

इंटरनेट

मानक

Disclosure to Promote the Right To Information

Whereas the Parliament of India has set out to provide a practical regime of right to information for citizens to secure access to information under the control of public authorities, in order to promote transparency and accountability in the working of every public authority, and whereas the attached publication of the Bureau of Indian Standards is of particular interest to the public, particularly disadvantaged communities and those engaged in the pursuit of education and knowledge, the attached public safety standard is made available to promote the timely dissemination of this information in an accurate manner to the public.

“जानने का अधिकार, जीने का अधिकार”

Mazdoor Kisan Shakti Sangathan

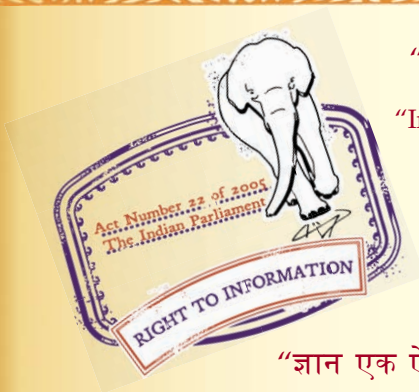
“The Right to Information, The Right to Live”

“पुराने को छोड़ नये के तरफ”

Jawaharlal Nehru

“Step Out From the Old to the New”

IS/IEC 60079-15 (2005): Electrical apparatus for explosive gas atmospheres, Part 15: Construcation, test and marking of type of protection 'n' electrical apparatus [ETD 22: Electrical Apparatus for Explosive Atmosphere]



“ज्ञान से एक नये भारत का निर्माण”

Satyanarayan Gangaram Pitroda

“Invent a New India Using Knowledge”



“ज्ञान एक ऐसा खजाना है जो कभी चुराया नहीं जा सकता है”

Bhartrhari—Nitiśatakam

“Knowledge is such a treasure which cannot be stolen”

BLANK PAGE



भारतीय मानक

विस्फोटी गैस पर्यावरणों के लिए बिजली के उपकरण

भाग 15 संरक्षण “n” श्रेणी के विद्युत उपकरणों का निर्माण, परीक्षण और टाइप की मार्किंग

Indian Standard

ELECTRICAL APPARATUS FOR EXPLOSIVE GAS ATMOSPHERES

**PART 15 CONSTRUCTION, TEST AND MARKING OF TYPE OF PROTECTION “n”
ELECTRICAL APPARATUS**

ICS 29.260.20

© BIS 2007

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

October 2007

Price Group 16

NATIONAL FOREWORD

This Indian Standard (Part 15) which is identical with IEC 60079-15 : 2005 'Electrical apparatus for explosive gas atmospheres — Part 15: Construction, test and marking of type of protection "n" electrical apparatus' 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.

This Indian Standard supersedes IS 8289 : 1976 'Electrical equipment with type of protection "n"'. This adoption has been undertaken to harmonize it with IEC 60079-15 : 2005.

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:

<i>International Standard</i>	<i>Corresponding Indian Standard</i>	<i>Degree of Equivalence</i>
IEC 60034-5 (2006) Rotating electrical machines — Part 5: Degrees of protection provided by the integral design of rotating electrical machines (IP code) — Classification	IS 4691 : 1985 Degrees of protection provided by enclosure for rotating electrical machinery (<i>first revision</i>)	Technically Equivalent
IEC 60061 (all parts) Lamp caps and holders together with gauges for the control of interchangeability and safety	IS 9206 : 1979 Dimensions of caps for tungsten filament general service electric lamps	do
IEC 60068-2-27 (1987) Environmental testing — Part 2: Tests — Test Ea and guidance: Shock	IS 9000 (Part 7/Sec 1) : 1979 Basic environmental testing procedures for electronic and electrical items: Part 7 Impact test, Section 1 Shock (Test Ea)	do
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 (2003) Electrical apparatus for explosive gas atmospheres — Part 1: Flameproof enclosures "d"	IS/IEC 60079-1 : 2003 Electrical apparatus for explosive gas atmospheres: Part 1 Flameproof enclosures "d"	do

<i>International Standard</i>	<i>Corresponding Indian Standard</i>	<i>Degree of Equivalence</i>
IEC 60079-11 (1999) ¹⁾ Electrical apparatus for explosive gas atmospheres — Part 11: Intrinsic safety "i"	IS 5780 : 2002 Electrical apparatus for explosive gas atmospheres — Intrinsic safety "i" — Specification (<i>second revision</i>)	Identical
IEC 60079-17 (2002) Electrical apparatus for explosive gas atmospheres — Part 17: Inspection and maintenance of electrical installations in hazardous areas (other than mines)	IS/IEC 60079-17 : 2002 Electrical apparatus for explosive gas atmospheres: Part 17 Inspection and maintenance of electrical installations in hazardous areas (other than mines)	do
IEC 60081 (2002) Double-capped fluorescent lamps — Performance specifications	IS 2418 (Part 1) : 1977 Tubular fluorescent lamps for general lighting service: Part 1 Requirements and tests (<i>first revision</i>)	Technically Equivalent
IEC 60112 (2003) 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 (<i>first revision</i>)	do
IEC 60155 (1993) Glow-starters for fluorescent lamps	IS 2215 : 2006 Starters for fluorescent lamps (<i>third revision</i>)	do
IEC 60238 (2004) Edison screw lampholders	IS 10276 (Part 1) : 1982 Edison screw lampholders: Part 1 Requirements and tests IS 10276 (Part 2) : 1982 Edison screw lampholders: Part 2 Standard data sheets for lampholders and gauges	do
IEC 60269-3 (2006) Low-voltage fuses — Part 3: Supplementary requirements for fuses for use by unskilled persons (fuses mainly for household and similar applications) — Examples of standardized systems of fuses A to F	IS 8187 : 1976 D-type fuses	do
IEC 60400 (2004) Lampholders for tubular fluorescent lamps and starterholders	IS 3324 : 1982 Holders for starters for tubular fluorescent lamps (<i>first revision</i>)	do
IEC 60529 (2001) Degrees of protection provided by enclosures (IP Code)	IS 12063 : 1987 Classification of degrees of protection provided by enclosures of electrical equipment	do
IEC 60598-1 (2006) Luminaires — Part 1: General requirements and tests	IS 10322 (Part 1) : 1982 Luminaires: Part 1 General requirements IS 10322 (Part 2) : 1982 Luminaires: Part 2 Constructional requirements	do
IEC 60598-2-1 (1979) Luminaires — Part 2: Particular requirements — Section 1: Fixed general purpose luminaire	IS 10322 (Part 5/Sec 1) : 1985 Luminaires: Part 5 Particular requirements, Section 1 General purpose luminaires	do

¹⁾ Since revised in 2006.

<i>International Standard</i>	<i>Corresponding Indian Standard</i>	<i>Degree of Equivalence</i>
IEC 60598-2-2 (1997) Luminaires — Part 2: Particular requirements — Section 2: Recessed luminaires	IS 10322 (Part 5/Sec 2) : 1985 Luminaires: Part 5 Particular requirements, Section 2 Recessed luminaires	Technically Equivalent
IEC 60598-2-3 (2002) Luminaires — Part 2: Particular requirements — Section 3 Luminaires for road and street lighting	IS 10322 (Part 5/Sec 3) : 1985 Luminaires: Part 5 Particular requirements, Section 3 Luminaires for road and street lighting	do
IEC 60664-1(2002) Insulation coordination for equipment within low-voltage systems — Part 1: Principles, requirements and tests	IS 15382 (Part 1) : 2003 Insulation coordination for equipment within low-voltage systems: Part 1 Principles, requirements and tests	Identical
IEC 60927 (2004) Auxiliaries for lamps — Starting devices (other than glow starters) — Performance requirements	IS 12449 (Part 2) : 1988 Starting devices (other than glow starters): Part 2 Performance requirements	Technically Equivalent
IEC 61048 (2006) Auxiliaries for lamps — Capacitors for use in tubular fluorescent and other discharge lamp circuits — General and safety requirements	IS 1569 : 1976 Capacitors for use in tubular fluorescent high pressure mercury and low pressure sodium vapour discharge lamp circuits (<i>first revision</i>)	do
IEC 61184 (1997) Bayonet lampholders	IS 1258 : 2005 Bayonet lampholders (<i>fourth revision</i>)	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:

<i>International Standard</i>	<i>Title</i>
IEC 60034-1 (2004)	Rotating electrical machines — Part 1: Rating and performance
IEC 60034 (all parts)	Rotating electrical machines
IEC 60034-7	Rotating electrical machines — Part 7: Classification of type of construction, mounting arrangements and terminal box position (IM Code)
IEC 60034-25	Rotating electrical machines — Part 25: Guide for the design and performance of cage induction motors specifically designed for converter supply
IEC 60998-2-4:1993	Connecting devices for low-voltage circuits for household and similar purposes — Part 2-4: Particular requirements for twist-on connecting devices
IEC 61347-1	Lamp controlgear — Part 1: General and safety requirements
IEC 61347-2-1	Lamp controlgear — Part 2-1: Particular requirements for starting devices (other than glow starters)
IEC 61347-2-2	Lamp controlgear — Part 2-2: Particular requirements for d.c. or a.c. supplied electronic step-down convertors for filament lamps
IEC 61347-2-3	Lamp controlgear — Part 2-3: Particular requirements for a.c. supplied electronic ballasts for fluorescent lamps
IEC 61347-2-4	Lamp controlgear — Part 2-4: Particular requirements for d.c. supplied electronic ballasts for general lighting

<i>International Standard</i>	<i>Title</i>
IEC 61347-2-7	Lamp controlgear — Part 2-7: Particular requirements for d.c. supplied electronic ballasts for emergency lighting
IEC 61347-2-8	Lamp controlgear — Part 2-8: Particular requirements for ballasts for fluorescent lamps
IEC 61347-2-9	Lamp controlgear — Part 2-9: Particular requirements for ballasts for discharge lamps (excluding fluorescent lamps)
EN 50262	Metric cable glands for electrical installations

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

*Indian Standard***ELECTRICAL APPARATUS FOR EXPLOSIVE GAS
ATMOSPHERES****PART 15 CONSTRUCTION, TEST AND MARKING OF TYPE OF PROTECTION "n"
ELECTRICAL APPARATUS****1 Scope**

This part of IEC 60079 specifies requirements for the construction, testing and marking for Group II electrical apparatus with type of protection, "n" intended for use in explosive gas atmospheres.

This part is applicable to non-sparking electrical apparatus and also to electrical apparatus with parts or circuits producing arcs or sparks or having hot surfaces which, if not protected in one of the ways specified in this standard, could be capable of igniting a surrounding explosive gas atmosphere. This standard describes several different methods by which this can be achieved which may be combined with other methods described in IEC 60079-0.

This part supplements the general requirements in IEC 60079-0. The relationship of IEC 60079-0 to this part is as indicated in Table 1.

Table 1 – Relationship of this part to IEC 60079-0

Clause of IEC 60079-0		IEC 60079-0 clause application to IEC 60079-15				
		Type of protection nC	Non sparking apparatus nA and nA nL	Restricted breathing apparatus nR	Energy limited apparatus nL	Associated energy limited apparatus [nL] and [Ex nL]
4	Apparatus grouping and temperature classification	Yes	Yes	Yes	Yes	Yes
5	Temperatures					
5.1	Environmental influences	Yes	Yes	Yes	Yes	Yes
5.2	Service temperature	Yes	Yes	Yes	Yes	Yes
5.3	Maximum surface temperature	Yes	Yes	Yes	Yes	No
5.4	Surface temperature and ignition temperature	No	No	No	No	No
5.5	Small components	Yes	Yes	Yes	Yes	No
6	Requirements for all electrical apparatus					
6.1	General	Yes	Yes	Yes	Yes	Yes
6.2	Mechanical strength of apparatus	Yes	Yes	Yes	Yes ^{c)}	No
6.3	Opening times	No	No	Yes	No	No
6.4	Circulating currents	Yes	Yes	Yes	No	No
6.5	Gasket retention	Yes	Yes	Yes	Yes	No

Clause of IEC 60079-0		IEC 60079-0 clause application to IEC 60079-15				
		Type of protection nC	Non sparking apparatus nA and nA nL	Restricted breathing apparatus nR	Energy limited apparatus nL	Associated energy limited apparatus [nL] and [Ex nL]
7	Non-metallic enclosures and non-metallic parts of enclosures					
7.1	General	Yes	Yes	Yes	Yes	No
7.2	Thermal endurance	Yes	Yes	Yes	Yes	No
7.3	Electrostatic charges on external non-metallic materials of enclosures	Yes	Yes	Yes	Yes	No
7.4	Threaded holes	Yes	Yes	Yes	Yes	No
8	Enclosures containing light metals					
8.1	Material composition	Yes	Yes	Yes	Yes	No
8.2	Threaded holes	Yes	Yes	Yes	Yes	No
9	Fasteners					
9.1	General	Yes	Yes	Yes	Yes	No
9.2	Special fasteners	No	No	No	No	No
9.3	Holes for special fasteners	No	No	No	No	No
10	Interlocking devices	No	No	No	No	No
11	Bushings	Yes	Yes	Yes	Yes	No
12	Materials used for cementing	No	No	No	No	No
13	Ex components	No	No	No	No	No
14	Connection facilities and terminal compartments	No	No	No	No	No
15	Connection facilities for earthing or bonding conductors	Yes	Yes	Yes	Yes	No
16	Entries into enclosures	Yes	Yes	Yes	Yes	No
17	Supplementary requirements for rotating electrical machines	No	Yes	No	No	No
18	Supplementary requirements for switchgear	Yes	Yes	Yes	No	No
19	Supplementary requirements for fuses	No	No	No	No	No
20	Supplementary requirements for plugs and sockets	No	No	No	No	No
21	Supplementary requirements for luminaires	No	No	No	No	No
22	Supplementary requirements for cap lights and handlights	Yes	Yes	Yes	No	No
23	Apparatus incorporating cells and batteries	Yes	Yes	Yes	Yes	No
24	Documentation	Yes	Yes	Yes	Yes	Yes

