evaluated as an Ex component.

13.2 Conduit sealing devices

Conduit sealing devices, whether integral or separate, shall meet the requirements of this standard, the requirements of C.2.1.2 and C.3.1.2 with "conduit sealing device" substituted for "cable gland" and create, on the enclosure, the joint widths and gaps prescribed in Clause 5.

NOTE As such constructions preclude reuse, the requirement of C.2.1.2 that a conduit sealing device be capable of being fitted and removed without disturbing the compound seal after the specified curing period of the compound should not apply.

Where conduit sealing devices are integral with the enclosure or specific to the enclosure they shall be tested as part of the enclosure concerned.

Where conduit sealing devices are separate:

- threaded Ex conduit sealing devices can be evaluated as equipment. Such conduit sealing devices do not have to be submitted to the tests of 15.1, nor to the routine test of Clause 16;
- other conduit sealing devices can only be evaluated as an Ex component.

13.2.1 Conduit entries are permitted only for electrical equipment of group II.

13.2.2 A sealing device such as a stopping box with setting compound shall be provided, either as part of the flameproof enclosure or immediately at the entrance thereto. It shall satisfy the type test for sealing prescribed in Annex C. An evaluated sealing device may be applied by the installer or user of the equipment according to instructions provided by the manufacturer of the equipment.

NOTE A sealing device is considered as fitted immediately at the entrance of the flameproof enclosure when the device is fixed to the enclosure either directly or through an accessory necessary for coupling.

The sealing compound(s) and method(s) of application shall be specified in the certificate either of the stopping box or of the complete flameproof equipment. The part of the stopping box between the sealing compound and the flameproof enclosure shall be treated as a flameproof enclosure, i.e. the joints shall comply with Clause 5 and the assembly shall be submitted to the tests for non-transmission of 15.2.

The distance from the face of the seal closest to the enclosure (or intended end-use enclosure), and the outside wall of the enclosure (or intended end-use enclosure) shall be as small as practical, but in no case more than the size of the conduit or 50 mm, whichever is the lesser.

13.3 Plugs and sockets and cable couplers

13.3.1 Plugs and sockets shall be constructed and mounted so that they do not alter the flameproof properties of the enclosure on which they are mounted, even when the two parts of the plugs and sockets are separated.

13.3.2 The widths and the gaps of the flameproof joints (see Clause 5) of the flameproof enclosures of plugs and sockets and cable couplers shall be determined by the volume which exists at the moment of separation of the contacts other than those for earthing or bonding or those which are parts of circuits complying with IEC 60079-11.

13.3.3 For plugs and sockets and cable couplers, the flameproof properties of the enclosure shall be maintained in the event of an internal explosion, both when the plugs and sockets or cable couplers are connected together and at the moment of separation of the contacts, other than those for earthing or bonding or those which are parts of circuits complying with IEC 60079-11.

13.3.4 The requirements of 13.3.2 and 13.3.3 do not apply to plugs and sockets nor to cable couplers fixed together by means of special fasteners conforming to 11.1 and which bear a marking per 20.2(b), Table 9.

13.4 Bushings

Bushings, whether integral or separate, shall meet the requirements of this standard, the relevant requirements of Annex C and create, on the enclosure, the joint widths and gaps prescribed in Clause 5.

Where bushings are integral with the enclosure or specific to the enclosure they shall be tested as part of the enclosure concerned.

Where bushings are separate:

- threaded Ex bushings can be evaluated as equipment. Such bushings do not have to be submitted to the tests of 15.1, nor to the routine test of Clause 16; and
- other bushings can only be evaluated as an Ex component.

14 Verification and tests

The requirements of IEC 60079-0 concerning verification and testing are, for the type of protection flameproof enclosure "d", supplemented by the following requirements.

The determination of the maximum surface temperature specified in IEC 60079-0 shall be made under the conditions defined in Table 5 of this standard.

Table 5 – Conditions for the determination of maximum surface temperature

Type of electrical equipment	Test voltage	Overload or fault conditions
Luminaires (without ballast)	U_n + 10 %	None
Ballast, electro-magnetic type	U_n + 10 %	U_n + 10 % Rectifier effect simulated by diode[a]
Ballast, electronic type	U_n + 10 %	[c]
Motors	U_n ± 10 %[b]	None
Resistors	U_n + 10 %	None
Electromagnets	U_n + 10 %	U_n and worst-case air-gap
Other equipment	U_n ± 10 %	As specified by the applicable standard for industrial equipment

NOTE U_n is the rated voltage of the equipment. For equipment involving a voltage range (as opposed to discrete rated voltages), the test voltage should be the worst case voltage within the range.

[a] The rectifier effect is only to be simulated in the case of ballasts for tubular fluorescent lamps.

[c] Alternatively, determination of the maximum surface temperature may be conducted at only U_n ± 5 % (as per IEC 60034-1). In this case, this range for use shall be marked on the equipment and included in the manufacturer's instructions.

Additional testing to determine the luminaire temperature during "lamp end-of-life" is under consideration. Additional guidance can be found in IEC 60079-7.

15 Type tests

The type tests shall be carried out in the following sequence on one of the samples which has been subjected to the tests of enclosures in accordance with IEC 60079-0:

a) determination of the explosion pressure (reference pressure) in accordance with 15.1.2;

b) overpressure test in accordance with 15.1.3;

c) test for non-transmission of an internal ignition in accordance with 15.2.

Testing may deviate from this sequence in that the static or dynamic overpressure test may be carried out either after the test for non-transmission of an internal ignition or on another sample which has also been subjected to those other tests affecting mechanical strength already applied to the first sample. In no case, after the overpressure test, shall the joints of the enclosure have suffered a permanent deformation nor shall the enclosure have suffered any damage affecting the type of protection.

The enclosure shall, in general, be tested with all the enclosed equipment in place. However, this may be replaced by equivalent models.

If an enclosure is designed to take different types of equipment and components, with the detailed mounting arrangements declared by the manufacturer, the enclosure may be tested empty, provided that this is the most severe condition for explosion pressure development, and that compliance with the other safety requirements of IEC 60079-0 can be confirmed.

If the enclosure is designed so that it can be used in the absence of part of the enclosed equipment, the tests shall be made under the conditions considered to be the most severe. In both cases, the certificate shall indicate the types of enclosed equipment permitted and their mounting arrangements.

Joints of removable parts of flameproof enclosures shall be tested in the worst-case assembly conditions.

15.1 Tests of ability of the enclosure to withstand pressure

15.1.1 General

The object of these tests is to verify that the enclosure can withstand the pressure of an internal explosion.

The enclosure shall be subjected to tests in accordance with 15.1.2 and 15.1.3.

The tests are considered satisfactory if the enclosure suffers no permanent deformation or damage, affecting the type of protection. In addition, the joints shall in no place have been permanently enlarged.

15.1.2 Determination of explosion pressure (reference pressure)

The reference pressure is the highest value of the maximum smoothed pressure, relative to atmospheric pressure, observed during these tests. For smoothing, a low-pass filter with a 3 dB point of 5 kHz ± 10 % shall be used.

For electrical equipment intended for use at an ambient temperature below –20 °C, the reference pressure shall be determined by one of the following methods:

- For all electrical equipment, the reference pressure shall be determined at a temperature not higher than the minimum ambient temperature.
- For all electrical equipment, the reference pressure shall be determined at normal ambient temperature using the defined test mixture(s), but at increased pressure. The absolute pressure of the test mixture *(P)*, in kPa, shall be calculated by the following formula, using $T_{a,\,min}$ in °C:

$$P = [293 / (T_{a,\,min} + 273)] \text{ kPa}$$

- For electrical equipment other than rotating electrical machines (such as electric motors, generators and tachometers) that involve simple internal geometry (see Annex D) with an enclosure volume not exceeding 3 l, when empty, such that pressure-piling is not considered likely, the reference pressure shall be determined at normal ambient temperature using the defined test mixture(s), but is to be assumed to have a reference pressure increased by the factors given in the table below.
- For electrical equipment other than rotating electrical machines (such as electric motors, generators and tachometers) that involve simple internal geometry (see Annex D) with an enclosure volume not exceeding 10 l, when empty, such that pressure piling is not considered likely, the reference pressure shall be determined at normal ambient temperature using the defined test mixture(s), but is to be assumed to have a reference pressure increased by the factors given in the table below. Under this alternative, the test pressure for the overpressure type test in 15.1.3.1 shall be 4 times the increased reference pressure. The 1,5 times routine test is not permitted.
-

Minimum ambient temperature °C	Test factor
≥ –20 (see Note)	1,0
≥ –30	1,37
≥ –40	1,45
≥ –50	1,53
≥ –60	1,62

NOTE This covers equipment designed for the standard ambient temperature range specified in IEC 60079-0.

15.1.2.1 Each test consists of igniting an explosive mixture inside the enclosure and measuring the pressure developed by the explosion.

The mixture shall be ignited by one or more ignition sources. However, when the enclosure contains a device which produces sparks capable of igniting the explosive mixture, this device may be used to produce the explosion. (It is nevertheless not necessary to produce the maximum power for which the device is designed.)

The pressure developed during the explosion shall be determined and recorded during each test. The locations of the ignition sources as well as those of the pressure recording devices are left to the discretion of the testing laboratory to find the combination which produces the highest pressure. When detachable gaskets are provided by the manufacturer, these shall be fitted to the enclosure under test.

The number of tests to be made and the explosive mixture to be used, in volumetric ratio with air and at atmospheric pressure, are as follows:

- electrical equipment of group I: three tests with (9,8 ± 0,5) % methane;
- electrical equipment of group IIA: three tests with (4,6 ± 0,3) % propane;
- electrical equipment of group IIB: three tests with (8 ± 0,5) % ethylene;
- electrical equipment of group IIC: three tests with (14 ± 1) % acetylene and three tests with (31 ± 1) % hydrogen.

15.1.2.2 Rotating electrical machines shall be tested at rest and running. When they are tested running, they may be driven either by their own source of power or by an auxiliary motor. The minimum test speed shall be at least 90 % of the maximum rated speed of the machine.

NOTE If the motor is intended to be converter driven, there may be a need for the manufacturer to consider specifying a rated speed to cover present and future converter applications.

All motors shall be tested with at least two transducers, with one located in the end-turn area at each end of the motor. Ignition shall be initiated at each end of the motor, in turn, with the motor both at rest and running. This will result in at least four series of tests. If a termination compartment is provided that is interconnected to the motor and is not sealed, a three transducer setup and additional test series is to be considered.