Clause of IEC 60079-0		IEC 60079-0 clause application to IEC 60079-15				
		Type of protection nC	Non sparking apparatus nA and nL	Restricted breathing apparatus nR	Energy limited apparatus nL	Associated energy limited apparatus [nL] and [Ex nL]
25	Compliance of prototype or sample with documents	Yes	Yes	Yes	Yes	Yes
26	Type tests					
26.1	General	Yes	Yes	Yes	Yes	Yes
26.2	Test configuration	Yes	Yes	Yes	Yes	Yes
26.3	Tests in explosive test mixtures	Yes	Yes	Yes	Yes	Yes
26.4	Tests of enclosures					
26.4.1	Order of tests	No	No	No	No	No
26.4.2	Resistance to impact	Yes	Yes	Yes	Yes	No
26.4.3	Drop test	Yes	Yes	Yes	Yes	No
26.4.4	Acceptance criteria for test for resistance to impact and drop test	Yes	Yes	Yes	Yes	No
26.4.5	Degree of protection IP by enclosures	No	No	No	No	No
26.5	Thermal tests					
26.5.1	Temperature measurement	Yes	Yes	Yes	Yes	No
26.5.2	Thermal shock test	Yes	Yes	Yes	Yes	No
26.5.3	Small component ignition test	Yes	Yes	No	Yes	No
26.6	Torque test for bushings	Yes	Yes	Yes	Yes	Yes
26.6.1	Procedure	Yes	Yes	Yes	Yes	Yes
26.6.2	Acceptance criteria	Yes	Yes	Yes	Yes	Yes
26.7	Non-metallic enclosures or of non-metallic parts of enclosures					
26.7.1	General	Yes	Yes	Yes	Yes	No
26.7.2	Temperatures during tests	Yes	Yes	Yes	Yes	No
26.8	Thermal endurance to heat	Yes	Yes	Yes	Yes	No
26.9	Thermal endurance to cold	Yes	Yes	Yes	Yes	No
26.10	Resistance to light	Yes	Yes	Yes	Yes	No
26.11	Resistance to chemical agents for Group I electrical apparatus	No	No	No	No	No
26.12	Earth continuity	Yes	Yes	Yes	Yes	No
26.13	Surface resistance test of parts of enclosures of non-metallic materials	Yes	Yes	Yes	Yes	No
26.14	Charging tests to verify the inability to store a dangerous charge	Yes	Yes	Yes	Yes	No

Clause of IEC 60079-0		IEC 60079-0 clause application to IEC 60079-15				
		Type of protection nC	Non sparking apparatus nA and nA nL	Restricted breathing apparatus nR	Energy limited apparatus nL	Associate d energy limited apparatus [nL] and [Ex nL]
26.15	Measurement of capacitance to verify the inability to store a dangerous charge	Yes	Yes	Yes	Yes	Yes
26.15.1	Procedure	Yes	Yes	Yes	Yes	No
26.15.2	Acceptance criteria	Yes	Yes	Yes	Yes	No
27	Routine verifications and tests	Yes	Yes	Yes	Yes	Yes
28	Manufacturer's responsibility	Yes	Yes	Yes	Yes	Yes
28.1	Certificate	Yes	Yes	Yes	Yes	Yes
28.2	Responsibility for marking	Yes	Yes	Yes	Yes	Yes
29	Marking	Yes	Yes	Yes	Yes	Yes
30	Instructions	Yes	Yes	Yes	Yes	Yes
^{a)} An entry of "Yes" in the table indicates the requirements of the referenced section of IEC 60079-0 apply. An entry of "No" indicates the requirements either do not apply or have been modified by IEC 60079-15. ^{b)} Type of protection nC includes encapsulated devices, enclosed break devices, non-incendive components, sealed devices and hermetically sealed devices. ^{c)} Clause 6.2 is a calling clause for the tests in 26.4 which are different for both portable and fixed apparatus.						

NOTE 1 A non-incendive component is limited in use to the particular circuit for which it has been shown to be non-ignition capable and, therefore, cannot be separately assessed as complying with this standard.

NOTE 2 Compliance with this standard does not imply any removal of, or lowering of the requirements of any other standard with which the electrical apparatus complies.

NOTE 3 This part supplements, and may enhance, the requirements for apparatus for normal industrial applications. Where compliance with other IEC standards is indicated, such as IEC 60034 for motors and IEC 60598-2 for luminaires, proving compliance to those standards is normally the responsibility of the manufacturer.

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 60034 (all parts), *Rotating electrical machines*

IEC 60034-1, *Rotating electrical machines – Part 1: Rating and performance*

IEC 60034-5, *Rotating electrical machines – Part 5: Degrees of protection provided by the integral design of rotating electrical machines (IP Code) – Classification*

IEC 60034-7, *Rotating electrical machines – Part 7: Classification of type of construction, mounting arrangements and terminal box position (IM Code)*

IEC 60034-25, *Rotating electrical machines – Part 25: Guide for the design and performance of cage induction motors specifically designed for converter supply*

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

IEC 60068-2-27:1987, *Environmental testing – Part 2: Tests – Test Ea and guidance: Shock*

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

IEC 60079-1, *Electrical apparatus for explosive gas atmospheres – Part 1: Flameproof enclosures "d"*

IEC 60079-11:1999, *Electrical apparatus for explosive gas atmospheres – Part 11: Intrinsic safety "i"*

IEC 60079-17, *Electrical apparatus for explosive gas atmospheres – Part 17: Inspection and maintenance of electrical installations in hazardous areas (other than mines)*

IEC 60081, *Double-capped fluorescent lamps – Performance specifications*¹

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

IEC 60155, *Glow-starters for fluorescent lamps*

IEC 60238:1998, *Edison screw lampholders*¹

IEC 60269-3, *Low-voltage fuses – Part 3: Supplementary requirements for fuses for use by unskilled persons (fuses mainly for household and similar applications)*

IEC 60400, *Lampholders for tubular fluorescent lamps and starterholders*¹

IEC 60529:1989, *Degrees of protection provided by enclosures (IP Code)*¹

IEC 60598-1:1996, *Luminaires – Part 1: General requirements and tests*

IEC 60598-2 (all parts), *Luminaires – Part 2: Particular requirements*

IEC 60664-1, *Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests*¹

IEC 60927:1996, *Auxiliaries for lamps – Starting devices (other than glow starters) – Performance requirements*¹

IEC 60998-2-4:1993, *Connecting devices for low-voltage circuits for household and similar purposes – Part 2-4: Particular requirements for twist-on connecting devices*

IEC 61048, *Auxiliaries for lamps – Capacitors for use in tubular fluorescent and other discharge lamp circuits – General and safety requirements*¹

IEC 61184, *Bayonet lampholders*

IEC 61347-1, *Lamp controlgear – Part 1: General and safety requirements*

IEC 61347-2-1, *Lamp controlgear – Part 2-1: Particular requirements for starting devices (other than glow starters)*

¹ A consolidated version of this standard exists.

IEC 61347-2-2, *Lamp controlgear – Part 2-2: Particular requirements for d.c. or a.c. supplied electronic step-down convertors for filament lamps*

IEC 61347-2-3, *Lamp controlgear – Part 2-3: Particular requirements for a.c. supplied electronic ballasts for fluorescent lamps*²

IEC 61347-2-4, *Lamp controlgear – Part 2-4: Particular requirements for d.c. supplied electronic ballasts for general lighting*

IEC 61347-2-7, *Lamp controlgear – Part 2-7: Particular requirements for d.c. supplied electronic ballasts for emergency lighting*

IEC 61347-2-8, *Lamp controlgear – Part 2-8: Particular requirements for ballasts for fluorescent lamps*

IEC 61347-2-9, *Lamp controlgear – Part 2-9: Particular requirements for ballasts for discharge lamps (excluding fluorescent lamps)*²

EN 50262, *Metric cable glands for electrical installations*

3 Terms and definitions

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

3.1

(battery) container

enclosure to contain the battery

NOTE The cover is a part of the battery container.

3.2

cable sealing box

auxiliary enclosure provided specifically for the purpose of sealing the insulation of a cable (for example, oil insulated cable) where it is connected to an apparatus. The enclosure may also provide for the connection of separate cable tails to the cable

3.3

clearance

shortest distance in air between two conductive parts

[IEC 60664-1, definition 1.3.2]

3.4

creepage distance

shortest distance along the surface of an electrically insulating material between two conductive parts

3.5

duty cycle

repetitive variation of load in which the cycle time is too short for thermal equilibrium to be attained in the first cycle

[IEV 411-51-07]

² A consolidated version of this standard exists.

3.6

energy limitation

concept applicable to circuits in which no spark or any thermal effect produced in the test conditions prescribed in this standard is capable of causing ignition of a given flammable gas or vapour

3.7

separation

shortest distance through solid insulating material between two conductive parts

3.8

sealing device

device to prevent the flow of a gas or a liquid between apparatus and a conduit by providing sealing facilities

3.9

type of protection "n"

type of protection applied to electrical apparatus such that, in normal operation and in certain specified abnormal conditions, it is not capable of igniting a surrounding explosive gas atmosphere

NOTE 1 Additionally, the requirements of this standard are intended to ensure that a fault capable of causing ignition is not likely to occur.

NOTE 2 An example of a specified abnormal condition is a luminaire with failed lamp.

3.9.1

non-sparking device "nA"

device constructed to minimize the risk of occurrence of arcs or sparks capable of creating an ignition hazard during conditions of normal operation

NOTE For the purposes of this standard normal operation is considered to exclude the removal or insertion of components with the circuit energized

3.9.2

devices and components "nC"

3.9.2.1

encapsulated device "nC"

device, which may or may not contain voids, which is so constructed that it is totally immersed in an encapsulating compound so that it is sealed to prevent entry of an external atmosphere

NOTE For the purpose of this standard, an encapsulated device is considered to be a particular form of sealed device. It does not provide equivalent protection to encapsulated apparatus constructed in accordance with IEC 60079-18.

3.9.2.2

enclosed-break device "nC"

device incorporating electrical contacts that are made and broken and that will withstand an internal explosion of the flammable gas or vapour which may enter it without suffering damage and without communicating the internal explosion to the external flammable gas or vapour

3.9.2.3

hermetically-sealed device "nC"

device which is so constructed that the external atmosphere cannot gain access to the interior and in which the seal is made by fusion, for example by soldering, brazing, welding or the fusion of glass to metal

3.9.2.4

non-incendive component "nC"

components having contacts for making or breaking a specified ignition capable circuit but in which the contacting mechanism is constructed so that the component is not capable of causing ignition of the specified explosive gas atmosphere

NOTE The enclosure of the non-incendive component is not intended to either exclude the explosive gas atmosphere or contain an explosion.

3.9.2.5

sealed device "nC"

device which is so constructed that it cannot be opened during normal service and is sealed effectively to prevent entry of an external atmosphere

3.9.3

energy-limited apparatus "nL"

electrical apparatus in which the circuits and components are constructed according to the concept of energy limitation

3.9.4

associated energy-limited apparatus "[nL]" or "[Ex nL]"

electrical apparatus which contains both energy-limited and non-energy-limited circuits and is constructed so that the non-energy-limited circuits cannot adversely affect the energy-limited circuits. Associated energy-limited apparatus may be either:

- a) electrical apparatus which has an alternative method of protection included in this standard for use in the appropriate explosive gas atmosphere [nL];
- b) electrical apparatus which has an alternative type of protection listed in IEC 60079-0 for use in the appropriate explosive gas atmosphere [nL];
- c) electrical apparatus not so protected and which therefore shall not be used within an explosive gas atmosphere, for example, a recorder which is not of itself in an explosive gas atmosphere but is connected to a thermocouple situated within an explosive gas atmosphere where only the recorder input circuit is energy-limited [Ex nL]

3.9.5

self protected energy-limited apparatus "nA nL"

apparatus which contains energy-limited sparking contacts, the circuits (including, energy-limiting components and devices) supplying energy-limited power to these contacts, as well as the non-energy limited source of supply to the circuit

3.9.6

restricted-breathing enclosure "nR"

enclosure that is designed to restrict the entry of gases, vapours and mists

4 General

4.1 Apparatus grouping and temperature classification

Apparatus grouping and temperature classification shall be in accordance with Clause 4 of IEC 60079-0.

4.2 Potential ignition sources

In normal operation and in certain abnormal conditions specified by this standard, the apparatus shall not:

- a) produce an operational arc or spark unless that arc or spark is prevented from causing ignition of a surrounding explosive atmosphere by one of the methods described in Clauses 26 to 31;
- b) develop a maximum surface temperature in excess of the maximum value appropriate to the temperature class of the apparatus, unless the temperature of the surface or hot spot is prevented from causing ignition of a surrounding explosive atmosphere by one of the methods described in Clauses 26 to 31 as appropriate, or is otherwise shown to be safe as specified in 5.5

NOTE Contacts with provision for sliding are considered as sparking in normal operation unless precautions are taken such as clamping of the contact itself to the conductive track.

5 Temperatures

5.1 Environmental influences

5.1.1 Ambient temperature

For ambient temperature requirements, 5.1.1 of IEC 60079-0 applies.

5.1.2 External source of heating or cooling

For external sources of heating or cooling, 5.1.2 of IEC 60079-0 applies.

5.2 Service temperature

For service temperature, 5.2 of IEC 60079-0 applies.

5.3 Maximum surface temperature

5.3.1 Determination of maximum surface temperature

For determination of maximum surface temperature, 5.3.1 of IEC 60079-0 applies except for [nL] and [Ex nL] apparatus.

5.3.2 Limitation of maximum surface temperature

For limitation of maximum surface temperature, 5.3.2 of IEC 60079-0 applies except for [nL] and [Ex nL] apparatus.

5.4 Surface temperature and ignition temperature

The requirements of 5.4 of IEC 60079-0 do not apply and are replaced by the following:

Except for the internal parts of type nR enclosures and type nC devices and components, or components complying with 5.5, no surface of any part of an electrical apparatus, including the surface of internal parts to which the potentially explosive atmosphere might have access, shall attain a temperature in excess of the maximum surface temperature prescribed in 5.4 of IEC 60079-0.

5.5 Small components

For evaluation of small components, 5.5 and 5.6 of IEC 60079-0 apply except for [nL] and [Ex nL] apparatus. Temperature relaxations for thin wires and printed circuit tracks contained in IEC 60079-11 may also be used in application of this standard.

6 Requirements for electrical apparatus

6.1 General

Electrical apparatus with type of protection "n" shall comply with the requirements of this standard and the applicable parts of IEC 60079-0 for the method(s) of protection used.

6.2 Mechanical strength of apparatus

Mechanical strength of apparatus shall comply with 6.2 of IEC 60079-0, except for [nL] and [Ex nL] apparatus.

6.3 Opening times

Except for nR restricted breathing enclosures, the requirements of 6.3 of IEC 60079-0 do not apply.

6.4 Circulating currents

The provisions of 6.4 of IEC 60079-0 apply, except for nL, [nL] or [EX nL] apparatus.

6.5 Gasket retention

The provisions of 6.5 of IEC 60079-0 apply, except for [nL] and [Ex nL] apparatus.

6.6 Degree of protection of enclosure (IP)

6.6.1 Minimum degree of protection

Unless specified elsewhere in this standard, the enclosure of the apparatus, when tested in accordance with 33.3.4 shall provide at least the degree of protection described in a) or b) unless safety would not be impaired by contact with solid foreign bodies or water (for example, strain gauges, resistance thermometers, or thermocouples). In this case the documentation (see Clause 36) shall explain why and shall prescribe any special installation requirements which may be necessary and the apparatus shall be marked with the symbol "X" to indicate this special condition of use (see Clause 29 of IEC 60079-0):

- a) IP54 where there are bare live parts or IP44 where there are insulated live parts;
- b) IP4X where there are bare live parts, or IP2X where there are insulated live parts and the apparatus is intended for installation only in locations providing adequate protection against the entry of solid foreign objects or water capable of impairing safety, and the apparatus is marked with the symbol "X" (see Clause 29 of IEC 60079-0).

For protected apparatus, the degree of protection shall be marked according to Clause 35.

NOTE 1 For requirements for rotating electrical machines, see Clause 17.

NOTE 2 For requirements for non-sparking low power apparatus, see Clause 23.

6.6.2 Degree of protection provided by installation

Where the enclosure is completed by the installation of the apparatus the marking shall include the symbol "X" and the manufacturer shall provide relevant information in the documentation in accordance with Clause 36.

6.7 Clearances, creepage distances and separations

6.7.1 General

Clearances, creepage distances and separations between conductive parts at different potentials shall meet the appropriate values given in Table 2, except in the following cases:

- neutral point connections of rotating electrical machines complying with 17.3;
- luminaires complying with 21.2.7;
- with regard to sealed, encapsulated or solid insulation separations only, apparatus subject to the routine electric strength test of 6.8.2;
- with regard to energy-limited apparatus, associated energy-limited apparatus and circuits (see Clause 30), where separations not meeting the above requirements may be assessed or tested on the basis that the relevant conducting parts are intermittently connected together, in which case consequential effects shall be taken into account;
- instruments and low power apparatus complying with Clause 23.

A circuit which is not referred to earth in normal operation shall be assumed to be earthed at the point by which the highest voltage U is obtained.

6.7.2 Determination of working voltage

Clearances and creepage distances shall be determined as a function of the working voltage specified by the manufacturer of the apparatus. Where the apparatus is intended for more than one rated voltage or for a range of rated voltage, the value of the working voltage to be used shall be based on the highest value of rated voltage.

6.7.3 Conformal coating

A conformal coating, if applied, shall have the effect of sealing the conductors and the insulating material in question against ingress of moisture. It shall adhere to the conductive parts and the insulating material. If the conformal coating is applied by spraying then two separate coats are to be applied. Other methods of application require only one coat, for example dip coating, brushing, vacuum impregnating, but the intention is to achieve an effective, lasting, unbroken seal. A solder mask is considered as one of two coatings, provided it is not damaged during soldering.

Where bare conductors emerge from the coating, the requirements given in Table 2 shall apply taking account of the comparative tracking index (CTI) applicable to both insulation and conformal coating.

6.7.4 Comparative tracking index (CTI)

The required values of creepage distance are dependent on the working voltage, the resistance to tracking of the electrical insulating material and its surface profile.

Table 3 gives the grouping of electrical insulating materials according to the CTI determined in accordance with IEC 60112. The material groups are identical with those given in IEC 60664-1. Inorganic insulating materials, for example glass and ceramics, do not track and need not therefore be subjected to the determination of the CTI. They are conventionally classified in material group I.

NOTE Transient overvoltages are ignored as they will not normally influence tracking phenomena. However, temporary and functional overvoltages may have to be considered depending upon the duration and frequency of occurrence. See 21.2.7 and Table 8 for pulse voltages in luminaire circuits or IEC 60664-1 for additional information.

6.7.5 Measurement of creepage and clearance

Clearances, creepage distances and separations shall be determined with any movable parts adjusted to give the lowest values possible.

Terminals shall be assessed by measurements made with and without conductors of the largest cross-sectional area specified by the terminal manufacturer.

NOTE 1 This implies that screws of unused terminals always should be fully tightened when the apparatus is in service.

Clearances and creepage distances for external connections shall comply with Table 2, but with a minimum value of 1,5 mm.

Figure 1 (examples taken from IEC 60664-1) illustrates the features to be taken into account when determining the appropriate clearances or creepage distance.

NOTE 2 Cement within a joint would normally be considered as obstructing a clearance or creepage path.

The effect of ribs or grooves shall be taken into account provided that

- ribs on the surface have a minimum height of 1,5 mm and a minimum thickness of 0,4 mm appropriate to the mechanical strength of the material;
- grooves in the surface have a minimum depth of 1,5 mm and a minimum width of 1,5 mm.

NOTE 3 Projections above or depressions below the surface are considered as being either ribs or grooves irrespective of their geometric form.

Table 2 – Minimum creepage distances, clearances and separations

Voltage a.c. r.m.s. or d.c. (Note 1) V	Minimum creepage distance (Note 2) mm				Minimum clearances and separation mm		
	Material group				In air	Sealed (Note 3)	Encapsulated or solid insulation (Note 4)
	I	II	IIIa	IIIb			
≤10 (see Note 5)	1	1	1	1	0,4	0,3	0,2
≤12,5	1,05	1,05	1,05	1,05	0,4	0,3	0,2
≤16	1,1	1,1	1,1	1,1	0,8	0,3	0,2
≤20	1,2	1,2	1,2	1,2	0,8	0,3	0,2
≤25	1,25	1,25	1,25	1,25	0,8	0,3	0,2
≤32	1,3	1,3	1,3	1,3	0,8	0,3	0,2
≤40	1,4	1,6	1,8	1,8	0,8	0,6	0,3
≤50	1,5	1,7	1,9	1,9	0,8	0,6	0,3
≤63	1,6	1,8	2	2	0,8	0,6	0,3
≤80	1,7	1,9	2,1	2,1	0,8	0,8	0,6
≤100	1,8	2	2,2	2,2	0,8	0,8	0,6
≤125	1,9	2,1	2,4	2,4	1	0,8	0,6
≤160	2	2,2	2,5	2,5	1,5	1,1	0,6
≤200	2,5	2,8	3,2	3,2	2	1,7	0,6
≤250	3,2	3,6	4	4	2,5	1,7	0,6
≤320	4	4,5	5	5	3	2,4	0,8
≤400	5	5,6	6,3	6,3	4	2,4	0,8
≤500	6,3	7,1	8	8	5	2,4	0,8
≤630	8	9	10	10	5,5	2,9	0,9
≤800	10	11	12,5	–	7	4	1,1
≤1 000	11		13	–	8	5,8	1,7
≤1 250	12		15	–	10	–	–
≤1 600	13		17	–	12	–	–
≤2 000	14		20	–	14	–	–
≤2 500	18		25	–	18	–	–
≤3 200	22		32	–	22	–	–
≤4 000	28		40	–	28	–	–
≤5 000	36		50	–	36	–	–
≤6 300	45		63	–	45	–	–
≤8 000	56		80	–	56	–	–
≤10 000	71		100	–	70	–	–
≤11 000	78		110	–	75	–	–
≤13 800	98		138	–	97	–	–
≤15 000	107		150	–	105	–	–

- NOTE 1 Voltage steps up to 10 000 V are based on the R10 series. For working voltages up to 1 000 V, the actual working voltage may exceed the value given in the table by up to 10 %.
- NOTE 2 Values for creepage distances are derived from IEC 60664-1. Up to 800 V, creepage distances are based on pollution degree 3; values between 2 000 V and 10 000 V are based on pollution degree 2. Other values are interpolated or extrapolated.
- NOTE 3 Sealed by a conformal coating, see 6.7.3.
- NOTE 4 Completely encapsulated in compound to a minimum depth of 0,4 mm, or separation through solid insulating material, for example the thickness of a printed wiring board.
- NOTE 5 At 10 V and below, the value of CTI is not relevant and materials not meeting the requirements for material group IIIb may be acceptable.
- NOTE 6 The creepage and clearance values shown are based on a maximum rated voltage tolerance of $\pm 10\%$.

Table 3 – Tracking resistance of insulating materials

Material group	Comparative tracking index
I	$600 \leq \text{CTI}$
II	$400 \leq \text{CTI} < 600$
IIIa	$175 \leq \text{CTI} < 400$
IIIb	$100 \leq \text{CTI} < 175$

6.7.6 Compound filled cable sealing boxes

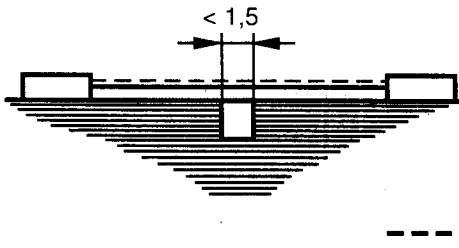
Where compound filled cable sealing boxes are used for the termination of external cables supplying apparatus with rated voltages in excess of 750 V, the construction shall be such that the creepage distances and clearances given in Table 4 are obtainable for bare live parts, prior to the pouring of the compound.

NOTE The requirements in Table 4 differ from those in Table 2 to take account of the properties of the compound and the lower degree of certainty as to whether the designed separations are actually achieved in a particular installation.

Table 4 – Separation in compound-filled cable sealing boxes

Rated voltage, <i>U</i> a.c. r.m.s. or d.c. V	Creepage distances mm		Clearances mm	
	Between phases	Between phase and earth	Between phases	Between phase and earth
$750 < U \leq 1\,100$	19	19	12,5	12,5
$1\,100 < U \leq 3\,300$	37,5	25	19	12,5
$3\,300 < U \leq 6\,600$	63	31,5	25	19
$6\,600 < U \leq 11\,000$	90	45	37,5	25
$11\,000 < U \leq 13\,800$	110	55	45	31,5
$13\,800 < U \leq 15\,000$	120	60	50	35

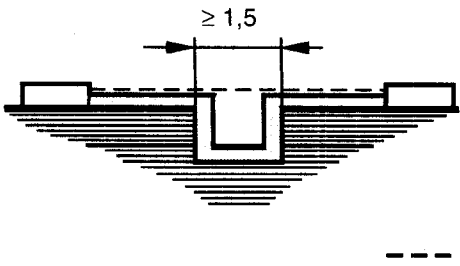
Example 1



Condition: Path under consideration includes a parallel- or converging-sided groove of any depth with a width less than 1,5 mm

Rule: Creepage distance and clearance are measured directly across the groove as shown

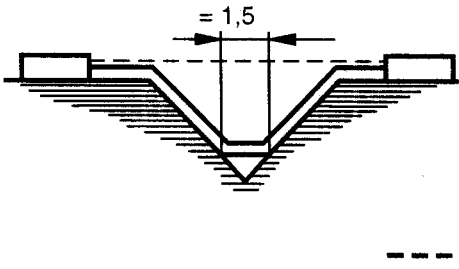
Example 2



Condition: Path under consideration includes a parallel-sided groove of any depth d equal to or more than 1,5 mm

Rule: Clearance is the "line of sight" distance. Creepage path follows the contour of the groove

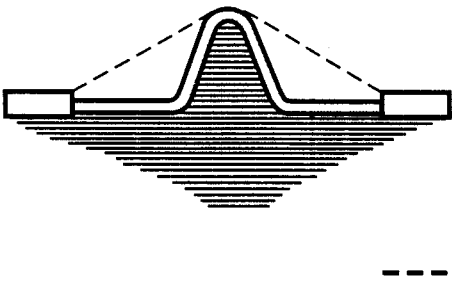
Example 3



Condition: Path under consideration includes a V-shaped groove with a width greater than 1,5 mm