15.1.2.3 In cases where pressure piling may occur during the test of flameproof enclosures, the tests shall be made at least five times with each gas of 15.1.2.1 for the applicable gas group. For group IIB, they shall afterwards be repeated at least five times with a mixture of (24 ± 1) % hydrogen/methane (85/15).

NOTE 1 There is presumption of pressure-piling when

- either the pressure values obtained during a series of tests, deviate from one to another by a factor of ≥1,5, or
- the pressure rise time is less than 5 ms.

NOTE 2 The need to conduct this repeat testing is based on the principles that (1) when pressure piling is not involved, ethylene will result in worst case representative pressures, and (2) when pressure piling is involved, it will not. Therefore, under this premise, when pressure piling is an issue, the additional testing with the mixture of (24 ± 1) % hydrogen/methane (85/15) is included.

15.1.2.4 Electrical equipment intended to be used in a single specified gas may be tested with the mixture of that gas with air at atmospheric pressure that gives the highest explosion pressure. Such electrical equipment shall then be evaluated not for the corresponding group but only for the gas considered. The restriction of use shall be indicated accordingly, as specified in 29.2 item e) of IEC 60079-0.

Where exclusion of a specific gas or gases is required, the equipment shall be marked "X" in accordance with 29.2 item i) of IEC 60079-0, and specified on the certificate.

Double marking can be applied for a specific gas and for the next lowest group to the group of this gas (for example, IIB + H_2), if the enclosure has been submitted not only to the tests for the specific gas, but also to those necessary for the lower group.

15.1.3 Overpressure test

This test shall be made using either of the following methods, which are considered as equivalent.

For electrical equipment intended for use at an ambient temperature below –20 °C, the overpressure test shall be conducted at a temperature not higher than the minimum ambient temperature. Where the tensile and yield strength properties of the material used are shown by material specifications to not decrease significantly at low temperature, the overpressure test may be conducted at normal room ambient.

15.1.3.1 Overpressure test – First method (static)

The relative pressure applied shall be

- 1,5 times the reference pressure, or
- 4 times the reference pressure for enclosures not subject to routine overpressure testing, or
- at the following pressures, when reference pressure determination has been impracticable due to the small size of the equipment.

Volume cm^3	Group	Pressure kPa
≤10	I, IIA, IIB, IIC	1 000
>10	I	1 000
>10	IIA, IIB	1 500
>10	IIC	2 000

The period of application of the pressure shall be at least 10 s.

The test is made once.

The overpressure test shall be considered satisfactory if the test result is in compliance with 15.1.1 and if there is no leakage through the walls of the enclosure.

15.1.3.2 Overpressure test – Second method (dynamic)

The dynamic tests shall be carried out in such a way that the maximum pressure to which the enclosure is subjected is 1,5 times the reference pressure.

When the test is carried out with mixtures specified in 15.1.2.1, these may be precompressed to produce an explosion pressure of 1,5 times the reference pressure.

The test shall be made once only except for electrical equipment of group IIC for which each test shall be made three times with each gas.

The overpressure test shall be considered satisfactory if the test result is in compliance with 15.1.1.

15.2 Test for non-transmission of an internal ignition

Gaskets (see 5.4) shall be removed. The enclosure is placed in a test chamber. The same explosive mixture is introduced into the enclosure and the test chamber at atmospheric pressure.

The flamepath lengths (engagement) of threaded joints of the test specimen(s) shall be reduced according to Table 6.

The flamepath lengths of spigot, cylindrical and flanged joints of the test specimen(s) shall not be greater than 115 % of the minimum length(s) stated by the manufacturer.

Flanged gaps of spigot joints, where the width of the joint L consists only of a cylindrical part (see Figure 2b) shall be enlarged to values of not less than 1 mm for groups I and IIA, not less than 0,5 mm for group IIB and not less than 0,3 mm for group IIC.

NOTE Gap requirements for the test specimen(s) are included in 15.2.1 (for groups I, IIA and IIB) and in 15.2.2 (for group IIC).

For equipment with flamepaths, other than threaded joints, and intended for use at an ambient temperature above 60 °C, the non-transmission tests shall be conducted under one of the following conditions:

- at a temperature not less than the specified maximum ambient temperature;
- at normal ambient temperature using the defined test mixture at increased pressure according to the factors in Table 7;
- at normal atmospheric pressure and temperature, but with the test gap i_E increased by the factors noted in Table 7.

If enclosures are constructed from different materials with different temperature coefficients, and if this has an influence on the gap dimensions (e.g. in case of a glass window forming a cylindrical gap with a metallic frame), one of the following shall apply for the flame transmission test:

- the calculated maximum gap, $i_{C,T}$, taking into account the maximum constructional gap at 20 °C and the gap enlargement at specified maximum ambient temperature, $T_{a,max}$, shall be verified by increasing the test gap i_E to at least 90 % of the calculated maximum gap at $T_{a,max}$; or
- the calculated maximum gap $i_{C,T}$, taking into account the maximum constructional gap at 20 °C and the gap enlargement at specified maximum ambient temperature $T_{a,max}$, shall be verified by using the defined test mixture at increased pressure according to the formula

$$P_V = (i_{C,T} / i_E) \times (0,9)$$

Table 6 – Reduction in length of a threaded joint for non-transmission test

Type of threaded joint	Reduction in length by			
	Groups I, IIA and IIB (15.2.1)		Group IIC (15.2.2)	
	15.2.1.1	15.2.1.2	15.2.2.1	15.2.2.2
Cylindrical, complying with ISO 965, fit medium or better	No reduction	No reduction	No reduction	No reduction
Cylindrical, with larger tolerances than permitted above	1/3	1/2	1/2	1/3
NPT	No reduction	No reduction	No reduction	No reduction
NOTE For tapered threads, the joint should be tested with the minimum handtight engagement permitted by the thread standard at the extremes of tolerances.				

Table 7 – Test factors to increase pressure or test gap (i_E)

Temperature up to °C	Group I 12,5 % CH_4/H_2	Group IIA 55 % H_2	Group IIB 37 % H_2	Group IIC 27,5 % H_2 7,5 % C_2H_2
60	1,00	1,00	1,00	1,50
70	1,06	1,05	1,04	1,67
80	1,07	1,06	1,05	1,70
90	1,08	1,07	1,06	1,73
100	1,09	1,08	1,06	1,74
110	1,10	1,09	1,07	1,77
120	1,11	1,10	1,08	1,80
125	1,12	1,11	1,09	1,83

IEC 60079-14 limits the installation of equipment employing type of protection "d" that incorporates flanged (flat) joints. Specifically, the flanged joints of such equipment are not permitted to be installed closer to solid objects, not part of the equipment, than the dimensions shown in Table 8, unless the equipment is so tested.

If so tested at distance less than in Table 8, this equipment shall have the minimum distance of obstructions specified on the certificate. Also, the equipment may be marked in accordance with 20.3(c), Table 10.

Table 8 – Minimum distance of obstructions from flameproof "d" flange openings

Gas group	Minimum distance mm
IIA	10
IIB	30
IIC	40

15.2.1 Electrical equipment of groups I, IIA and IIB

15.2.1.1 The gaps i_E of the enclosure shall be at least equal to 90 % of the maximum constructional gap i_C as specified in the manufacturer's drawings ($0,9\ i_C \leq i_E \leq i_C$).

The explosive mixtures to be used, in volumetric ratio with air and at atmospheric pressure, are as follows:

- electrical equipment of group I: (12,5 ± 0,5) % methane-hydrogen [(58 ± 1) % methane and (42 ± 1) % hydrogen] (MESG = 0,8 mm);
- electrical equipment of group IIA: (55 ± 0,5) % hydrogen (MESG = 0,65 mm);
- electrical equipment of group IIB: (37 ± 0,5) % hydrogen (MESG = 0,35 mm).

NOTE The explosive mixtures chosen for this test ensure that the joints prevent the transmission of an internal ignition, with a known margin of safety. This margin of safety, K, is the ratio of the maximum experimental safe gap of the representative gas of the group concerned to the maximum experimental safe gap of the chosen test gas.

- electrical equipment of group I: $K = \frac{1,14}{0,8} = 1,42$ (methane);
- electrical equipment of group IIA: $K = \frac{0,92}{0,65} = 1,42$ (propane);
- electrical equipment of group IIB: $K = \frac{0,65}{0,35} = 1,85$ (ethylene).

Alternatively, if the gaps of a test specimen do not fulfil the above condition, one of the following methods may be used for the type test for non-transmission of an internal ignition:

- a gas/air mixture with a smaller MESG value:

	i_E / i_C	Mixture
Group I	≥0,75	55 % H_2 ± 0,5
	≥0,6	50 % H_2 ± 0,5
Group IIA	≥0,75	50 % H_2 ± 0,5
	≥0,6	45 % H_2 ± 0,5
Group IIB	≥0,75	28 % H_2 ± 1
	≥0,6	28 % H_2 ± 1 at 140 kPa

- precompression of the normal test mixtures according to the following formula:

$$P_k = \frac{i_C}{i_E} \times 0,9$$

where P_k is the precompression factor.

15.2.1.2 If enclosures of groups IIA and IIB could be destroyed or damaged by the test in 15.2.1.1, it is permitted that the test be made by increasing the gaps above the maximum values specified by the manufacturer. The enlargement factor of the gap is 1,42 for group IIA electrical equipment and 1,85 for group IIB electrical equipment. The explosive mixtures to be used in the enclosure and in the test chamber, in volumetric ratio with air and at atmospheric pressure, are as follows:

- electrical equipment of group IIA: (4,2 ± 0,1) % propane;
- electrical equipment of group IIB: (6,5 ± 0,5) % ethylene.

15.2.1.3 The test in 15.2.1.1 or 15.2.1.2 shall be made five times. The test result is considered satisfactory if the ignition is not transmitted to the test chamber.

15.2.2 Electrical equipment of group IIC

The following methods can be used for this test.

NOTE The first and second methods below are equivalent in their factors of safety, 1.5, and the minimum test gap of 90 %. This is accomplished by either increasing the pressure or by increasing the test gap dimension in an equivalent fashion.

15.2.2.1 First method

All gaps of joints other than threaded joints shall be increased to the value

$$1{,}35\ i_C \leq i_E \leq 1{,}5 i_C$$

with a minimum of 0,1 mm for flanged joints

where

i_E is the test gap;

i_C is the maximum constructional gap, as specified on the manufacturer's drawings.

The following explosive mixtures, in volumetric ratio with air and at atmospheric pressure, are to be used in the enclosure and in the test chamber:

- (27,5 ± 1,5) % hydrogen, and
- (7,5 ± 1) % acetylene.

Five tests shall be made with each mixture. If the equipment is intended for use solely with hydrogen or solely with acetylene, the tests shall be made only with the corresponding gas mixture.

NOTE When preparing a test sample employing a cylindrical joint of a shaft gland for a rotating machine with roller element bearings, the test gap i_E is based on the diametrical clearance from Table 1 or Table 2, and not the radial clearance of 8.2.2.

15.2.2.2 Second method

The enclosure shall be tested with a test gap i_E according to the following formula:

$$0{,}9\ i_C \leq i_E \leq i_C$$

The enclosure and the test chamber are filled with one of the gas mixtures specified for the first method at a pressure equal to 1,5 times atmospheric pressure.

The test shall be carried out five times with each explosive mixture.

Alternatively, if the gaps of a test specimen do not fulfil the above condition, the following method may be used.

Precompression of the normal test mixtures according to the following formula:

$$P_k = \frac{i_C}{i_E} \times 1{,}35$$

where P_k is the precompression factor.

NOTE When preparing a test sample employing a cylindrical joint of a shaft gland for a rotating machine with roller element bearings, the test gap i_E is based on the diametrical clearance from Table 1 or Table 2, and not the radial clearance of 8.2.2.

15.2.2.3 Electrical equipment which are a single piece production shall be tested five times with unaltered test gaps and with each of the explosive mixtures specified in 15.2.2.1 at atmospheric pressure and the dimensional requirements of 5.1 apply.

15.3 (Reserved for future use)

15.4 Tests of flameproof enclosures with breathing and draining devices

The tests in accordance with 15.4.1 to 15.4.3 shall be carried out in the following order on a sample after the impact strength test of 10.8.

For devices with non-measurable paths, the maximum bubble test pore size of the sample shall not be less than 85 % of the specified maximum bubble test pore size. See Annex B.

15.4.1 Tests of ability of the enclosure to withstand pressure

The tests shall be made in accordance with 15.1 with the following additions and modifications.

15.4.1.1 For the determination of the explosion pressure in accordance with 15.1.2, breathing and draining devices shall be replaced by solid plugs.

15.4.1.2 For the overpressure test in accordance with 15.1.3, a thin flexible membrane (for example, a thin plastic sheet) shall be fitted to the inner surfaces of the breathing and draining devices. After the overpressure test, the device shall show no permanent deformation or damage likely to affect the type of protection.

15.4.2 Thermal tests

15.4.2.1 Test procedure

The enclosure, with the device(s) fitted, shall be tested in accordance with the method 15.4.3.1 but with the ignition source only in the position giving the most unfavourable thermal results.

The temperature of the external surface of the device(s) shall be monitored during the test. The test shall be carried out five times. The test mixture to be used shall be (4,2 ± 0,1) % propane in volumetric ratio with air and at atmospheric pressure. Additionally, for devices intended for use in acetylene, (7,5 ± 1,0) % acetylene in volumetric ratio with air and at atmospheric pressure shall be used.

In an enclosure where there is the possibility of a forced or induced flow of a potentially dangerous gas, the enclosure shall be arranged during the tests so that the gas can flow through the device(s) and the enclosure.

Any ventilation or sampling system shall be operated as specified in the manufacturer's documentation. After each of the five tests, the external explosive mixture shall be maintained for a sufficient time to allow any continuous burning on the face of the device to become evident (for example, for at least 10 min so as to increase the temperature of the external surface of the device or to make heat transfer to the outer face possible).

15.4.2.2 Acceptance criterion

No continuous burning shall be observed. No flame transmission shall occur. The measured external surface temperature rise of the device shall be multiplied by a safety factor of 1,2 for the determination of the temperature class of the electrical equipment.

15.4.3 Test for non-transmission of an internal ignition

This test shall be made in accordance with 15.2 with the following additions and modifications.

15.4.3.1 Test procedure

An ignition source shall be placed first close to the inner surface of the breathing and draining device and subsequently in one or more places if a high peak explosion pressure and rate of rise of pressure at the face of the device is likely to occur. Where the enclosure has more than one identical device, the device to be tested shall be that which gives the most unfavourable results. The test mixture within the enclosure shall be ignited. The test shall be made five times for each position of the ignition source.

15.4.3.2 Non-transmission test for breathing and draining devices

For breathing and draining devices of groups I, IIA and IIB the non-transmission test of 15.2.1 shall be applied.

For breathing and draining devices of group IIC with measurable paths, 15.2.2 and either 15.4.3.2.1 or 15.4.3.2.2 shall be applied. For breathing and draining devices of group IIC with non-measurable paths, 15.4.3.2.1 or 15.4.3.2.2 shall be applied.

15.4.3.2.1 Method A

For devices intended for use only in hydrogen, only the test with the hydrogen/air mixture is required. The tests are carried out five times with each test mixture. The tests are made according to 15.2.2.2 and 15.4.3.1.

15.4.3.2.2 Method B

The use of this method involves limitation of the range of group IIC gases covered. The restriction of use shall be indicated accordingly, as specified in 29.2 item e) of IEC 60079-0.

Where exclusion of a specific gas or gases is required, the equipment shall be marked "X" in accordance with 29.2 item i) of IEC 60079-0, and specified on the certificate.

Carbon disulphide is excluded for enclosures with a volume greater than 100 cm^3.

The test mixtures to be used consist of the following, in volumetric ratio and at atmospheric pressure:

a) (40 ± 1) % hydrogen, (20 ± 1) % oxygen and the rest nitrogen;

b) (10 ± 1) % acetylene, (24 ± 1) % oxygen and the rest nitrogen.

The tests shall be carried out five times with each test mixture, in accordance with 15.4.3.1.

For devices intended for use only in hydrogen, only test mixture a) is to be used.

15.4.3.3 Acceptance criterion

The test result is considered satisfactory if no ignition is transmitted to the test chamber.

16 Routine tests

16.1 The following routine tests are intended to ensure that the enclosure withstands the pressure and also that it contains no holes or cracks connecting to the exterior.

The routine tests include an overpressure test made according to one of the methods described for the type tests in 15.1.3. For equipment intended for use at an ambient temperature below –20 °C, a pressure test at normal ambient temperature is sufficient.

16.1.1 The routine overpressure test may be made by the first method even when the overpressure type test has been made by the second method.

When the determination of the reference pressure has been impracticable and when a dynamic test involves a risk to the enclosed equipment (windings, etc.), the static pressures to be applied are as follows:

Volume cm^3	Group	Pressure kPa
≤10	I, IIA, IIB, IIC	1 000
>10	I	1 000
>10	IIA, IIB	1 500
>10	IIC	2 000

16.1.2 When the second method is chosen, the routine test consists of

- either an explosion test with, inside and outside the enclosure, the appropriate explosive mixture specified in 15.1.2 (for the determination of explosion pressure) at 1,5 times atmospheric pressure,
- or a dynamic overpressure test as described in 15.1.3.2 for type tests, followed by a non-transmission test with explosive mixtures as specified in 15.2.1.2 or 15.2.2.1 (test for non-transmission of an internal ignition, with enlarged gaps) inside and outside the enclosure at atmospheric pressure,
- or a dynamic overpressure test as described in 15.1.3.2 for type tests, followed by a static test at a pressure of at least 200 kPa.

16.1.3 For the routine test, it is sufficient to test the enclosure empty. However, if the routine test is dynamic and the enclosed equipment influences the pressure rise during an internal explosion, the test conditions shall address this influence.

The individual parts of a flameproof enclosure (for example, cover and base) can be tested separately. The test conditions shall be such that the stresses are comparable to those to which these parts are exposed in the complete enclosure.

16.2 Routine tests are not required for enclosures with a volume less than or equal to 10 cm^3. This exception also applies to enclosures with a volume greater than 10 cm^3 when the prescribed type test has been made at a static pressure equal to four times the reference pressure. However, enclosures of welded construction shall in every case be submitted to the routine test.

For enclosures where reference pressure measurement is impractical, exemption from routine pressure testing shall not apply.

Routine tests are not required for bushings not specific to one flameproof enclosure, if the assembly procedure is sufficiently documented (see C.2.1.4).

16.3 The routine tests are considered satisfactory if

- the enclosure withstands the pressure without suffering permanent deformation of the joints or damage to the enclosure, and
- when the test has been made by the dynamic followed by the static tests of 16.1.2, there is no leakage through the walls of the enclosure or, if tested dynamically, there is no transmission of an internal ignition.

17 Switchgear for group I

Group I flameproof enclosures which are to be opened from time to time on site, for example, for adjustment purposes or for resetting of protection relays, and which contain remotely operated switching devices in which circuits can be made or broken by a separate influence (e.g. mechanical, electrical, electro-optical, pneumatic, acoustic, magnetic, or thermal) when this influence is not applied manually to the equipment itself, and which produce in-service arcs or sparks capable of igniting an explosive mixture, shall comply with the following requirements.

17.1 Means of isolation

All accessible conductors, except those of intrinsically safe circuits complying with IEC 60079-11 and those for bonding or earthing, shall be capable of being isolated from the supply before the opening of the flameproof enclosure.

The means of isolation of these flameproof enclosures shall be in accordance with 17.1.1, 17.1.2 or 17.1.3.

17.1.1 The means of isolation shall be fitted inside the flameproof enclosure, in which case the parts which remain energized after the means of isolation has been opened shall either

- be protected by one of the standard types of protection listed in IEC 60079-0, or
- have clearances and creepage distances between phases and to earth in accordance with the requirements of IEC 60079-7, and be protected by an enclosure that provides a degree of protection of at least IP20 according to IEC 60529, arranged so that a tool cannot contact the energized parts through any openings. This does not apply to parts of intrinsically safe circuits complying with IEC 60079-11 which remain energized.

In either case, a marking per 20.2(c), Table 9, shall be provided on the cover protecting the parts which remain energized.

17.1.2 The means of isolation shall be fitted inside another enclosure complying with one of the standard types of protection listed in IEC 60079-0.

17.1.3 The means of isolation shall consist of a plug and socket or a cable coupler complying with the requirements of 13.3.