Rule: Clearance is the "line of sight" distance. Creepage path follows the contour of the groove but "short-circuits" the bottom of the groove by 1,5 mm link

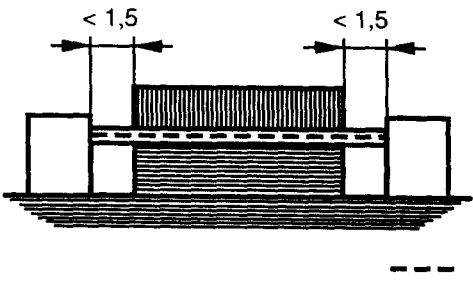
Example 4



Condition: Path under consideration includes a rib

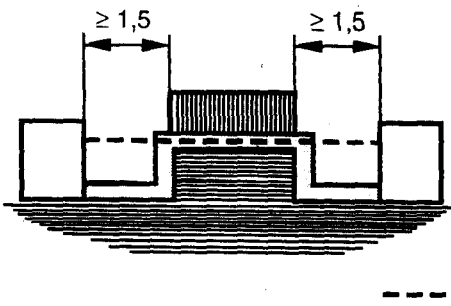
Rule: Clearance is the shortest direct air path over the top of the rib. Creepage path follows the contour of the rib

Example 5



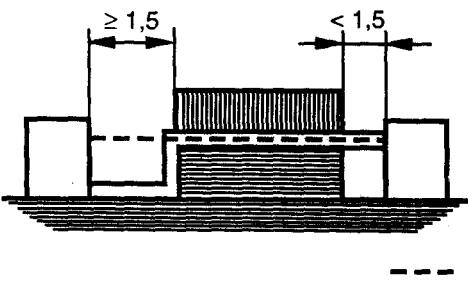
Condition: Path under consideration includes an uncemented joint with grooves less than 1,5 mm wide on each side
Rule: Creepage and clearance path is the "line of sight" distance shown

Example 6



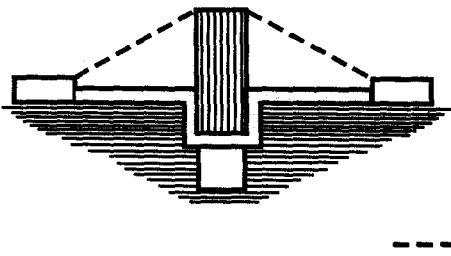
Condition: Path under consideration includes an uncemented joint with grooves equal to or more than 1,5 mm wide on each side
Rule: Clearance is the "line of sight" distance. Creepage path follows the contour of the grooves

Example 7



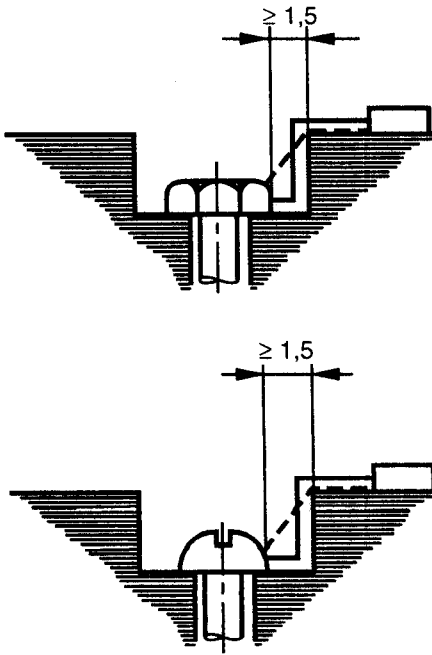
Condition: Path under consideration includes an uncemented joint with a groove on one side less than 1,5 mm wide and the groove on the other side equal to or more than 1,5 mm wide
Rule: Clearance and creepage paths are as shown

Example 8



Condition: Creepage distance through uncemented joint is less than creepage distance over barrier
Rule: Clearance is the shortest direct air path over the top of the barrier

Example 9

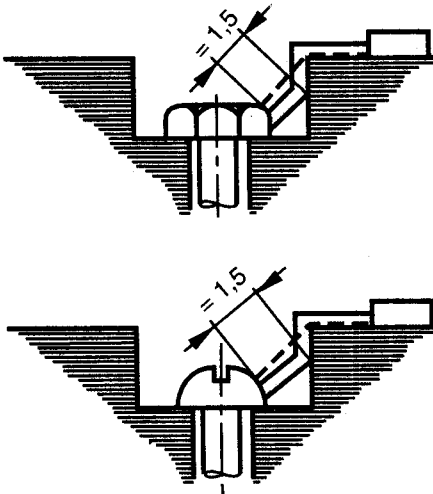


--- 1

— 2

Gap between head of screw and wall of recess wide enough to be taken into account

Example 10



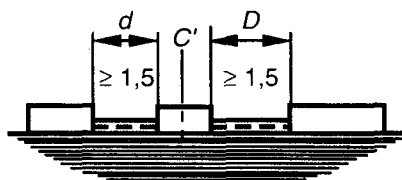
--- 1

— 2

Gap between head of screw and wall of recess too narrow to be taken into account.

Measurement of creepage distance is from screw to wall when the distance is equal to 1,5 mm

Example 11



--- 1

= 2

C – conductive part interposed in the insulating path between the conductors.

Clearance is the distance $d + D$.

Creepage distance is also $d + D$

Key

1 clearance

2 creepage distance

Figure 1 – Examples for determining clearances and creepage distances

6.8 Electric strength

6.8.1 Insulation from earth or frame

Where the electrical circuits within the apparatus are not connected directly to the frame of the apparatus or not intended to be connected to the frame in service, the insulation or separation distance used shall withstand without breakdown the following test voltages for 60 s, with a relative tolerance of $^{+5}_{0}\%$:

- for apparatus supplied with voltages not exceeding 90 V peak or in which internal voltages not exceeding 90 V peak are present, 500 V r.m.s, with a relative tolerance of $^{+5}_{0}\%$;
- for other apparatus, or where internal voltages in excess of 90 V peak are present, $(2 U + 1\,000 \text{ V})$ r.m.s, with a relative tolerance of $^{+5}_{0}\%$ or 1 500 V r.m.s. with a relative tolerance of $^{+5}_{0}\%$, whichever is the greater.

The use of a d.c. test voltage is permitted as an alternative to the specified a.c. test voltage and shall be 170 % of the specified a.c. r.m.s test voltage for insulated windings or 140 % of the specified a.c. r.m.s test voltage for situations where air or creepage distance is the insulating medium.

NOTE U is the higher of either the rated supply voltage or the maximum voltage occurring within the apparatus.

For apparatus with galvanically isolated parts, the test voltages shall be applied separately, at the appropriate voltage, to each part.

Apparatus complying with a normal industrial standard may, as an alternative, satisfy the requirements of that standard provided the intent of the requirement is to ensure an equivalent level of protection against electrical breakdown

6.8.2 Insulation between conductive parts

In the case of apparatus subject to the exception of 6.7.1 with regard to sealed, encapsulated or solid insulation separations, and where breakdown could cause an ignition capable arc, spark or hot surface, the insulation or separation between relevant conductive parts shall be subjected to a routine electric strength test carried out in accordance with 6.8.1

NOTE As such testing can damage electronic components, for example semiconductors, the test may be carried out on apparatus using such devices before they are fitted except where they form the actual path to be measured (for example a metal transistor bolted to the apparatus frame, where failure of the insulation may directly produce an ignition capable spark or hot surface in the apparatus).

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

7.1 General

The general requirements specified in 7.1 of IEC 60079-0 apply, except for [nL] and [Ex nL] apparatus.

7.2 Thermal endurance

The requirements of 7.2 of IEC 60079-0 do not apply and are replaced by the following:

Except for [nL] and [Ex nL] apparatus, the enclosure shall be subjected to thermal endurance testing in accordance with 33.3.2.1 and 33.3.2.2. Plastic materials shall have a relative thermal index (RTI-mechanical impact), or TI corresponding to the 20 000 h point, of at least 10 K greater than the temperature of the hottest point of the enclosure or part of the enclosure having regard to the maximum ambient temperature in rated service.

7.3 Electrostatic charges on external non-metallic materials of enclosures

Except for [nL] and [Ex nL] apparatus, the requirements of 7.3 of IEC 60079-0 apply.

7.4 Threaded holes

The requirements of 7.4 of IEC 60079-0 apply.

7.5 Thermal shock

Except for [nL] and [Ex nL] apparatus, for glass parts of luminaires, windows and other glass parts of enclosures, the requirements of 26.5.2 of IEC 60079-0 apply.

7.6 Resistance to light

Except for [nL] and [Ex nL] apparatus, for non-metallic parts of enclosures, the requirements of 26.10 of IEC 60079-0 apply.

8 Enclosures containing light metals

8.1 Material composition

The requirements of 8.1 of IEC 60079-0 apply, except for [nL] and [Ex nL] apparatus.

8.2 Threaded holes

The requirements of 8.2 of IEC 60079-0 apply except for [nL] and [Ex nL] apparatus.

9 Fasteners

9.1 General

The requirements of 9.1 of IEC 60079-0 apply except for [nL] and [Ex nL] apparatus.

9.2 Special fasteners

The requirements of 9.2 and 9.3 of IEC 60079-0 do not apply.

10 Interlocking devices

The requirements of Clause 10 of IEC 60079-0 do not apply.

11 Bushings

Except for [nL] and [Ex nL] apparatus, the requirements of Clause 11 of IEC 60079-0 apply.

12 Materials used for cementing

The requirements of Clause 12 of IEC 60079-0 do not apply and are replaced by the following.

The materials used for cementing on which safety depends shall have a thermal stability adequate for the minimum and maximum temperatures to which they are subjected within the rating of the apparatus.

The thermal stability shall be considered adequate if the lower limiting value of temperature for the material are below or equal to the lowest working temperature specified for the material and the continuous operating temperature (COT) is at least 10 K above the maximum service temperature.

13 Ex components

The requirements of Clause 13 of IEC 60079-0 do not apply and are replaced by the following.

13.1 Type of protection "n"

Ex components with type of protection "n" shall comply with the relevant requirements of this standard and may be

- a) an empty enclosure,
- b) components or assemblies of components.

13.2 Mounting

Ex components may be mounted:

- a) completely within an apparatus enclosure (for example, a terminal, ammeter, lampholder, heater or indicator); or
- b) completely external to the apparatus enclosure (for example, an earth terminal); or
- c) partly within and partly external to the apparatus enclosure (for example, an indicating lamp or push-button switch).

13.3 Internal mounting

In the case of mounting completely within the enclosure, additional testing or assessment is only necessary with regard to those aspects of operation or construction of the component which are affected by its mounting within the enclosure (for example, surface temperature, creepage distance and clearance and other conditions dependent upon mounting when the component is mounted).

13.4 External mounting

In the case of mounting external to the enclosure or partly within and partly external to the enclosure the interface between the Ex component and the enclosure shall be tested or assessed for compliance with the relevant requirements of this standard.

14 Connection facilities and terminal compartments

The requirements of Clause 14 of IEC 60079-0 do not apply and are replaced by the following.

14.1 General

The contact pressure of electrical connections shall be reliably maintained in normal operation. In particular it shall not be adversely affected by dimensional changes in service (due to temperature, humidity, etc.) of insulating materials.

Non-sparking connections shall be designed to prevent sparking under conditions of vibration.

NOTE 1 Information for vibration tests is given in IEC 60068-2-6 in relation to the conditions of use.

NOTE 2 Connection facilities for luminaires are specified in Clause 21.

14.2 Connection for external conductors

14.2.1 Connection facilities

Electrical apparatus intended for connection to external circuits shall include connection facilities. This can be

- a) terminals,
- b) a cable permanently connected to it or a cable permanently connected to it and provided with loose leads

14.2.1.1 Terminals

The terminals shall effectively be protected against corrosion, and be so designed that

- a) the conductors can be connected readily
- b) the conductors can be clamped without reducing significantly their cross-sectional area in such a manner that they are gripped and secured against loosening and twisting
- c) the contact pressure will be reliably maintained.

For terminals suitable for cable lugs, means shall be provided for preventing accidental non-permissible reduction of clearances.

NOTE For example this may be achieved by the use of insulating barriers at least as high as the terminals or by insulating the shanks of lugs.

14.2.1.2 Permanently connected cable, provided with loose leads

Where electrical apparatus is provided with loose leads, sufficient length of loose lead shall be provided to permit more than one reconnection to be made.

NOTE 1 Loose leads are often connected by a means which necessitates removing a short length of the lead each time the connection is severed and remade. The intention is that apparatus should be capable of being connected at least three times, though additional length of lead should be provided if it is known that a particular apparatus may be liable to further connections.

NOTE 2 It is intended that the form of connection used with loose leads, the provision of any necessary insulation and the maintenance of clearances and creepage distances required by 6.7 are the responsibility of the installer of the apparatus.

14.2.2 Conductor accommodation

Connection facilities shall accommodate at least the size of conductor appropriate to the rated current of the apparatus.

NOTE System conditions (voltage drop, for example) may make it necessary to provide terminals suitable for larger conductors than are required by thermal considerations.

14.2.3 Cable glands

Cable glands shall conform to the requirements of IEC 60079-0.

14.3 Internal connection facilities

Within electrical apparatus, connections shall not be subject to undue mechanical stress. Only the following means for the connection of conductors are permitted:

- connection methods acceptable for external connections;
- insulated crimped connectors;
- soldering;
- brazing;
- welding;
- twist-on connecting devices meeting the requirements of IEC 60998-2-4;
- pinch screw terminals if ferrules are fitted on the conductor; and
- connections made by spring pressure. Contact pressure on the electrical connections shall be maintained and not be affected by dimensional changes of insulating materials in service, due to factors such as temperature or humidity.

NOTE If certification (third party) is sought, it is not a requirement of this standard that the certification body confirm conformance to IEC 60998-2-4. The manufacturer should state the basis of compliance in the documentation, see Clause 36.

15 Connection facilities for earthing or bonding conductors

Except for [nL] and [Ex nL] apparatus, connection facilities for earthing and bonding conductors shall comply with the requirements of Clause 15 of IEC 60079-0.

16 Entries into enclosures

Except for [nL] and [Ex nL] apparatus, entries into enclosures shall conform to the requirements of Clause 16 of IEC 60079-0.

17 Supplementary requirements for non-sparking electrical machines

17.1 General

The requirements in this clause apply to rotating machines within the scope of IEC 60034 (all parts). The basis of compliance with IEC 60034 shall be included in the documentation required in Clause 36.

For other rotating devices, for example clock motors, and servo motors, the requirements of this standard including those of this clause, shall apply where they are appropriate.

For non-rotating machines, for example linear motors, the requirements of this standard including those of this clause, shall apply where they are appropriate

NOTE 1 If certification (third party) is sought, it is not a requirement of this standard that the certification body confirm conformance to IEC 60034 (series). The manufacturer should state the basis of compliance in the documentation, see Clause 36.

NOTE 2 The requirements of IEC 60034-5 replace those of 6.6.

17.1.1 Machine enclosure

Machine enclosures containing bare live parts shall provide a degree of protection not less than IP54, as determined in accordance with 33.3.4, and not less than IP20 in other cases.

NOTE The bars and rings of rotor cages are not considered to be bare live parts when determining the degree of protection.

17.1.2 Terminal boxes

Terminal boxes attached to machines operating at voltages up to 1 000 V, may be opened to the interior of the machine, only when the IP rating of the machine is IP44 or higher. The external IP protection of the box shall be not less than IP54, as determined in accordance with 33.3.4.

17.1.3 Conduit stopping boxes, cable sealing and dividing boxes

If fitted, conduit stopping boxes, cable sealing and dividing boxes shall provide a degree of protection not less than IP54 as determined in accordance with 33.3.4.

17.2 Connection facilities for external conductors

The connection facilities of rotating machines shall comply with 14.2. In addition, for all forms of cable connection, it shall be possible to remove the machine while ensuring that cable sealing is not disturbed (for example in the case of a sealing compound) or can be replaced without subjecting the cable to stresses liable to damage the cable insulation or the conductors.

This subclause does not apply if there is no requirement to disconnect and reconnect the machine during maintenance.

17.3 Neutral point connections

In the case of neutral point connections which are not intended for use as an alternative supply connection to the machine, the minimum creepage and clearance requirements shall be determined according to the assumed working voltage given in Table 5.

Table 5 – Assumed working voltage of neutral points

Working voltage <i>U</i> a.c. r.m.s or d.c. V	Assumed working voltage of neutral point V
$\leq 1\,100$	U
$1\,100 < U \leq 3\,300$	1 100
$3\,300 < U \leq 6\,600$	3 300
$6\,600 < U \leq 11\,000$	6 600
$11\,000 < U \leq 15\,000$	11 000

In the case of neutral point connections within the enclosure of the machine, the neutral connection shall be fully insulated unless the ingress protection is IP44 or greater and the machine is not intended to be connected to an earthed line supply.

17.4 Radial air gap

The minimum radial air gap between stator and rotor (in mm), when the rotating electrical machine is at rest, shall not be less than the value calculated using the following equation:

$$\text{minimum radial air gap} = \left[0,15 + \left(\frac{D - 50}{780} \right) \left(0,25 + 0,75 \frac{n}{1\,000} \right) \right] r \times b$$

where

$D = 75$ (for rotor diameters less than 75 mm); or

D is the rotor diameter in millimetres (for values between 75 mm and 750 mm);

$D = 750$ (for rotor diameters greater than 750 mm);

$n = 1\,000$ (for maximum rated speeds below 1 000 r/min); or

n is the maximum rated speed (for values above 1 000 r/min);

$r = 1$ (when the ratio of core length to rotor diameter is less than 1,75);

$r = \frac{\text{core length}}{1,75 \times \text{diameter of rotor}}$ (when the value of the expression is greater than 1);

$b = 1$ (for machines with rolling bearings); or

$b = 1,5$ (for machines with plain bearings).

17.5 Ventilation systems

Internal and external fans and fanhoods shall comply with 17.1 of IEC 60079-0.

17.6 Bearing seals and shaft seals

17.6.1 Non-rubbing seals and labyrinths

For rolling element bearings, the minimum radial or axial clearance between the stationary and rotating parts of any non-rubbing seal or labyrinth seal shall be not less than 0,05 mm. For plain (sleeve) bearings, this clearance shall be no less than 0,1 mm. The minimum clearance shall apply for all possible positions of the shaft within the bearings.

NOTE 1 The axial movement in a typical ball bearing is likely to be up to 10 times the radial movement.

NOTE 2 Bearings with covers supplied as an integral part of the bearing by the bearing manufacturer (that is to say, "sealed for life" bearings) are exempted from the above requirement.

17.6.2 Rubbing seals

Where rubbing seals are incorporated they shall be either lubricated or made of material having a low coefficient of friction, for example polytetrafluoroethylene (PTFE). In the former case, the design of the bearing shall be such that a supply of lubricant to the seal is maintained.

Rubbing seals shall be assessed in accordance with Clause 5.

NOTE 1 In order that excess temperatures are not generated in service, information on any maintenance required to ensure continued compliance with the requirements of 17.6 should be provided by the manufacturer.

NOTE 2 Rubbing seals which reduce their cross-section when ageing (for example felt sealing rings) are considered to meet the requirements when the temperature is assessed to be within the limits during its new condition. Elastic seals which lift off during rotation (for example V rings) are also considered to meet the requirements.

17.7 Rotor cages

17.7.1 Rotor cages built from bars connected to end rings

Precautions shall be taken to guard against incensive arcs or sparks during normal operation of the rotating electrical machine. In particular, the joints between bars and short-circuiting rings shall be brazed or welded and compatible materials shall be used to enable high quality joints to be made.

17.7.2 Cast rotor cages

Cast rotor cages shall be made by pressure die-casting or centrifugal casting or equivalent techniques designed to ensure the complete filling of the slot.

17.7.3 Assessment for possible air gap sparking

Rotating electrical machines with a rated output exceeding 100 kW shall be assessed for possible air gap sparking.

Motors with a duty type S1 and S2 which are running continuously with an average starting frequency in normal operation not exceeding one start per week are excluded from these requirements.

If the total sum of the factors determined by Table 6 is greater than 5, the machine or a representative sample shall be tested in accordance with 33.14.1; or the machine shall be constructed to allow special measures to be employed to ensure that its enclosure does not contain an explosive gas atmosphere at the time of starting. The machine marking shall include the symbol "X", in accordance with IEC 60079-0, and the special conditions to be employed shall be specified in the documentation as required by Clause 36.

NOTE Special measures that can be applied include pre-start ventilation or the application of fixed gas detection inside the machine enclosure. Other methods may be applied with the agreement of the manufacturer and the user.

Table 6 – Potential air gap sparking risk assessment for cage rotor ignition risk factors

Characteristic	Value	Factor
Rotor cage construction	Fabricated rotor cage	2
	Cast aluminium rotor cage ≥ 200 kW per pole	1
	Cast aluminium rotor cage < 200 kW per pole	0
Number of poles	2-pole	2
	4-pole to 8-pole	1
	> 8 -pole	0
Rated output	> 500 kW per pole	2
	> 200 kW to 500 kW per pole	1
	≤ 200 kW per pole	0
Radial cooling ducts in rotor	Yes: $L < 200$ mm (Note 1)	2
	Yes: $L \geq 200$ mm (Note 1)	1
	No	0
Rotor or stator skew	Yes: > 200 kW per pole	2
	Yes: ≤ 200 kW per pole	0
	No	0
Rotor overhang parts	Non-compliant (Note 2)	2
	Compliant (Note 2)	0
Temperature class	T1 / T2	2
	T3	1
	$\geq T4$	0

NOTE 1 L is the length of end packet of core. Experimental tests have shown that sparking occurs predominantly in ducts near the ends of the core.

NOTE 2 Rotor overhang parts should be designed to eliminate intermittent contact and to operate within the temperature classification. Compliance with this ruling gives a factor of 0, otherwise it is 2.

17.8 Surface temperature limitation

NOTE Calculations or tests may be accepted as evidence of compliance with Clause 5 of IEC 60079-0.

17.8.1 Prevention of thermal ignition

The temperature of any external or internal surface to which the explosive atmosphere has access shall not, under normal operating conditions exceed the temperature class in accordance with Clause 5.

The temperature rise during starting is not one of the factors when determining the temperature class if the duty type is S1 or S2 in accordance with IEC 60034-1.

For duty types S3 to S10 starting and load variations shall be taken into consideration.

If a rotating electrical machine is to operate on more than one duty type, it may, as a consequence, have more than one temperature class. In this case the machine shall be marked with the relevant duty types (S1 – S10) and the related temperature classes.

NOTE 1 The exclusion of the consideration of starting conditions in assigning temperature class is appropriate for machines that start infrequently as the statistical probability of an explosive gas atmosphere being present during the starting sequence is considered acceptable.

NOTE 2 For the purpose of assigning temperature class, synchronization of a generator should be treated as equivalent to the starting of a motor.

17.8.2 Operation with a frequency convertor or a non-sinusoidal supply

17.8.2.1 Type test methods

To prove that the thermal limits are not exceeded and functional performance is demonstrated throughout the operational speed range, two methods may be used: a type test or calculation.

17.8.2.2 Type test

Motors supplied at varying frequency and voltage by a convertor shall be tested with the specified convertor or with a comparable convertor in reference to the output voltage and current specifications. The test shall be performed using the detecting or measurement devices used for protection in normal operation. The descriptive documentation for the motor shall include the necessary parameters and conditions required for use with a convertor.

NOTE Additional information on the application of convertor fed motors can be found in IEC 60034-17 and IEC 60034-25. Major concerns include over-temperature, high frequency and over-voltage effects, bearing currents and requirements for high frequency earthing.

17.8.2.3 Alternative type test by calculation

Alternatively to the type test of 17.8.2.2, the temperature class may be determined by calculation. In cases where the temperature class is determined by calculation, the calculation shall be based on previously established representative test data and in accordance to IEC 60034-7 and IEC 60034-25.

NOTE 1 The determination of the temperature class by calculation should be agreed between the manufacturer and the user as appropriate.

NOTE 2 The temperature differential between stator and rotor of a machine operating with a non-sinusoidal supply, or generating into a thyristor load, may vary greatly from the temperature differential that would occur on the same machine operating with a sinusoidal supply, or generating into a linear load. Therefore special attention needs to be paid to the rotor temperature which may be a limiting feature of the machine, particularly in the case of rotor cage windings.

17.9 Additional requirements for machines with rated voltage greater than 1 kV

17.9.1 General

The requirements of this standard assume that the occurrence of a flammable gas atmosphere and a motor start sequence do not occur simultaneously, and may not be suitable in those cases where these two conditions do occur simultaneously.

NOTE Type 'n' high-voltage motors should not be used where the probability of a gas release cannot be totally disassociated with the start sequence as an independent event. The seal systems of centrifugal compressors are known to produce such releases during starting and should be subject to assessment.

17.9.1.1 Assessment and test

All machines with a rated voltage >1 kV shall be assessed according to 17.9.2 and, where required, tested according to 33.14.2.

Motors with a duty type S1 and S2 which are running continuously with an average starting frequency in normal operation not exceeding one start per week are excluded from these requirements.

17.9.1.2 "As new" condition

All tests or assessments shall be carried out on machines, components or test models in an "as new" condition.

17.9.1.3 High-voltage rated machines

The marking of high-voltage rotating electrical machines shall include the symbol "X", in accordance IEC 60079-0 and the documentation required by Clause 36 and shall include appropriate information regarding the permitted starting frequency, the recommended time between major overhauls (disassembly and cleaning) and the intended environmental conditions.

17.9.2 Potential incendivity of the stator winding insulation system

NOTE 1 Some degree of surface discharge activity can occur on high-voltage windings without affecting the performance of the machine. Not all such activity is capable of causing ignition. Ignition is most probable from short-term discharges that occur as a result of switching transients, particularly those associated with motor starting conditions.

Table 7 gives the ignition risk factors for potential stator winding discharge. If the total sum of the factors determined by Table 7 is greater than 6 then anti-condensation space heaters shall be employed and

- a) tests shall be conducted in accordance with 33.14.2, or
- b) the machine shall be constructed to allow special measures to be employed to ensure that its enclosure does not contain an explosive gas atmosphere at the time of starting. In the latter case the documentation required by Clause 36 shall specify the special measures to be employed.

NOTE 2 Special measures that can be applied include pre-start ventilation or the application of fixed gas detection inside the machine enclosure. Other methods may be applied with the agreement of the manufacturer and the user.