17.2 Doors or covers

17.2.1 Quick-acting doors or covers

These doors or covers shall be mechanically interlocked with an isolator so that

17.2.1.1 the enclosure retains the properties of the flameproof enclosure, type of protection "d", as long as the isolator is closed and

17.2.1.2 the isolator can only be closed when these doors or covers ensure the properties of the flameproof enclosure, type of protection "d".

17.2.2 Doors or covers fixed by screws

These doors or covers shall bear a marking per 20.2(c), Table 9.

17.2.3 Threaded doors or covers

These doors or covers shall bear a marking per 20.2(c), Table 9.

18 Lampholders and lamp caps

The following requirements apply to lampholders and lamp caps which together have to form a flameproof enclosure, type of protection "d", so that they may be used in luminaires of increased safety, type of protection "e".

18.1 Device preventing lamps working loose

The device which prevents lamps working loose, required in IEC 60079-7, increased safety "e", may be omitted for threaded lampholders provided with a quick-acting switch in a flameproof enclosure, type of protection "d", which breaks all poles of the lamp circuit before contact separation.

18.2 Holders and caps for lamps with cylindrical caps

18.2.1 Holders and caps for tubular fluorescent lamps shall comply with the dimensional requirements of data sheets Fa6 of IEC 60061.

18.2.2 For other holders, the requirements of Clause 5 shall apply, but the width of the flameproof joint between the holder and the cap shall be at least 10 mm at the moment of contact separation.

18.3 Holders for lamps with threaded caps

18.3.1 The threaded part of the holder shall be of a material which is resistant to corrosion under the likely conditions of service.

18.3.2 At the moment of contact separation when unscrewing the lamp, at least two complete turns of the thread shall be engaged.

18.3.3 For threaded lampholders E26/E27 and E39/E40, electrical contact shall be established by spring-loaded contact elements. In addition, for electrical equipment of group IIB or IIC, the making and breaking of contact during insertion and removal of the lamp shall take place within a flameproof enclosure, type of protection "d", of group IIB or IIC, respectively.

NOTE For threaded lampholders E10 and E14, the requirements of 18.3.3 are not necessary.

19 Non-metallic enclosures and non-metallic parts of enclosures

The following requirements apply to non-metallic enclosures and non-metallic parts of enclosures, except for

- sealing rings of cable glands or conduit sealing devices; and
- non-metallic parts on which the type of protection does not depend.

19.1 (Reserved for future use)

19.2 Special constructional requirements

19.2.1 Resistance to tracking and creepage distances on internal surfaces of the enclosure walls

When an enclosure or a part of an enclosure of non-metallic material serves directly to support live bare parts, the resistance to tracking and the creepage distances on the internal surfaces of the walls of the enclosure shall comply with the requirements of IEC 60079-7.

However, for enclosures of electrical equipment of group I which may be subjected to electrical stresses capable of producing arcs in air and which result from rated currents of more than 16 A, the requirements stated in 12.6 shall be observed.

19.3 Supplementary requirements for type tests

The type tests according to IEC 60079-0 shall be supplemented by the tests indicated in 19.3.1 and 19.3.2.

19.3.1 Tests for flameproofness

19.3.1.1 Test procedure

The tests for flameproofness shall be made in the following order as detailed in 19.3.1.2 through 19.3.1.4.

19.3.1.2 Tests of ability of the enclosure to withstand pressure

Reference pressure determination as specified in 15.1.2 may be performed on a sample not previously subjected to the tests of enclosures in IEC 60079-0.

Overpressure testing as specified in 15.1.3 shall be performed on all of the samples previously subjected to the tests of enclosures in IEC 60079-0.

19.3.1.3 Test of erosion by flame

This test only applies to enclosures of volume greater than 50 cm^3 and of which the flameproof joints have at least one face of plastic material.

This testing may be performed on a sample not previously subjected to the tests of enclosures in IEC 60079-0. The sample shall be prepared as described in 15.2, except that gaps of flanged joints and plane parts of spigot joints shall be set to a value between 0,1 mm and 0,15 mm.

For bushings which are common to two adjacent flameproof enclosures, the test shall be carried out in the enclosure giving the worst conditions.

The test consists of 50 ignitions of the explosive mixture specified in 15.1.2.1 for the corresponding group. In the case of electrical equipment of group IIC, 25 ignitions shall be made with each of the two explosive mixtures specified in 15.1.2.1.

The test is judged satisfactory if the following test for non-transmission is satisfactory.

19.3.1.4 Test for non-transmission of an internal ignition

This test shall be carried out as specified in 15.2, and may be performed on a sample not previously subjected to the tests of enclosures in IEC 60079-0.

19.3.2 Flammability

The test shall be carried out only for enclosures, or parts of enclosures, of plastic materials. The test shall be in accordance with IEC 60695-11-10 (Method V-2).

20 Marking

20.1 General

Flameproof enclosures "d" shall be marked in accordance with IEC 60079-0 with the following additional marking for the type of protection "d".

20.2 Caution and warning markings

Where any of the following markings are required, the text as described in Table 9, following the word "CAUTION" or "WARNING," may be replaced by technically equivalent text or symbols. Multiple warnings may be combined into one equivalent warning.

Table 9 – Text of caution or warning markings

	Reference	Caution or warning marking
20.2(a)	11.3, 11.4	"CAUTION – USE FASTENERS WITH YIELD STRESS ≥ (VALUE)", where the (value) is determined by the applicable testing
20.2(b)	13.3.4	"WARNING – DO NOT SEPARATE WHEN ENERGIZED"
20.2(c)	17.1.1, 17.2.2, 17.2.3	"WARNING – DO NOT OPEN WHEN ENERGIZED"
20.2(d)	E.3.2	"WARNING – DO NOT OPEN WHEN AN EXPLOSIVE GAS ATMOSPHERE IS PRESENT"

20.3 Informative markings

Where any of the following markings are required, the text as described in Table 10 may be replaced by technically equivalent text or symbols. Multiple warnings may be combined into one equivalent warning.

Table 10 – Text of informative markings

	Reference	Informative marking
20.3(a)	13	Identification of thread size and type, e.g. "½ NPT", "M25"
20.3(b)	13	"SEE INSTALLATION INSTRUCTION DOCUMENT"
20.3(c)	15.2	"THIS EQUIPMENT SHALL BE INSTALLED SO THAT THE FLANGED JOINT(S) ARE NOT WITHIN (VALUE) OF A SOLID OBJECT THAT IS NOT PART OF THIS EQUIPMENT" where the (value) is determined by the proximity of the solid object during flame transmission testing, with the tested values less than those stated in Table 8
20.3(d)	D.3.8	"EMPTY ENCLOSURE WITH Ex COMPONENT CERTIFICATE"

Annex A
(normative)

Additional requirements for crimped ribbon elements and multiple screen elements of breathing and draining devices

A.1 Crimped ribbon elements and multiple screen elements shall be constructed from cupro-nickel, stainless steel or other metal found suitable for the application. Aluminium, titanium, magnesium and their alloys shall not be used.

NOTE See 10.2 for limits on copper content.

A.2 Where the paths through the device can be specified in the drawings and measured in the complete device, an upper and lower tolerance limit for the path dimensions shall be specified and monitored in production.

A.3 Where Clause A.2 does not apply, the relevant requirements of Annex B shall apply.

A.4 The type tests of 15.4.3 shall be carried out with samples manufactured with not less than 90 % of the largest permitted gap dimensions.

Annex B
(normative)

Additional requirements for elements, with non-measurable paths, of breathing and draining devices

B.1 Sintered metal elements

B.1.1 Sintered metal elements shall be constructed from one of the following:

- stainless steel;
- 90/10 copper-tin bronze;
- a specific metal or specific alloy found suitable for the application. Aluminium, titanium, magnesium and their alloys shall not be used.

NOTE See 10.2 for limits on copper content.

B.1.2 The maximum bubble test pore size shall be determined by the method specified in ISO 4003.

B.1.3 The density of the sintered metal element shall be determined in accordance with ISO 2738.

B.1.4 Where determination of open porosity and/or fluid permeability of elements is required in connection with functional aspects of devices, measurements shall be made in accordance with ISO 2738 and ISO 4022.

B.1.5 Sintered metal elements shall be clearly identified in the documentation by declaring

- the material in accordance with 10.2 and B.1.1,
- the maximum bubble test pore size in micrometers in accordance with B.1.2,
- the minimum density in accordance with B.1.3,
- the minimum thickness,
- where appropriate, the fluid permeability and open porosity in accordance with B.1.4.

B.2 Pressed metal wire elements

B.2.1 Pressed metal wire elements shall be constructed from stainless steel wire braid or another specified metal found suitable for the application.

NOTE See 10.2 for limits on copper content.

Aluminium, titanium, magnesium and their alloys shall not be used. Manufacture shall start from a wire braid which is compressed in a die to form an homogeneous matrix.

B.2.2 In order to evaluate the density, the wire diameter shall be specified. Information shall also be given on the mass, length of wire braid, thickness of the element, and mesh size. The ratio between the mass of the element and the mass of an identical volume of the same solid metal shall be between 0,4 and 0,6.

B.2.3 The maximum bubble test pore size shall be determined by the method specified in ISO 4003.

B.2.4 The density of the element shall be determined in accordance with ISO 2738.

B.2.5 Where determination of open porosity and/or fluid permeability is required in connection with functional aspects of elements, measurements shall be made in accordance with ISO 2738 and ISO 4022.

B.2.6 Metal wire elements shall be clearly identified in the documentation by declaring

- the material in accordance with 10.2 and B.2.1,
- the maximum bubble test pore size in micrometers in accordance with B.2.3,
- the minimum density in accordance with B.2.4,
- the dimensions, including tolerances,
- the original wire diameter,
- where appropriate, the fluid permeability and open porosity in accordance with B.2.5.

B.3 Metal foam elements

B.3.1 Metal foam elements shall be produced by coating a reticulated polyurethane foam with nickel, removing the polyurethane by thermal decomposition, converting the nickel into a nickel-chrome alloy, for example, by gaseous diffusion, and compressing the material as necessary.

B.3.2 Metal foam elements shall contain at least 15 % chromium by mass.

B.3.3 The maximum bubble test pore size shall be determined by the method specified in ISO 4003.

B.3.4 The density of the element shall be determined in accordance with ISO 2738.

B.3.5 Where determination of open porosity and/or fluid permeability is required in connection with functional aspects of elements, measurements shall be made in accordance with ISO 2738 and ISO 4022.

B.3.6 Metal foam elements shall be clearly defined in the documentation by declaring

- the material, in accordance with 10.2, B.3.1 and B.3.2,
- the maximum bubble test pore size in micrometers in accordance with B.3.3,
- the minimum thickness,
- the minimum density,
- where appropriate, the open porosity and fluid permeability in accordance with B.3.5.

Annex C
(normative)

Additional requirements for flameproof entry devices

C.1 General

This annex contains specific requirements which apply, in addition to those in IEC 60079-0, to the construction and testing of flameproof entry devices. Entry devices include cable glands, conduit sealing devices, Ex blanking elements, Ex thread adaptors, and bushings.

C.2 Constructional requirements

C.2.1 Sealing methods

C.2.1.1 Cable glands and conduit sealing devices with elastomeric sealing rings

C.2.1.1.1 If a cable gland or conduit sealing device can accept any sealing ring with the same outside diameter but with different internal dimensions, the ring shall have a minimum uncompressed axial sealing height (i.e. gap length) between the body of the gland and sealing ring and between the sealing ring and the cable of

- 20 mm, for circular cables of diameter not greater than 20 mm, and for non-circular cables of perimeter not greater than 60 mm,
- 25 mm, for circular cables of diameter greater than 20 mm, and for non-circular cables of perimeter greater than 60 mm.

C.2.1.1.2 If a cable gland or conduit sealing device can accept only one specific elastomeric sealing ring, this ring shall have a minimum uncompressed axial sealing height of 5 mm between body of gland and sealing ring and between cable and sealing ring.

C.2.1.2 Cable glands sealed with setting compound

The minimum length of the compound shall be 20 mm when installed.

The manufacturer shall specify:

- the maximum diameter over cores of the cable that the gland is intended to accept;
- the maximum numbers of cores that can pass through the compound.

These specified values shall ensure that, throughout the required 20 mm compound length, at least 20 % of that cross-sectional area is filled with compound.

The cable gland shall be capable of being fitted and removed from electrical equipment without disturbing the compound seal after the specified curing period of the compound.

The filling compound and appropriate installation instructions shall be provided with the cable gland.

C.2.1.3 Conduit sealing devices with setting compound

The minimum length of the compound shall be 20 mm when installed.

The manufacturer shall specify the maximum numbers of cores that can pass through the compound.

These specified values shall ensure that, throughout the required 20 mm compound length, at least 20 % of that cross-sectional area is filled with compound.

The filling compound and appropriate installation instructions shall be provided with the conduit sealing device.

C.2.1.4 Bushings

Bushings may contain one or more conductors. When they are correctly assembled and mounted in the walls of the enclosure, all joint widths, gaps or cemented joints shall conform with the relevant requirements of Clauses 5, 6 and C.2.2.

When the bushing is formed by moulding insulation on metallic parts, the requirements of 5.2, 5.3 and 5.4 do not apply, but Clause 6 is applicable. The insulation material itself can contribute to the mechanical strength of the enclosure.

When the bushing includes parts assembled with adhesive, this is considered as a cement if it complies with the requirements of Clause 6. Should this not be the case, the requirements of 5.2.1, 5.3 and 5.4 are applicable.

The parts of bushings outside the flameproof enclosure shall be protected in accordance with IEC 60079-0.

Bushings specific to a flameproof enclosure shall satisfy the type tests and routine tests for that enclosure.

Bushings not specific to one flameproof enclosure shall be submitted to a type test for resistance to pressure carried out by means of a static pressure test as specified in 15.1.3.1 at the following values:

- 2 000 kPa for electrical equipment of group I;
- 3 000 kPa for electrical equipment of group II.

These bushings shall be subject to a routine pressure test as specified in 16.1, except where the assembly procedure used is described in the manufacturer's documentation and is such as to ensure consistency in the manufactured products.

C.2.2 Threads

Threads forming a flameproof joint shall comply with the relevant requirements of 5.3.

For male metric threads intended for installation in a threaded entry of a flameproof equipment, the threaded part shall be at least 8 mm in length and comprise at least eight full threads. If the thread is provided with an undercut, then a non-detachable and non-compressible washer or equivalent device shall be fitted to ensure the required length of thread engagement.

NOTE The requirement for at least eight full threads is to ensure that at least five full threads will be engaged when the cable gland is installed in a threaded entry of a flameproof equipment – taking into account the presence of any chamfer or undercut (see Clause 13).

C.2.3 Constructional requirements for Ex blanking elements

C.2.3.1 Ex blanking elements having male metric threads shall comply with one or more of the requirements of 11.9. Ex blanking elements having male NPT threads shall be as type 22b (Figure 22) and with the external surface located at L1 (–0 +1/4).

NOTE This requirement is intended to address concerns over entry into the enclosure by maintaining the outer surface of the blanking elements as close to the enclosure as possible.

C.2.3.2 All parallel threads shall comply with the relevant requirements of C.2.2.

C.2.4 Constructional requirements for Ex thread adapters

C.2.4.1 All threads shall comply with the relevant requirements of C.2.2.

C.2.4.2 The threads of Ex thread adapters shall be co-axial.

C.2.4.3 The length and internal volume of Ex thread adapters shall be kept to the minimum necessary for good construction.

C.3 Type tests

C.3.1 Sealing test

The requirements for thermal endurance to heat and thermal endurance to cold prescribed in IEC 60079-0 shall be applied on samples assembled according to the manufacturer's instructions either with a mandrel or a cable as required.

C.3.1.1 Cable glands and conduit sealing devices with sealing ring

These tests shall be carried out using, for each type of cable gland or conduit sealing device, one sealing ring from each of the different permitted sizes. In the case of elastomeric sealing rings, each ring is mounted on a clean, dry, polished mild steel cylindrical mandrel of diameter, equal to the smallest cable diameter permissible in the ring, as specified by the manufacturer of the cable gland or conduit sealing device.

In the case of metallic or composite sealing rings, each ring is mounted on the metal sheath of a clean dry sample of cable, of diameter equal to the smallest diameter permissible in the ring, as specified by the manufacturer of the cable gland or conduit sealing device.

In the case of sealing rings for non-circular cables, each ring is mounted on a clean dry sample of cable, of perimeter equal to the smallest value permitted in the ring, as specified by the manufacturer of the cable gland or conduit sealing device.

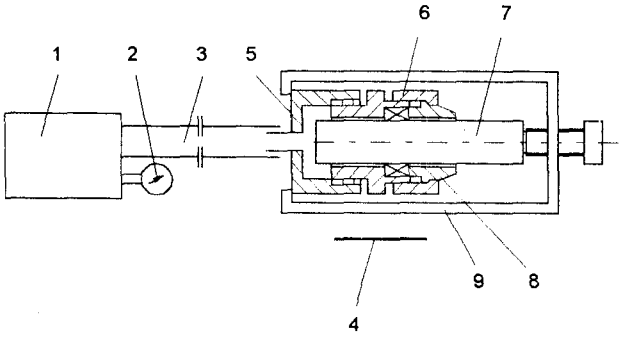
The assembly is then fitted into the entry and a torque is applied to the screws (in the case of a flanged compression device) or to the nut (in the case of a screwed compression device) to obtain a seal under a hydraulic pressure of 2 000 kPa for group I and 3 000 kPa for group II.

NOTE 1 The torque figures referred to in the preceding paragraph may be determined experimentally prior to the tests, or they may be supplied by the manufacturer of the cable gland or conduit sealing device.

The assembly is then mounted into a hydraulic testing device using coloured water or oil as the liquid, the principle of which is illustrated in Figure C.1. The hydraulic circuit is then purged. The hydraulic pressure is then gradually increased.

The sealing is considered satisfactory if the blotting paper is free from any trace of leakage when the pressure has been maintained at 2 000 kPa for group I or 3 000 kPa for group II, for at least 10 s.

NOTE 2 It may be necessary to seal all the joints of the cable gland or conduit sealing device mounted in the test device, other than those associated with the sealing ring under test. When a sample of metal-sheathed cable is used, it may be necessary to avoid the application of pressure to the ends of the conductors or to the interior of the cable.



Components

1 hydraulic pump
2 pressure gauge
3 hose
4 blotting paper
5 adapter
6 sealing ring
7 mandrel/metal-sheathed cable
8 compression component
9 retaining clamp

Figure C.1 – Device for the sealing tests for cable glands

C.3.1.2 Cable glands sealed with setting compound

For each size of cable gland, the test shall be carried out using metal mandrels, the number and diameter of which equate to the maximum diameter over cores with the maximum number of cores specified by the manufacturer in accordance with the requirements of C.2.1.2.

The setting compound is prepared following the manufacturer's instructions and then introduced into the appropriate volume. It is allowed to harden for the appropriate time.

The assembly is then mounted into the hydraulic testing device, defined in C.3.1.1 above, and the same procedure is applied. The acceptance criteria are also the same.

C.3.1.3 Conduit sealing devices sealed with setting compound

For each size of conduit sealing device, the test shall be carried out using metal mandrels, the number and diameter of which equate to the maximum number of cores specified by the manufacturer in accordance with the requirements of C.2.1.3.

The setting compound is prepared following the manufacturer's instructions and then introduced into the appropriate volume. It is allowed to harden for the appropriate time.

The assembly is then mounted into the hydraulic testing device, defined in C.3.1.1 above, and the same procedure is applied. The acceptance criteria are also the same.

C.3.2 Test of mechanical strength

C.3.2.1 Cable glands with a threaded compression element

A torque of twice that required in the sealing test shall be applied to the compression element; however, the value of this torque, expressed in Nm, shall always be at least three times the value in millimetres of the maximum permissible cable diameter when the cable gland is designed for circular cables or equal to the value in millimetres of the maximum permissible cable perimeter when the cable gland is designed for non-circular cables.

The cable gland is then dismantled and its parts are examined.

C.3.2.2 Cable glands with a compression element fixed by screws

A torque of twice that required in the sealing test shall be applied to the compression element screws; however, the value of this torque shall always be at least equal to the following values:

M6:	10 Nm	M12:	60 Nm
M8:	20 Nm	M14:	100 Nm
M10:	40 Nm	M16:	150 Nm

The cable gland is then dismantled and its parts are examined.

C.3.2.3 Cable glands sealed with setting compound

In the case of threaded glands, a torque in Nm equal to the minimum value specified in C.3.2.1 shall be applied to the gland when screwed into a steel test block having a suitable threaded hole.

The cable gland is then dismantled and its parts are examined.