Table 7 – Potential stator winding discharge risk assessment – Ignition risk factors

Characteristics	Value	Factor
Rated voltage	> 11 kV	6
	> 6,6 kV to 11 kV	4
	> 3,3 kV to 6,6 kV	2
	> 1 kV to 3,3 kV	0
Average starting frequency in service	> 1 / hour	3
	> 1 / day	2
	> 1 / week	1
	≤ 1 / week	0
Time between detailed inspections (see IEC 60079-17)	> 10 years	3
	> 5 to 10 years	2
	> 2 to 5 years	1
	< 2 years	0
Degree of protection (IP Code)	< IP44 ^a	3
	IP44 and IP54	2
	IP55	1
	> IP55	0
Environmental conditions	Very dirty and wet ^b	4
	Coastal outdoor ^c	3
	Outdoor	1
	Clean and dry indoor	0
^a Only in clean environments and regularly serviced by trained personnel, see 6.6.1. ^b "Very dirty and wet" locations include those that may be subjected to deluge systems or comprise open deck on offshore locations. ^c Exposed to atmospheres containing salt.		

18 Supplementary requirements for switchgear

Switchgear shall comply with the requirements of IEC 60079-0.

19 Supplementary requirements for non-sparking fuses and fuse assemblies

19.1 Fuses

The requirements of IEC 60079-0 do not apply and are replaced by the following.

Fuses shall be deemed non-sparking devices if they are non-rewirable, non-indicating cartridge types or indicating cartridge types, according to IEC 60269-3, operating within their rating.

NOTE 1 Rupture of the fuse is not considered to be normal operation.

NOTE 2 If certification (third party) is sought, it is not a requirement of this standard that the certification body confirm conformance to IEC 60269-3. The manufacturer should state the basis of compliance in the documentation, see Clause 36.

19.2 Temperature class of an apparatus

The temperature class of an apparatus shall take account of the external surface of the cartridge, including the indicator if any, of each fuse mounted in the apparatus based on the rated current of the apparatus.

In the case of multiple sources of heat a diversity factor may be applied in which case it shall be stated in the documentation (see Clause 36).

19.3 Fuse mounting

Fuse shall be mounted in non-sparking enclosed holders or non-sparking spring holders or shall be soldered in place. Evaluation of the non-sparking properties shall be in accordance with 20.3.

19.4 Fuse enclosures

Enclosures containing fuses either shall be interlocked so that insertion or removal of replacement elements can be carried out only with the supply disconnected and so that the fuse cannot be energized until the enclosure is correctly closed, or shall carry a warning given in item a) of Table 13.

19.5 Replacement fuse identification

Unless the fuses are of a non-interchangeable type, provision shall be made for the correct type and value for replacement fuses to be marked adjacent to the fuse holders.

20 Supplementary requirements for non-sparking plugs and sockets

The requirements of IEC 60079-0 do not apply and are replaced by the following.

20.1 Plugs and sockets for external connections

Plugs and sockets for external connections shall comply with either item a) or item b) as follows:

- a) they shall be interlocked mechanically or electrically, or otherwise designed so that they cannot be separated when the contacts are energized and the contacts cannot be energized when plug and socket are separated. Switches used for this purpose shall comply with this standard or with one or more types of protection listed in IEC 60079-0;
- b) if they are allocated and connected to only one apparatus, they shall be secured mechanically to prevent unintentional separation and the apparatus shall be marked with the warning given in item b) of Table 13.

20.2 Maintaining degree of protection

Provision shall be made for the fixed part of a plug and socket connector to maintain the degree of protection of the enclosure on which it is mounted, even when the movable part has been removed. If the required safety level is effectively reduced by accumulation of dust or water, provision shall also be made for maintaining an appropriate degree of ingress protection for the plug and/or socket. Plugs and sockets for rated currents not exceeding 10 A and rated voltage not exceeding either 250 V a.c. or 60 V d.c. do not have to comply with the requirements of 20.1 if all the following conditions are complied with:

- the part which remains energized is a socket outlet;
- the plug and socket break the rated current with delayed release to permit the arc to be extinguished before separation;
- the plug and socket remain flameproof according to IEC 60079-1 during the arc quenching period;
- the contacts remaining energized after separation are protected according to one of the specific types of protection listed in this standard or in IEC 60079-0. •

20.3 Plugs and sockets for internal connections

Plugs and sockets and similar connectors for internal connections in ignition capable circuits shall be deemed to be normally sparking unless they require a separating force of at least 15 N or they are prevented by mechanical means from loosening or separating. Where a socket is provided for the mounting of a lightweight component (for example a fuse or connection jumper) the separating force (in N) shall not be less than 100 times the mass of the component (in kg).

20.4 Sockets that do not have plugs inserted in normal operation

Sockets within apparatus which in normal operation do not have a plug inserted and which are used only for maintenance and repairing, are deemed to be non-sparking.

21 Supplementary requirements for non-sparking luminaires

The requirements of IEC 60079-0 do not apply and are replaced by the following.

NOTE Portable luminaires should also comply with the relevant requirements of this clause.

21.1 General

Luminaires shall comply with the relevant clauses of IEC 60598-2 together with the additional requirements for luminaires where specified in this standard. The basis for compliance with the relevant sections of IEC 60598-2 shall be stated by the manufacturer and included in the documentation required in Clause 36.

In addition to their classification in accordance with IEC 60598-1, luminaires shall be classified as "restricted-breathing" if they incorporate a restricted-breathing enclosure.

This standard excludes the use of luminaires for use with lamps containing free metallic sodium, i.e. low-pressure sodium lamps.

Lamps with internal ignitors can cause uncontrolled voltages which can damage ballasts or electronic ignitors. Such lamps shall not be specified for use with luminaires having type of protection "n" unless special precautions are taken to limit possible damage to auxiliaries.

NOTE 1 If certification (third party) is sought, it is not a requirement of this standard that the certification body confirm conformance to IEC 60598-1, IEC 60598-2, IEC 61184, IEC 60238, IEC 60400, IEC 61347-1, IEC 61347-2-1, IEC 61347-2-2, IEC 61347-2-3, IEC 61347-2-4, IEC 61347-2-7, IEC 61347-2-8, IEC 61347-2-9, IEC 61048, IEC 60155, IEC 60297, and IEC 60998-2-4. The manufacturer should state the basis of compliance in the documentation, see Clause 36.

NOTE 2 In order to reduce the time of testing and to allow for any tests that may be destructive, the tests may be performed on additional luminaires or parts of luminaires, provided that these are in the same materials as the original sample and the results of the test are considered to be the same as if carried out on a single sample.

21.2 Construction

21.2.1 General

The constructional requirements of the relevant section of IEC 60598-2 and also 5.3.1, 5.3.2 and 5.4 shall apply together with the requirements specified in 21.2.2 to 21.2.12.

21.2.2 Enclosure of lamp

The whole of the lamp(s) shall be enclosed within the luminaire.

21.2.3 Mounting arrangement

The mounting arrangement for restricted-breathing luminaires shall be so designed that the luminaire can pass the test for restricted-breathing whether or not it is mounted and any gaskets and/or special components necessary for this purpose shall be supplied with the luminaire.

21.2.4 Lampholders

21.2.4.1 General

Lampholders, in addition to complying with the safety and interchangeability requirements of the relevant standard, shall be of the non-sparking type according to 21.2.4.2, 21.2.4.3 and 21.2.4.4

NOTE Normal operation does not include the removal and insertion of lamps when their circuits are energized.

21.2.4.2 Bayonet non-sparking lampholders

Bayonet non-sparking lampholders shall comply with the requirements of IEC 61184. They shall incorporate spring contacts so designed that the springs are not the principal means of carrying the current. The connecting wires and their insulation shall not be damaged when the lamp is inserted or removed. The lampholder shall be of a type designed to prevent sparking under conditions of vibration.

NOTE Information for vibration tests is given in IEC 60068-2-6 in relation to the conditions of use.

21.2.4.3 Screw non-sparking lampholders

Screw non-sparking lampholders shall comply with the safety and interchangeability requirements of IEC 60238 when mounted in the luminaire. They shall also be designed to prevent the lamp becoming loose in the holder, for example, under conditions of temperature change or vibration. Compliance shall be checked by the test specified in 33.8.

21.2.4.4 Bi-pin non-sparking lampholders

Bi-pin non-sparking lampholders shall comply with the safety and interchangeability requirements of IEC 60400 when mounted in the luminaire. They shall also be designed to make and maintain contact on the barrels of the lamp pins. Contact pressures shall be adequate and the pins of the lamp shall be supported to prevent distortion when they are subject to contact side pressure. The design of the lampholder and/or the method of mounting the lampholders in the luminaire shall be such as to take the tolerance in the length of the tubular fluorescent lamps as specified in IEC 60081 or other relevant specification. The lampholder shall be of a type designed to prevent sparking under conditions of vibration.

NOTE Information for vibration tests is given in IEC 60068-2-6 in relation to the conditions of use.

21.2.5 Auxiliaries**21.2.5.1 General**

When mounted in the luminaire, auxiliaries shall comply with the electrical and mechanical safety requirements of IEC 61347-1, IEC 61347-2-1, IEC 61347-2-2, IEC 61347-2-3, IEC 61347-2-4, IEC 61347-2-7, IEC 61347-2-8, IEC 61347-2-9, IEC 61048 and IEC 60155, as applicable, or of other appropriate standards.

21.2.5.2 Glow-type starters

Glow-type starters shall be of the type in which the contacts are enclosed in a hermetically-sealed envelope (for example, glass bottle inside a metal or plastics enclosure; the enclosure does not have to be hermetically sealed).

21.2.5.3 Electronic starters and ignitors

Electronic starters and ignitors with a starting pulse voltage not exceeding 5 kV shall comply with the safety and performance requirements of IEC 61347-2-1 and IEC 60927, respectively, shall be non sparking devices and meet the requirements of 33.10. If the case is made of metal, it shall be bonded to the earth terminal of the luminaire. Electronic starters and ignitors that are either encapsulated or sealed in a case shall additionally comply with the relevant requirements specified in 33.10 and with the relevant requirements of 33.5.

Ignitors shall be subject to the endurance test in 33.10.4.1.

NOTE 1 The requirements of 33.5 and 33.10 are additional to those in the auxiliary standards. Electronic starters or ignitors which are neither encapsulated nor sealed should be assessed in accordance with the relevant clauses of this standard.

NOTE 2 Whether or not the starter is fitted with a cut-out device will influence the temperature classification (see 33.10).

21.2.5.4 Starter holders

Starter holders shall be of the non-sparking type and shall comply with the safety and interchangeability requirements of IEC 60400 when mounted in the luminaire.

Both starter and holder shall be mounted within the enclosure in such a way that the assembly is adequately supported to prevent movement that could give rise to sparking under conditions of vibration.

In particular, contacts shall be resilient and shall provide adequate contact pressure.

Compliance shall be checked by the test specified in 33.9.

21.2.5.5 Ballasts

Ballasts shall be designed so that their life is not unduly shortened when operating under the specified abnormal operating conditions (for example, failure to ignite or rectifier effect of ageing lamps). This may be achieved by the use of a thermal switch (see the specific variation from IEC 60598-1 for windings as given in 21.2.10.3.2).

Ballasts in accordance with IEC 61347-2-8 and IEC 61347-2-9 which are used with ignitors which stress the insulation of the ballast above 1 500V shall not be of the type which can only be used with ignitors having a timed cut-out. Such ballasts subjected to only the 30 day voltage impulse type test shall only be used with timed cut-out ignitors. If ignitors without timed cut-out are used, the voltage impulse test in IEC 61347-2-8 and IEC 61347-2-9 shall be run for 60 days.

Electronic ballasts according to IEC 61347-2-3, IEC 61347-2-4, IEC 61347-2-7, shall not produce temperatures in excess of the temperature class when subjected to the abnormal conditions given in those standards.

For printed circuit boards of electronic ballasts, the requirements for creepage and clearance distances in Table 3 of IEC 61347-1 apply without the exemptions permitted in that standard.

21.2.6 Reflectors

Where provision has been made on the luminaire for the attachment of reflectors, the means of attachment shall not impair the restricted breathing properties of such luminaires.

21.2.7 Creepage distances and clearances

The creepage distance and clearance requirements of the relevant clause of IEC 60598 shall apply.

In addition where circuits include ignitors that can subject lamps, lampholders and other components to high-voltage impulses in excess of 1,5 kV peak, the relevant minimum creepage distances and clearances shall comply with Table 8.

Table 8 – Creepage distances and clearances at peak values of pulse voltages greater than 1,5 kV

Part	Peak pulse voltages V_{pk}			
	kV	kV	kV	kV
	Above 1,5 and up to 2,8	Above 2,8 and up to 5,0	Above 1,5 and up to 2,8	Above 2,8 and up to 5,0
	Creepage mm		Clearances mm	
Lamp cap	4	6	4	6
Inside parts of lampholders	6	9	4	6
External parts of lampholders	8	12	6	9
Other built-in components ^a that are subject to the pulsed voltage of the ignitor	8	12	6	9

^a Unless the component itself is an encapsulated device or a sealed device.

21.2.8 Terminals

21.2.8.1 General

The terminal requirements of the relevant section of IEC 60598-2 shall apply together with the requirements specified in 21.2.8.2 to 21.2.8.4.