C.3.2.4 Acceptance criteria

The tests C.3.2.1 to C.3.2.3 shall be considered to be satisfactory if no damage is found to any of the parts of the cable gland.

NOTE Any damage to the sealing ring may be disregarded, as the test is intended to show that the mechanical strength of the cable gland is sufficient to withstand the conditions of use.

C.3.3 Type tests for Ex blanking elements

C.3.3.1 Torque test

A sample Ex blanking element of each size shall be screwed into a test-block containing a threaded entry hole of size and form appropriate to the device under test. The sample shall be tightened to a torque at least equivalent to the appropriate torque given in column 2 of Table C.1, using a suitable tool. The test shall be deemed to be satisfactory if the correct thread engagement has been achieved and if, when dismantled, no damage is found, except of failure of the shearable neck of a type 22c plug which is required. Type 22b plugs shall be capable of being removed only by the appropriate tool.

Blanking elements of type 22b shall then be subjected to a further test at a torque at least equivalent to the appropriate torque given in column 3 of Table C.1, and shall be deemed to be satisfactory if the lip has not pulled fully into the thread.

C.3.3.2 Over-pressure test

The blanking element shall be submitted to a type test for resistance to pressure carried out by means of a static pressure test as specified in 15.1.3.1 at the following values:

- 2 000 kPa for electrical equipment of group I;
- 3 000 kPa for electrical equipment of group II.

C.3.4 Type tests for Ex thread adapters

C.3.4.1 Torque test

A sample Ex thread adapter of each size shall be screwed into a test-block, containing a threaded entry of size and form appropriate to the device under test. A steel or brass threaded plug of appropriate form and size shall be screwed into the entry in the adapter.

The plug shall be tightened to a torque at least equivalent to the torque given in column 2 of Table C.1, appropriate to the larger of the two threads on the adapter. The test shall be deemed to be satisfactory if no deformation to the adapter is found when the assembly is dismantled.

C.3.4.2 Impact test

A sample Ex thread adapter of each size shall be screwed into a test-block, containing a threaded entry hole of size and form appropriate to the device under test. A solid steel or brass bar of appropriate diameter, threaded at one end to suit the entry in the adapter and of a length so that it protrudes one entry diameter, subject to a minimum of 50 mm, shall then be screwed into the adapter with a torque at least equivalent to the appropriate torque specified in Column 2 of Table C.1. The assembly shall then be subjected to a test of resistance to impact, according to the appropriate requirements given in IEC 60079-0. The impact shall be applied at right angles to the axis of the bar and as near to the end of the bar as practicable.

C.3.4.3 Over-pressure test

The thread adapter shall be submitted to a type test for resistance to pressure carried out by means of a static pressure test as specified in 15.1.3.1 at the following values:

- 2 000 kPa for electrical equipment of group I;
- 3 000 kPa for electrical equipment of group II.

Table C.1 – Tightening torque values

Thread size mm	Tightening torque for torque and impact tests Nm	Tightening torque for type 22b stopping plugs Nm
16	40	65
20	40	65
25	55	95
32	65	110
40	80	130
50	100	165
63	115	195
75	140	230
>75	2d [a]	3,5 d [a]

[a] The variable *d* is the major diameter of thread in millimetres.

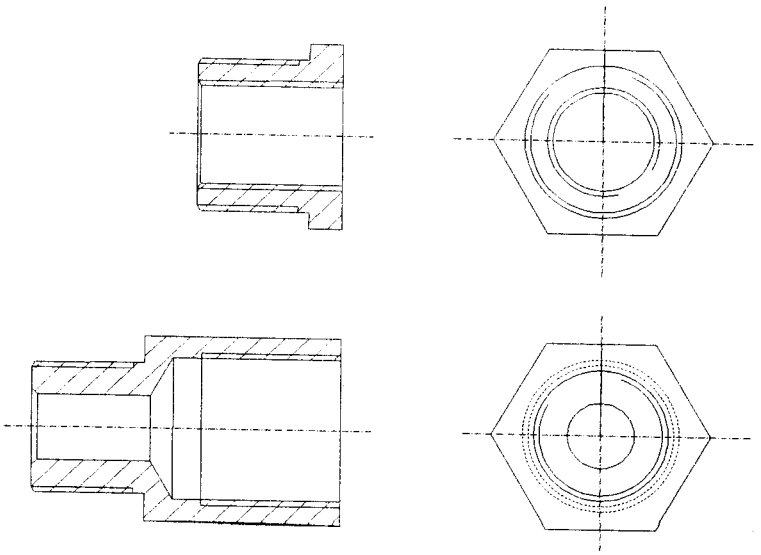


Figure C.2 – Examples of Ex thread adapters

Annex D
(normative)

Empty flameproof enclosures as Ex components

D.1 General

The purpose of an Ex component enclosure certificate for empty enclosures is to enable a manufacturer of flameproof enclosures to obtain a certificate without the internal equipment being defined, so as to enable the empty enclosure to be made available to third parties for incorporation into a full equipment certificate without the need for repetition of all the type tests. When a certificate concerning the full equipment is required, an Ex component enclosure certificate for the empty enclosure is not necessary.

D.2 Introductory remarks

The requirements for an Ex component enclosure certificate for an empty enclosure are contained in this annex. This does not eliminate the need for a subsequent equipment certificate, but it is intended to facilitate such a certificate.

The Ex component enclosure manufacturer shall be responsible for ensuring that each and every unit supplied

a) is identical in construction with the original design as detailed in the documents mentioned in the Ex component enclosure certificate,

b) has been subjected to such routine overpressure testing as is required, and

c) meets the requirements of the applicable schedule of limitations imposed by the Ex component enclosure certificate.

D.3 Ex component enclosure requirements

D.3.1 Ex component enclosures shall comply with the requirements, as applicable, of IEC 60079-0 and of this standard.

D.3.2 Ex component enclosures shall consist of a basically simple geometry of only square, rectangular, or cylindrical cross-section with taper not exceeding 10 %.

NOTE When major dimensions exceed any other dimension by 4:1 for group I, IIA and IIB, or exceed any other dimension by 2:1 for group IIC, additional considerations may be necessary.

D.3.3 Enclosures for rotating machines shall not be evaluated as Ex component enclosures.

NOTE "Machines" are taken to mean electric motors which substantially fill the enclosure.

D.3.4 Ex component enclosures shall be provided with adequate means for the mounting and location of internal components.

D.3.5 No holes, whether for mechanical or electrical purposes, and whether blind or clear, shall be drilled in the Ex component enclosure other than those permitted by the Ex component enclosure certificate.

D.3.6 For Group I, IIA and IIB Ex component enclosures, the reference pressure is determined according to 15.1.2, with modifications to the test sample as follows:

- when no major dimension exceeds any other major dimension by more than 2:1, no modification is needed;
- for all other permitted constructions, a solid obstruction (baffle plate) of approximately 80 % of the cross-sectional area shall be located centrally on the minor axis, and located approximately two-thirds of the way along the major axis. The solid obstruction shall reasonably replicate the cross-section of the enclosure.

For group IIC Ex component enclosures, the reference pressure is determined according to 15.1.2, with a solid obstruction (baffle plate) of approximately 60 % of the cross-sectional area located centrally on the minor axis, and located approximately two-thirds of the way along the major axis. The solid obstruction shall reasonably replicate the cross-section of the enclosure.

When the sample is required to be modified by inclusion of the solid obstruction, ignition sources and pressure recording devices shall be positioned on both sides of the solid obstruction to simultaneously measure the resultant pressures.

D.3.7 Ex component enclosures shall withstand an overpressure type test with the maximum number of apertures of the maximum sizes at a pressure which shall be equal to 1,5 times the peak explosion pressure (reference pressure) measured according to 15.1.2 with the Ex component enclosure empty, and with the entries closed by suitable means.

Routine tests are not required for Ex component enclosures when the prescribed type test has been made at a static pressure of four times the reference pressure. However, Ex component enclosures of welded construction shall, in every case, be submitted to the routine test.

The routine test shall consist of either a dynamic test with, inside and outside the Ex component enclosure, the appropriate explosive mixture specified in 15.1.2 (for the determination of explosion pressure) at a pressure of 1,5 times atmospheric pressure; or a static test at a pressure of at least 350 kPa and not less than 1,5 times the reference pressure.

D.3.8 The Ex component enclosures shall be permanently marked internally according to the applicable requirements. The marking shall be per 20.3(d), Table 10.

The marking shall also include the requirements for marking of Ex components given in IEC 60079-0.

This marking may be omitted if the Ex component enclosure manufacturer is also the holder of the equipment certificate.

D.3.9 Provision shall be made for the mounting of external marking as for an electrical equipment according to IEC 60079-0.

D.3.10 The following information shall be given in the Ex component enclosure certificate as part of the schedule of limitations as follows:

- the maximum number of apertures, their maximum sizes and their positions shall be addressed through direct statement or reference to a drawing number;
- rotating machines, or other devices which create turbulence, shall not be incorporated;
- oil-filled circuit-breakers and contactors shall not be used;
- (if other than -20 °C to +40 °C) the ambient range;

- (for group I, IIA and IIB Ex component enclosures) the content of the Ex component enclosure equipment may be placed in any arrangement, provided that an area of at least 20 % of each cross-sectional area remains free to permit an unimpeded gas flow and, therefore, unrestricted development of an explosion. Separate relief areas may be aggregated provided that each area has a minimum dimension in any direction of 12,5 mm;
- (for group IIC Ex component enclosures) the content of the Ex component enclosure equipment may be placed in any arrangement provided that an area of at least 40 % of each cross-sectional area remains free to permit unimpeded gas flow and, therefore, unrestricted development of an explosion. Separate relief areas may be aggregated provided that each area has a minimum dimension in any direction of 12,5 mm; and
- any additional limitation required for the particular construction, e.g. maximum operating temperature of the window.

D.4 Utilization of an Ex component enclosure certificate to prepare an equipment certificate

D.4.1 Procedure

Enclosures which have an Ex component enclosure certificate may be considered for incorporation in equipment certificates with IEC 60079-0 and this standard, normally without repetition of application of those requirements already applied to the Ex component enclosure, subject to compliance with the schedule of limitations detailed in D.3.10.

Documents shall be prepared for an equipment certificate depicting the specified equipment, any permitted substitutions or omissions, together with the mounting conditions within the Ex component enclosure, so that compliance can be verified with the schedule of limitations of the Ex component enclosure certificate.