21.2.8.2 Looping connections

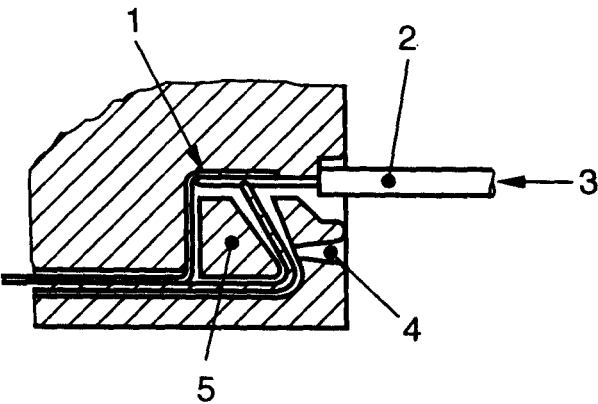
For luminaires with more than one cable or conduit entry where the entries are to be used for looping the supply and earthing conductors the manufacturer shall provide the looping connections. These shall be one of the following types:

- non-rotatable stud terminals not less than 4 mm in diameter, where each stud shall be complete with an effective arrangement of nuts and washers to ensure continuous and positive contact;
- terminals with conductors secured between pressure plates under screw pressure, provided that no more than one conductor is required to be inserted into each terminal way;
- other terminals complying with 14.1 and 14.2.1.

21.2.8.3 Internal connections

Terminals for the connection of wiring other than supply conductors shall be one of the following types:

- terminals as described in 21.2.8.2;
- pinch screw terminals if ferrules are fitted on the conductor;
- screwless terminals of the following types:
 - those that comply with the relevant clause of IEC 60598-1, except for spring-leaf terminals of the type shown in Figure 2b) of this standard;
 - the "acceptable" type of spring-leaf terminal with the conductor clamped between metal surfaces as shown in Figure 2a) for circuits meeting the relevant requirements for non-permanent connections using spring type terminals complying with 15.5 of IEC 60598-1, together with an additional type test consisting of pulling on the conductor with a force of 15 N for 1 min during which period the conductor shall not move from the terminals, damage to the conductor being disregarded;
 - twist-on connecting devices meeting the requirements of IEC 60998-2-4;
 - insulated crimped connectors.



- Key**
- | | | |
|-------------------------------|-------------------------------|-----------------------|
| 1 current-carrying conductor | 2 to withstand 15 N pull test | 3 maximum current 2 A |
| 4 connection release facility | 5 overtravel stop | |

Figure 2a) – Example of acceptable spring leaf screwless terminal construction

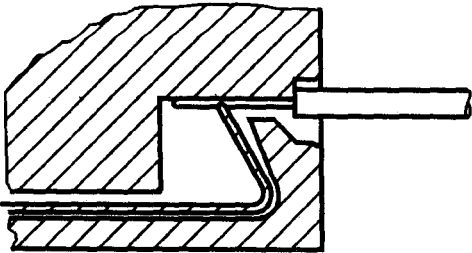


Figure 2b) – Example of non-acceptable spring leaf screwless terminal construction

Figure 2 – Spring leaf terminal

21.2.8.4 Screw type lampholder polarity

Where a screw-type lampholder is used, the centre contact of the lampholder shall be connected directly or indirectly to the live terminal of the supply connection in the luminaire.

21.2.9 External and internal wiring

The external and internal wiring requirements of the relevant clause of IEC 60598-1 shall apply together with the following.

Wiring shall be chosen and applied in accordance with temperatures and voltages that may be encountered. Where circuits include ignitors that subject some internal wiring to high-voltage impulses, such wiring shall be chosen so that the insulation is satisfactory for such impulses, which is shown by meeting the electric strength test of 33.11.

21.2.10 Endurance tests and thermal tests

21.2.10.1 General

The endurance and thermal test requirements of the relevant section of IEC 60598-2 shall apply together with the requirements specified in 21.2.10.2 to 21.2.10.4.

21.2.10.2 Thermal test (normal operation)

When tested in accordance with 12.4 of IEC 60598-1, the temperatures shall not exceed the values shown in Tables 12.1 and 12.2 of that standard.

21.2.10.3 Thermal test (abnormal conditions)

21.2.10.3.1 Temperatures except for windings

Except for windings (see 21.2.10.3.2), the temperatures shall not exceed the values given in 12.5 of IEC 60598-1 under conditions representing abnormal service conditions (where applicable but not representing a defect in the luminaire or misuse) using a test voltage of:

- a) for filament lamp luminaires, 1,10 times the voltage that would provide rated watts;
- b) for tubular fluorescent and other discharge lamp luminaires, 1,10 times the rated voltage;
- c) for luminaires containing electronic ballasts and similar devices, that value between 0,90 and 1,10 times the rated voltage which produces the most onerous condition.

21.2.10.3.2 Temperatures for windings

For windings, the values in Table 12.3 of IEC 60598-1 for the maximum temperature of a winding shall be reduced by 20 °C.

The temperature of windings of ballasts containing thermal protective devices may exceed these temperatures by up to 15 K for 15 min, prior to operation of the protective device.

21.2.10.4 Surface temperatures

21.2.10.4.1 Restricted-breathing luminaires

Under both normal and specified abnormal conditions the temperature of any part of the external surface of a restricted-breathing luminaire shall not exceed that of the declared temperature class or the declared maximum surface temperature.

21.2.10.4.2 Other luminaires

Under both normal and specified abnormal conditions, the temperature of any part of any internal or external surface of other luminaires shall not exceed that of the declared temperature class or the declared maximum surface temperature.

21.2.10.4.3 Illuminated surfaces

For spotlights and the like, the distance at which a surface illuminated by the luminaire exceeds the declared temperature class or the declared maximum surface temperature shall be determined according to the test in IEC 60598-1. If this distance exceeds 0,3 m it shall be marked on the luminaire.

21.2.11 Resistance to dust and moisture

The resistance to dust and moisture requirements of the relevant clause of IEC 60598-2 shall apply.

In addition, luminaires shall have a minimum degree of protection of IP54, which shall be marked in accordance with Clause 35.

NOTE The degree of protection requirements from IEC 60598-1 are not used.

21.2.12 Insulation resistance and electric strength

The provisions of the relevant section of IEC 60598-2 shall apply.

21.3 Other apparatus containing light sources

Light sources mounted within other apparatus shall comply with the relevant requirements of Clause 21.

22 Supplementary requirements for apparatus incorporating non-sparking cells and batteries

Except for [nL] and [Ex nL] apparatus, the requirements of IEC 60079-0 apply as modified in 22.1 through 22.6.

22.1 Categorization of cells and batteries

Cells and batteries are type categorized according to the likelihood of the evolution of electrolytic gases (for example hydrogen and/or oxygen). This standard places restrictions on the use of cells and batteries according to their type, see Table 9.

22.1.1 Type 1 cells and batteries

Type 1 cells and batteries are those which are most unlikely to vent electrolytic gases under the envisaged conditions of use.

These include all primary cells and sealed secondary cells where the operating parameters are within the manufacturer's recommended limits and the control system is either contained in the apparatus or defined in the apparatus documentation in such a way as to give equivalent control. These types of cells or batteries may be used in type "n" apparatus without additional precautions.

The technical requirements and special precautions are given in 22.2 and 22.3 and the verification and tests in 22.6.

22.1.2 Type 2 cells and batteries

Type 2 cells and batteries are those which are unlikely to vent electrolytic gas in normal operation but may do so under uncontrolled conditions.

These sealed valve regulated cells and sealed gas-tight cells, where the management system is not fully specified in accordance with the manufacturer's requirements, may be used in type "n" apparatus which does not contain parts which in normal operation produce arcs or sparks, as considered in Clauses 26 to 31.

It is, however, acceptable to incorporate these cells or batteries in such apparatus provided that they are in a separate compartment, vented directly to the atmosphere external to the enclosure. When using these cells or batteries special precautions shall be taken into account.

The technical requirements and special precautions are given in 22.2 and 22.4 and the verification and tests are given in 22.6.

22.1.3 Type 3 cells and batteries

Type 3 cells and batteries are those which are capable of venting electrolytic gas in normal operation, for example refillable lead-acid cells.

These types of cells and batteries shall be designed to avoid accumulation of gas in the compartments by directly venting them to the atmosphere external to the enclosure. The compartments shall contain no other electrical parts except those necessary to make the connections to the cells and batteries.

The technical requirements and special precautions are given in 22.5 and the verification and tests are given in 22.6.

Table 9 – Types and use of cells and batteries

Type of cell or battery	Capacity of cell or battery	Permitted activity in hazardous area			Remarks
		Discharging	Charging of secondary cells	Additional apparatus in the same compartment	
1	≤ 25 Ah	Yes	Yes	Yes	–
2	≤ 25 Ah	Yes	No ^a	Yes Only apparatus without arcs or sparks	Apparatus with sparks or arcs shall be located in a separate compartment
3	No restriction	Yes	No ^a	No	–
^a For charging in hazardous areas, special precautions are required.					

22.2 General requirements for cells and batteries of types 1 and 2

The requirements of Clause 23 of IEC 60079-0 apply, except as modified by 22.2.1 to 22.2.14.

22.2.1 Maximum capacity

The maximum capacity of the cell or battery shall not exceed 25 Ah at the rated discharge time declared by the manufacturer.

22.2.2 Secondary cells

Secondary cells or batteries shall not be used in apparatus designed for primary cells or batteries or vice versa unless the apparatus is designed specifically for use with both.

22.2.3 Cell connection

Cells shall be connected in series except for the specific case where two cells are connected in parallel with no further cells connected in series.

22.2.4 Discharge mode

Cells and batteries in discharge mode shall be used as specified by the cell or battery manufacturer.

22.2.5 Temperature

The temperature of the cell container shall not exceed the value specified by the manufacturer.

22.2.6 Creepage and clearance

Creepage and clearance distances between the poles of a cell to normal industrial cell and battery standards are permissible.

22.2.7 Connections

The electrical connections between cells and batteries shall comply with Clause 6 and be of a type recommended by the manufacturer of the cell or battery to ensure there is no excessive stress to the cell or battery.

22.2.8 Connecting cells in series

If more than three cells are connected in series, precautions shall be taken to prevent reverse polarity charging of the cell.

NOTE The actual capacity of a cell may be reduced with time. If this occurs, cells of higher actual capacity may cause cells of lower capacity to reverse.

22.2.9 Deep discharge protection

If a deep discharge protection is installed to prevent reverse polarity charging of cells, the minimum cut-off voltage shall comply with the manufacturer's specification.

NOTE Generally a maximum of six cells can be protected by one deep discharge protection circuit. If too many cells are connected in series, there may be no safe protection due to the tolerances of individual cell voltages and of the deep discharge protection circuit.

22.2.10 Temperature test conditions

For verification and test of the temperature rating, the highest discharge current in normal operation shall be taken into account.

22.2.11 Battery packs

Secondary cells or batteries shall be securely connected and assembled as a battery-pack.

NOTE This prevents faulty connections, connections of cells with different status of charge or different age.

22.2.12 Battery pack connections

If the battery pack is not an integral part of the apparatus, precautions shall be taken to safeguard against incorrect connections between the battery pack and the apparatus charger.

NOTE Suitable precautions include polarized plugs and sockets or clear marking to indicate correct assembly.

22.2.13 Cell electrolyte and gas release

If electrolyte can be ejected from cells under abnormal conditions, provision shall be made to prevent contamination of live parts. Cells and batteries without gas release under abnormal conditions do not need protection.

22.2.14 Excessive load draw

If during discharging an excessive load drawn from the cell or battery can cause damage the cell or battery affecting the type of protection "n", the maximum load or a safety device shall be specified.

22.3 Charging of type 1 cells and batteries**22.3.1 Temperature range**

The design of the charger shall take into account the ambient temperature range in which the apparatus is designed to work.

22.3.2 Charger specifications

If cells and batteries which are an integral part of the electrical apparatus are to be charged in the hazardous area, the charger shall be fully specified as part of the apparatus design.

22.3.3 Charging separated cells or batteries

Separated cells or batteries shall not be charged inside the hazardous area.

22.3.4 Charger limitations

The charging system shall be such that in normal operation the charge voltage and current do not exceed the limits specified by the manufacturer based on the specified temperature range of the apparatus.

22.3.5 Charging outside the hazardous area

If cells or batteries which are an integral part of the electrical apparatus or can be separated from the apparatus are charged outside of the hazardous area, the charging shall be within the limits specified by the manufacturer of the apparatus.

22.4 Charging of type 2 cells and batteries**22.4.1 Temperature range**

The design of the charger shall take into account the ambient temperature range in which the apparatus is designed to work.

22.4.2 Charger specifications

If cells and batteries which are an integral part of the electrical apparatus are to be charged in the hazardous area, the charger shall be fully specified as part of the apparatus design.

22.4.2.1 Charging separated cells or batteries

Separated cells or batteries shall not be charged inside the hazardous area.

22.4.2.2 Charger limitations

The charging system shall be designed such that in normal operation the charge voltage and current do not exceed the limits specified by the manufacturer, based on the specified temperature range of the apparatus.

22.4.2.3 Gassing during charging

The charging system should not normally cause gassing. However, if gassing does occur the construction of the battery container shall be such that the H_2 level in it shall not exceed 2 % V/V after 48 h.

The test to verify this shall be that a H_2 concentration of greater than 90 % V/V shall be reduced to 2 % V/V in not more than 48 h by natural dissipation in still air at a constant temperature.

22.4.2.4 Charging outside the hazardous area

If cells or batteries which are an integral part of the electrical apparatus or can be separated from the apparatus, are charged outside of the hazardous area, the recharging levels shall be within the limits specified by the manufacturer of the apparatus.

22.5 Requirements for type 3 secondary batteries

22.5.1 Types of permissible batteries

Type 3 secondary batteries shall be of the lead-acid, nickel-iron, nickel-metal hydrides or nickel-cadmium type. The capacity of type 3 secondary batteries is not restricted. For liquid filled monobloc batteries, typically used for internal combustion engine starting or small standby applications, the relevant clauses and design principles shall be applied but connection arrangements can be appropriate to the method of construction in a unit.

The tests and verification are given in 22.6.