Any hole permitted in accordance with the Ex component enclosure certificate may be provided either by the Ex component enclosure manufacturer, or through agreement between the equipment manufacturer and the Ex component enclosure manufacturer.

D.4.2 Application of the schedule of limitations

In addition to compliance with the schedule of limitations, all application issues shall be considered and determined to comply with the applicable requirements of IEC 60079-0 and this standard.

Annex E
(normative)

Cells and batteries used in flameproof "d" enclosures

E.1 Introductory remarks

This annex contains the requirements for electrical equipment protected by type of protection "d" flameproof enclosures which contains one or more cells used as batteries to provide electrical power to circuits.

Irrespective of the type of electrochemical cell used, the main objective shall be to prevent a flammable mixture of electrolytic gases (usually hydrogen and oxygen) from occurring inside the flameproof enclosure. With this in mind, cells and batteries which are likely to release electrolytic gas in normal use (either by natural venting or by a pressure relief valve) shall not be used inside the flameproof enclosure.

NOTE It is not intended that these requirements be applied to an electrochemical cell used as a measurement device, (e.g. a zinc/oxygen cell per IEC 60086-1, Type A, used for measurement of oxygen concentration).

E.2 Acceptable electrochemical systems

Only those cells listed in Tables E.1 and E.2 below for which IEC cell standards exist shall be used.

Table E.1 – Acceptable primary cells

IEC 60086-1 type	Positive electrode	Electrolyte	Negative electrode	Nominal voltage V	Max. open circuit voltage V
–	Manganese dioxide	Ammonium chloride, zinc chloride	Zinc	1,5	1,73
A	Oxygen	Ammonium chloride, zinc chloride	Zinc	1,4	1,55
C	Manganese dioxide	Organic electrolyte	Lithium	3,0	3,7
E	Thionyl chloride ($SOCl_2$)	Non-aqueous inorganic	Lithium	3,6	3,9
L	Manganese dioxide	Alkali metal hydroxide	Zinc	1,5	1,65
S	Silver oxide (Ag_2O)	Alkali metal hydroxide	Zinc	1,55	1,63
T	Silver oxide (AgO, Ag_2O)	Alkali metal hydroxide	Zinc	1,55	1,87
[a]	Sulphur dioxide	Non-aqueous organic salt	Lithium	3,0	3,0
[a]	Mercury	Alkali metal hydroxide	Zinc	(data awaited)	(data awaited)
NOTE Zinc/manganese dioxide cells are listed in IEC 60086-1, but not classified by a type letter.					
[a] May only be used if an IEC cell standard exists.					

Table E.2 – Acceptable secondary cells

Relevant IEC standards/type	Type	Electrolyte	Nominal voltage	Max. open circuit voltage
			V	V
Type K IEC 61951-1 IEC 60623 IEC 60662	Nickel-cadmium	Potassium hydroxide (SGI.3)	1,2	1,55
[a]	Lithium	Non-aqueous organic salt	(data awaited)	(data awaited)
IEC 61951-2	Nickel metal hydride	Potassium hydroxide	1,2	1,5
[a] May only be used if an IEC cell standard exists.				

E.3 General requirements for cells (or batteries) inside flameproof enclosures

E.3.1 The following restrictions of use shall apply to certain types of cells:

- vented or open secondary cells shall not be used to form a battery inside flameproof enclosures;
- sealed valve regulated cells may be used inside a flameproof enclosure; but for discharge purposes only;
- subject to the requirements of Clause E.5, sealed gas tight secondary cells may be recharged inside flameproof enclosures.

E.3.2 Flameproof enclosures containing a battery shall be marked per 20.2(d), Table 9.

This need not apply when the battery and its associated connected circuits conform to IEC 60079-11 and the battery is not recharged in service.

E.3.3 Batteries and their associated safety devices shall be securely mounted (e.g. held in place by a purpose designed clip or bracket).

E.3.4 There shall be no relative movement between the battery and the associated safety device or devices such as would impair conformity with the requirements of the type of protection concerned.

NOTE Conformity with E.3.3 and E.3.4 should be checked before and after the tests of enclosures required by IEC 60079-0.

E.4 Arrangement of safety devices

E.4.1 Prevention of excessive temperature and cell damage

E.4.1.1 Under short-circuit discharge conditions, batteries shall either meet both conditions below, or be fitted with a safety device, as described in E.4.1.2:

- the external surface temperature of the cell or battery shall not exceed the continuous operating temperature specified by the cell or battery manufacturer, taking into account the local ambient temperature within the enclosure, and
- the maximum discharge current shall not exceed that specified by the cell or battery manufacturer.

E.4.1.2 Where the two conditions in E.4.1.1 above cannot be achieved, a safety device is required which shall comply with the requirements for infallible components as defined in IEC 60079-11, and be located as close to the cell or battery terminal as is reasonably practicable, and be either

- a resistor or current-limiting device, which limits the current to the maximum continuous withdrawal current specified by the battery manufacturer, or
- a fuse conforming with IEC 60127, selected so that the fusing characteristic prevents the maximum withdrawal current and allowable duration specified by the battery manufacturer from being exceeded. Where the fuse is of the replaceable type a label shall be provided adjacent to the fuse holder, specifying the type of fuse to be used.

E.4.2 Prevention of cell polarity reversal or reverse charging by another cell in the same battery

E.4.2.1 Where batteries are used having

- a capacity of 1,5 Ah or less (at a 1 h discharge rate), and
- a volume less than 1 % of the free volume of the enclosure,

no additional protection need be fitted to prevent the release of electrolytic gas by polarity reversal, or reverse charging of a cell by other cells in the same battery.

NOTE *These relaxations should* not be interpreted as allowing the release of electrolytic gas from such cells.

E.4.2.2 Where batteries are used having a capacity and/or volume which exceed the above values, arrangements shall be incorporated to prevent cell polarity reversal or reverse charging of a cell by others within the battery.

Two examples of how this may be achieved are given in below:

- monitoring the cell voltage across a cell (or a few cells) and cutting off the supply if the voltage decreases below the minimum voltage specified by the cell manufacturer;

  NOTE 1 Such protection is often used to prevent cells going into a state of "deep discharge". If an attempt is made to monitor too many cells connected in series, the protection may not function reliably due to tolerances in individual cell voltages and the protection circuit. Generally no more than six cells (in series) should be monitored by one protection unit.

- using shunt diodes connected so as to limit the reverse polarity voltage across each cell. For example, the protective arrangement for a battery of three cells connected in series is as shown in Figure E.1.

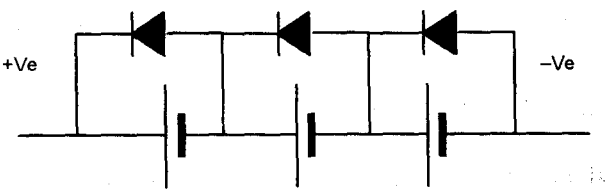


Figure E.1 – Fitting of diode arrangement for three cells in series

For this protective arrangement to be effective, the forward voltage drop across each diode used to prevent reverse charging of a cell shall not exceed the safe reverse charge voltage of that cell.

NOTE 2 Silicon diodes are considered suitable to meet this requirement.

E.4.3 Prevention of inadvertent charging of a battery by other voltage sources in the enclosure

Where there is another voltage source in the same enclosure (including other batteries), the battery and its associated circuits shall be protected against charging by other than the circuit specifically designed to do so. For example:

- separating the battery and its associated circuits from all other voltage source(s) inside the enclosure, using the clearance and creepage distances specified in IEC 60079-7 for the highest voltage capable of causing the contamination; or
- separating the battery and its associated circuits from all other voltage source(s) inside the enclosure, by an earthed metal barrier/screen capable of carrying the maximum fault current of the source for the time that it is likely to exist (taking account of any circuit protection provided, e.g. fuses, earth fault protection); or
- separating the battery only, from the other voltage source(s) using the clearance and creepage distances specified in IEC 60079-7, but with blocking diodes fitted as shown in Figure E.2 below, so arranged as to reduce the risk of a single fault causing both diodes to be short-circuited.

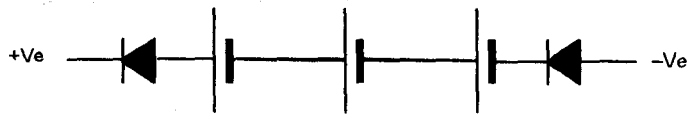


Figure E.2 – Fitting of blocking diodes to meet E.4.3 (third example)

The requirements of the examples in E.4.3 do not apply to circuits connected to a battery for the purpose of creating a voltage reference point or to a charging supply intended to recharge a secondary battery in accordance with Clause E.5.

E.5 Recharging of secondary cells inside flameproof enclosures

E.5.1 Only "K" type, sealed gas tight nickel-cadmium, as listed in Table E.2, shall be recharged inside flameproof enclosures. Nickel-metal hydride cells may be recharged only when an IEC cell standard exists.

E.5.2 Where cells or batteries are to be charged whilst inside the flameproof enclosure, the charging conditions shall be fully specified in the manufacturer's documents and safety devices shall be fitted to ensure that these conditions are not exceeded.

E.5.3 The charging arrangements shall be such as to prevent reverse charging.

E.5.4 Where batteries are used having

- a capacity of 1,5 Ah or less, and
- a volume less than 1 % of the free volume of the enclosure,

no additional safety device(s) needs to be fitted to the battery to prevent the release of electrolytic gas by recharging currents.

NOTE 1 These relaxations should not be interpreted as allowing the release of electrolytic gas from such cells.

NOTE 2 The above effectively limits the use of cells (or batteries) not fitted with a safety device, to those types commonly known as "button type cells" used, for example, inside flameproof enclosures to retain memory on programmable electronic circuits.

E.5.5 Where batteries are used having a capacity and/or volume exceeding the above values, recharging is only allowed within the flameproof enclosure if the battery is fitted with a

safety device(s) arranged to cut off the charging current and prevent the production and possible release of electrolytic gas, if the voltage of any cell within the battery exceeds the maximum voltage specified by the cell manufacturer for this purpose.

E.6 Rating of protection diodes and reliability of protection devices

E.6.1 The voltage rating of a protection diode fitted to comply with E.4.2 shall be not less than the maximum open circuit voltage of the battery.

E.6.2 The voltage rating of the series blocking diodes fitted to comply with E.4.3 (third example) shall be not less than the maximum peak voltage inside the flameproof enclosure.

E.6.3 The current rating of the protection diodes shall be not less than the maximum discharge current as limited by the arrangement in E.4.1.

E.6.4 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 integrity of the control system is consistent with the level of safety required by this standard.

Annex F
(informative)

Mechanical properties for screws and nuts

When applying the requirements of 11.3, the following information may prove useful.

Table F.1 – Mechanical properties for screws and nuts

Fastener material	Property class	Nominal tensile strength MPa	Minimum tensile strength MPa	Nominal yield stress MPa	Minimum yield stress MPa
Carbon steel	3.6	300	330	180	190
Carbon steel	4.6	400	400	240	240
Carbon steel	4.8	400	420	320	340
Carbon steel	5.6	500	500	300	300
Carbon steel	5.8	500	520	400	420
Carbon steel	6.8	600	600	480	480
Carbon steel	8.8 ≤ M16	800	800	640	640
Carbon steel	8.8 > M16	800	830	640	660
Carbon steel	9.8	900	900	720	720
Carbon steel	10.9	1000	1040	900	940
Carbon steel	12.9	1200	1220	1080	1100
Stainless steel (austenitic)	A*-50		500		210
Stainless steel (austenitic)	A*-70		700		450
Stainless steel (austenitic)	A*-80		800		600
Stainless steel (martensitic)	C*-50		500		250
Stainless steel (martensitic)	C*-70		700		410
Stainless steel (martensitic)	C*-80		800		640
Stainless steel (martensitic)	C*-110		1100		820
Stainless steel (ferritic)	F1-45		450		250
Stainless steel (serritic)	F1-60		600		410
NOTE For stainless steel property class A and C above, the "*" shown is replaced by a property grade numeral.					

Annex G
(informative)

Introduction of an alternative risk assessment method encompassing "equipment protection levels' for Ex equipment

G.0 Introduction

This annex provides an explanation of the concept of a risk assessment method encompassing equipment protection levels (EPLs). These EPLs are introduced to enable an alternative approach to current methods of selecting Ex equipment.

G.1 Historical background

Historically, it has been acknowledged that not all types of protection provide the same level of assurance against the possibility of an incendive condition occurring. The installation standard, IEC 60079-14, allocates specific types of protection to specific zones, on the statistical basis that the more likely or frequent the occurrence of an explosive atmosphere, the greater the level of security required against the possibility of an ignition source being active.

Hazardous areas (with the normal exception of coal mining) are divided into zones, according to the degree of hazard. The degree of hazard is defined according to the probability of the occurrence of explosive atmospheres. Generally, no account is taken of the potential consequences of an explosion, nor of other factors such as the toxicity of materials. A true risk assessment would consider all factors.

Acceptance of equipment into each zone is historically based on the type of protection. In some cases the type of protection may be divided into different levels of protection which again historically correlate to zones. For example, intrinsic safety is divided into levels of protection ia and ib. The encapsulation "m" standard includes two levels of protection "ma" and "mb"

In the past, the equipment selection standard has provided a solid link between the type of protection for the equipment and the zone in which the equipment can be used. As noted earlier, nowhere in the IEC system of explosion protection is there any account taken of the potential consequences of an explosion, should it occur.

However, plant operators often make intuitive decisions on extending (or restricting) their zones in order to compensate for this omission. A typical example is the installation of "zone 1 type" navigation equipment in zone 2 areas of offshore oil production platforms, so that the navigation equipment can remain functional even in the presence of a totally unexpected prolonged gas release. On the other hand, it is reasonable for the owner of a remote, well secured, small pumping station to drive the pump with a "zone 2 type" motor, even in zone 1, if the total amount of gas available that might explode is small and the risk to life and property from such an explosion can be discounted.

The situation became more complex with the publication of the first edition of IEC 60079-26 which introduced additional requirements to be applied for equipment intended to be used in zone 0. Prior to this, Ex ia was considered to be the only technique acceptable in zone 0.

It has been recognized that it is beneficial to identify and mark all products according to their inherent ignition risk. This would make equipment selection easier and provide the ability to better apply a risk assessment approach, where appropriate.

G.2 General

A risk assessment approach for the acceptance of Ex equipment has been introduced as an alternative method to the current prescriptive and relatively inflexible approach linking equipment to zones. To facilitate this, a system of equipment protection levels has been introduced to clearly indicate the inherent ignition risk of equipment, no matter what type of protection is used.

The system of designating these equipment protection levels is as follows.

G.2.1 Coal mining (group I)

G.2.1.1 EPL Ma

Equipment for installation in a coal mine, having a "very high" level of protection, which has sufficient security that it is unlikely to become an ignition source, even when left energized in the presence of an outbreak of gas.

NOTE Typically, communication circuits and gas detection equipment will be constructed to meet the Ma requirements, for example an Ex ia telephone circuit.

G.2.1.2 EPL Mb

Equipment for installation in a coal mine, having a "high" level of protection, which has sufficient security that it is unlikely to become a source of ignition in the time span between there being an outbreak of gas and the equipment being de-energized.

NOTE Typically, all the coal winning equipment will be constructed to meet the Mb requirements, for example Ex d motors and switchgear.

G.2.2 Gases (group II)

G.2.2.1 EPL Ga

Equipment for explosive gas atmospheres, having a "very high" level of protection, which is not a source of ignition in normal operation, expected faults or when subject to rare faults.

G.2.2.2 EPL Gb

Equipment for explosive gas atmospheres, having a "high" level of protection, which is not a source of ignition in normal operation or when subject to faults that may be expected, though not necessarily on a regular basis.

NOTE The majority of the standard protection concepts bring equipment within this equipment protection level.

G.2.2.3 EPL Gc

Equipment for explosive gas atmospheres, having an "enhanced" level of protection, which is not a source of ignition in normal operation and which may have some additional protection to ensure that it remains inactive as an ignition source in the case of regular expected occurrences (for example failure of a lamp).

NOTE Typically, this will be Ex n equipment.

G.2.3 Dusts (group III)

G.2.3.1 EPL Da

Equipment for combustible dust atmospheres, having a "very high" level of protection, which is not a source of ignition in normal operation or when subject to rare faults.

G.2.3.2 EPL Db

Equipment for combustible dust atmospheres, having a "high" level of protection, which is not a source of ignition in normal operation or when subject to faults that may be expected, though not necessarily on a regular basis.

G.2.3.3 EPL Dc

Equipment for combustible dust atmospheres, having an "enhanced" level of protection, which is not a source of ignition in normal operation and which may have some additional protection to ensure that it remains inactive as an ignition source in the case of regular expected occurrences.

For the majority of situations, with typical potential consequences from a resultant explosion, it is intended that the following would apply for use of the equipment in zones (this is not directly applicable for coal mining, as the zone concept does not generally apply). See Table G.1.

Table G.1 – Traditional relationship of EPLs to zones (no additional risk assessment)

Equipment protection level	Zone
Ga	0
Gb	1
Gc	2
Da	20
Db	21
Dc	22

G.3 Risk of ignition protection afforded

The various levels of protection of equipment must be capable of functioning in conformity with the operational parameters established by the manufacturer to that level of protection.

Table G.2 – Description of risk of ignition protection provided

Protection afforded	Equipment protection level Group	Performance of protection	Conditions of operation
Very high	Ma Group I	Two independent means of protection, or safe even when two faults occur independently of each other	Equipment remains functioning when explosive atmosphere present
Very high	Ga Group II	Two independent means of protection, or safe even when two faults occur independently of each other	Equipment remains functioning in zones 0, 1 and 2
Very high	Da Group III	Two independent means of protection, or safe even when two faults occur independently of each other	Equipment remains functioning in zones 20, 21 and 22
High	Mb Group I	Suitable for normal operation and severe operating conditions	Equipment de-energized when explosive atmosphere present
High	Gb Group II	Suitable for normal operation and frequently occurring disturbances or equipment where faults are normally taken into account	Equipment remains functioning in zones 1 and 2
High	Db Group III	Suitable for normal operation and frequently occurring disturbances or equipment where faults are normally taken into account	Equipment remains functioning in zones 21 and 22
Enhanced	Gc Group II	Suitable for normal operation	Equipment remains functioning in zone 2
Enhanced	Dc Group III	Suitable for normal operation	Equipment remains functioning in zone 22

G.4 Implementation

The 4th edition of IEC 60079-14 (encompassing the former requirements of IEC 61241-14) will introduce the EPLs to allow a system of "risk assessment" as an alternative method for the selection of equipment. Reference will also be included in the classification standards IEC 60079-10 and IEC 61241-10.

The additional marking and the correlation of the existing types of protection are being introduced into the revisions to the following IEC standards:

- IEC 60079-0 (encompassing the former requirements of IEC 61241-0)
- IEC 60079-1
- IEC 60079-2 (encompassing the former requirements of IEC 61241-4)
- IEC 60079-5
- IEC 60079-6
- IEC 60079-7
- IEC 60079-11 (encompassing the former requirements of IEC 61241-11)
- IEC 60079-15
- IEC 60079-18 (encompassing the former requirements of IEC 61241-18)

- IEC 60079-26
- IEC 60079-28

For the types of protection for explosive gas atmospheres the EPLs require additional marking. For explosive dust atmospheres the present system of marking the zones on equipment is being replaced by marking the EPLs.

Bibliography

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IEC 60050-426, *International Electrotechnical Vocabulary (IEV) – Chapter 426: Electrical apparatus for explosive atmospheres*

IEC 60079 (all parts), *Explosive atmospheres*

IEC 60079-2, *Electrical apparatus for explosive gas atmospheres – Part 2: Pressurized enclosures "p"*

IEC 60079-5, *Electrical apparatus for explosive gas atmospheres – Part 5: Powder filling "q"*

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

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IEC 61241-0, *Electrical apparatus for use in the presence of combustible dust – Part 0: General requirements*

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IEC 61241-10, *Electrical apparatus for use in the presence of combustible dust – Part 10: Classification of areas where combustible dusts are or may be present*

IEC 61241-11, *Electrical apparatus for use in the presence of combustible dust – Part 11: Protection by intrinsic safety "iD"*

IEC 61241-18, *Electrical apparatus for use in the presence of combustible dust – Part 18: Protection by encapsulation "mD"*

IEC 61508 (all parts), *Functional safety of electrical/electronic/programmable electronic safety-related systems*

ISO 31-0:1992, *Quantities and units – Part 0: General principles*

ISO 468:1982, *Surface roughness – Parameters, their values and general rules for specifying requirements* (withdrawn 1998)

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