NOTE Compliance with these requirements does not ensure safety during charging. Charging should therefore take place outside the hazardous area, unless other safety measures are applied.

22.5.2 Battery containers

22.5.2.1 Internal surfaces

Internal surfaces shall not be adversely affected by the action of the electrolyte.

22.5.2.2 Mechanical requirements

Battery containers, including covers, shall be designed so as to withstand the mechanical stresses in use; including those due to transit and handling. The design shall protect against causing short-circuits in service.

22.5.2.3 Creepage distances

The creepage distance between the poles of adjacent cells and between these poles and the battery container shall be at least 35 mm. Where nominal voltages between adjacent cells of the battery exceed 24 V, these creepage distances shall be increased by at least 1 mm for every 2 V in excess of 24 V.

22.5.2.4 Covers

The covers of battery containers shall be fixed in such a way that any inadvertent opening or displacement while in service is avoided.

22.5.2.5 Cell assembly

The assembly of cells shall be constructed in such a way that there is no significant displacement in service.

22.5.2.6 Liquid extraction

The extraction of liquid, which may have entered battery containers that do not have drain holes, shall be possible without the removal of the cells.

22.5.2.7 Ventilation

The battery container shall be provided with adequate ventilation. A degree of protection of IP23 according to IEC 60529 is sufficient for a battery container.

22.5.2.8 Plugs and sockets

Plugs and sockets shall comply with the requirements of Clause 20. This does not apply to plugs and sockets which can only be separated with the use of a tool and which bear the warning given in item c) of Table 13. Where there are single-pole positive and negative plugs and sockets, they shall not be interchangeable.

22.5.2.9 Polarity marking

The polarity of the battery connections and of plugs and sockets shall be marked clearly in a durable manner.

22.5.2.10 Other apparatus

Any other electrical apparatus affixed to or incorporated in the battery container shall comply with the relevant requirements of this standard.

22.5.2.11 Insulation resistance

New batteries, fully charged and ready for service, shall have an insulation resistance of at least 1 M Ω between the live parts and the battery container.

22.5.3 Cells

22.5.3.1 Lids

The cell lid shall be sealed to the cell container so as to prevent detachment of the cell lid and leakage of the electrolyte. Readily ignitable materials shall not be used.

22.5.3.2 Support

The positive and negative plates shall be supported effectively.

22.5.3.3 Electrolyte maintenance

Each cell requiring maintenance of the electrolyte level shall be provided with a means of indicating that the electrolyte level lies between the minimum and maximum permissible levels. Precautions shall be taken to avoid excessive corrosion of the plate lugs and the busbars when the electrolyte is at the minimum level.

22.5.3.4 Expansion space

In each cell sufficient space shall be provided to prevent the cell overflowing due to expansion of the electrolyte and also for deposition of slurry where this is likely to occur. These spaces shall be related to the anticipated life of the battery.

22.5.3.5 Filling and vent plugs

Filling and vent plugs shall be designed to prevent any ejection of the electrolyte under normal conditions of use. They shall be located in such a manner that they are easily accessible for maintenance.

22.5.3.6 Electrolyte seals

A seal shall be provided between each pole and the lid of the cell to prevent leakage of the electrolyte.

22.5.4 Connections

22.5.4.1 Intercell connections

The intercell connectors between cells that can move relative to one another shall be non-rigid. When non-rigid connections are used, each end of the connection shall be

- a) welded or soldered into the terminal post, or
- b) crimped into a copper sleeve cast into the terminal post, or
- c) crimped into a copper termination screwed by a threaded fastening to a copper insert cast into the cell terminal post.

In cases b) and c) the conductor shall be copper. In case c) the effective contact area between the termination and the cell terminal post shall be at least equal to the conductor cross-section. In calculating the effective contact area, no account shall be taken of the area of male and female threads in contact.

NOTE Although the word "copper" is used in item c) above, copper alloyed with a small amount of another metal (for example chromium or beryllium) is acceptable where it is necessary to improve the mechanical properties of the connection (for example to prevent stripping of screw threads in the copper insert). Where such alloys are used, it may be necessary to increase the contact area of the inter-cell connection to counteract any decrease in electrical conductivity caused by the other metal.

22.5.4.2 Temperature assessment

The connectors and terminations shall be able to carry the current required for the duty without exceeding the temperature class. Where the duty cannot be specified, the battery shall be assessed at the 1 h discharge rate specified by the battery manufacturer.

22.5.4.3 Connector protection

All connectors susceptible to attack by the electrolyte shall be protected in a suitable manner.

22.6 Verification and tests

NOTE These type tests apply to batteries to which the additional requirements of 22.5 apply.

22.6.1 Insulation resistance

The test conditions are given in 33.13.

22.6.2 Mechanical shock test

Batteries which are subject to mechanical shocks in normal service, for example large lead acid batteries used in lift trucks, shall be submitted to the test of 33.12. Other batteries need not be submitted to this test but this shall be noted in the descriptive documentation. The test shall be carried out only on samples of cells and their connections. Where cells of similar construction are foreseen in a range of capacities, it is not necessary to test every capacity, but only a sufficient number to allow assessment of the behaviour of the complete range.

23 Supplementary requirements for non-sparking low power apparatus

Electronic and allied low power apparatus, assemblies and sub-assemblies used, for example, for measurement, control or communication purposes, used in an area of not more than pollution degree 2, as defined in IEC 60664-1, and which do not comply with 6.7 and 6.8.2 shall comply with the following:

- a) The enclosure for the apparatus shall provide a degree of protection not less than IP54 in accordance with IEC 60529 unless the apparatus is intended to be afforded an equivalent degree of protection by location.
- b) If the rated voltage of the apparatus or the working voltage of any part of the apparatus being considered does not exceed 60 V a.c. or 75 V d.c. no minimum creepage and clearance requirements are specified. Apparatus with a rated voltage of over 60 V a.c. or 75 V d.c. up to 275 V a.c. or d.c. shall comply with the creepage and clearance requirements in Table 10.
- c) Provision shall be made, either in the apparatus or external to the apparatus, to provide the transient protection device to be set at a level not exceeding 40 % of the rated voltage at the power supply terminals of the apparatus. Where transient protection is to be provided externally the apparatus shall be marked with the symbol "X" (see Clause 29 of IEC 60079-0) and the information shall be given in the documentation (see Clause 36).

NOTE Low power is considered to be typically less than or equal to 20 W.

Table 10 – Minimum creepage distances, clearances and separations
for low power apparatus

Voltage a.c. r.m.s. or d.c. (Note 1) V	Minimum creepage distance (Note 2) mm			Minimum clearances and separation mm		
	Material group			In air	Sealed (Note 3)	Encapsulated or solid insulation (Note 4)
	I	II	III			
63	0,63	0,9	1,25	0,4	0,3	0,15
80	0,67	0,95	1,3	0,4	0,4	0,3
100	0,71	1	1,4	0,4	0,4	0,3
125	0,75	1,05	1,5	0,5	0,4	0,3
160	0,8	1,1	1,6	0,75	0,55	0,3
200	1	1,4	2	1	0,85	0,3
250	1,25	1,8	2,5	1,25	0,85	0,3
NOTE 1 Voltage steps are based on the R10 series. The actual working voltage may exceed the value given in the table by up to 10 %.						
NOTE 2 Values for creepage distances are derived from IEC 60664-1 based on pollution degree 2.						
NOTE 3 Sealed by a conformal coating, see 6.7.3.						
NOTE 4 Completely encapsulated in compound to a minimum depth of 0,4 mm, or separation through solid insulating material, for example the thickness of a printed wiring board.						
Note 5 For printed circuit boards mounted in clean dry conditions as defined in IEC 60664-1, the minimum creepage distances can be reduced to the values of the clearances and separation.						

24 Supplementary requirements for non-sparking current transformers

Where the secondary circuit of a current transformer extends outside the apparatus, the descriptive documents shall draw attention to the need to guard against the secondary circuit becoming open circuited in service.

NOTE If current transformers are fitted, under open-circuit secondary conditions, they may be capable of producing voltages which are significantly in excess of the voltage rating of the terminals employed in the current transformer circuit. Dependent on the circumstances of a particular installation, it may be appropriate to take precautions to ensure that dangerous open-circuit voltages cannot occur. For apparatus having current transformers connected to matching transformers in the switchgear (for example a differential protection system), consideration should be given to the effect on the apparatus of any possible disconnection of either set of transformers.

25 Other electrical apparatus.

Electrical apparatus which is not specifically mentioned in Clauses 17 to 24 shall comply with the requirements in Clauses 4 to 16 together with any relevant requirements of Clauses 17 to 24.

26 General supplementary requirements for apparatus producing arcs, sparks or hot surfaces

Parts which in normal operation produce arcs, sparks or hot surfaces which otherwise would be capable of igniting a surrounding atmosphere shall be protected against causing ignition by one or more of the following methods:

- a) enclosed-break device (see Clause 27);
- b) non-incendive component (see Clause 27);
- c) hermetically sealed device (see Clause 28);
- d) sealed device (see Clause 29);
- e) encapsulated device (see Clause 29);
- f) energy-limited apparatus and circuits (see Clause 30);
- g) restricted-breathing enclosure (see Clause 31).

Except for f), the temperature class shall take account only of the maximum temperature attained by the outer surface of the enclosure.

NOTE Surface temperatures within such enclosures or devices will not affect the temperature class.

Parts of the apparatus may alternatively be protected by another appropriate type of protection listed in IEC 60079-0, in which case the apparatus marking shall include the symbol for that type of protection.

27 Supplementary requirements for enclosed-break devices and non-incendive components producing arcs, sparks or hot surfaces

27.1 Type testing

Enclosed-break devices and non-incendive components shall be subjected to the type test specified in 33.4. After the test, the device or component shall show no visible signs of damage, no external ignition shall occur, and there shall be no failure to clear the arc when the switch contacts are opened.

27.2 Ratings

27.2.1 Enclosed-break devices

Enclosed-break devices shall be limited to a maximum rating of 690 V a.c., r.m.s. or d.c. and 16 A a.c. r.m.s. or dc.

NOTE An enclosed-break device prevents flame transmission to the external atmosphere under the test conditions of 33.4 by the closeness of fit of its parts which, because of the construction, form an assembly that prevents external ignition of the explosive mixture.

27.2.2 Non-incendive components

Non-incendive components shall be limited to a maximum rating of 254 V a.c., r.m.s. or d.c. and 16 A a.c., r.m.s. or d.c.

NOTE The contact arrangements of a non-incendive component quench an incipient flame and thereby prevent ignition of an external explosive atmosphere from occurring. The use of non-incendive components is limited to circuits having electrical characteristics which are similar to those of the circuit of which the components were a constituent when tested, or to less dangerous circuits, in terms of voltage, current, inductance or capacitance, for example.

27.3 Construction of enclosed-break devices

27.3.1 Free internal volume

The free internal volume shall not exceed 20 cm³.

27.3.2 Continuous operating temperature (COT) requirements

Poured seals and encapsulating compounds shall have a continuous operating temperature (COT) at least 10 K higher than that occurring when operating in the most onerous rated service conditions.

27.3.3 Seal protection

Enclosures shall be capable of withstanding normal handling and assembly operations without damage to seals.

28 Supplementary requirements for hermetically sealed devices producing arcs, sparks or hot surfaces

Hermetically sealed devices are considered as meeting the requirements for sealed devices without test.

NOTE A leakage rate equivalent to a He-leakage rate less than 10⁻² Pa·l/s (10⁻⁴ mbar·l/s) at a pressure difference of 10⁵ Pa (1 bar) is sufficient.

The enclosure shall be capable of withstanding normal handling and assembly operations without damage to the seal.

29 Supplementary requirements for sealed devices or encapsulated devices producing arcs, sparks or hot surfaces

29.1 Non-metallic materials

Where encapsulation forms part of the external enclosure of apparatus it shall comply with the requirements of 7.2

Where a sealed device has a non-metallic enclosure the enclosure shall comply with the requirements of 7.2. Seals are tested using 33.5.

29.2 Opening

Sealed devices shall be so constructed that they cannot be opened in normal operation.

29.3 Internal spaces

Sealed devices shall have a free internal volume not exceeding 100 cm³, and shall be provided, where necessary, with external connections, for example flying leads or external terminals.

Free spaces within encapsulation for components such as relays and switches may each have a free volume of 100 cm³, maximum but there shall be a minimum thickness of encapsulant of 3 mm between such components if more than one is used within the encapsulation.

NOTE Where the free spaces contain switching contacts without additional inorganic housing, the rated current of each contact should not exceed 6 A.

29.4 Handling

The device shall be capable of withstanding normal handling and assembly operations without damage.

29.5 Resilient gasket and seals

Resilient gasket and seals, including poured seals, shall be positioned so that they are not subject to mechanical damage under normal operating conditions and they shall retain their sealing properties over the expected life of the device. They shall have a continuous operating temperature (COT) at least 10 K higher than that occurring when operating in the most onerous rated service conditions. Where the device is for use in a luminaire the COT shall be at least 20 K higher than that occurring when operating in the most onerous rated service conditions. The manufacturer shall provide a material specification to substantiate the continuous operating temperature (COT).

29.6 Encapsulating compounds

Encapsulating compounds and non-resilient seals shall have a continuous operating temperature (COT) at least 10 K higher than that occurring when operating in the most onerous rated service conditions. Where the device is for use in a luminaire the COT shall be at least 20 K higher than that the maximum marked case temperature (t_c) as defined in IEC 61347-1 occurring when operating in the most onerous rated service conditions.

The manufacturer shall provide a material specification to substantiate the continuous operating temperature (COT). Where no particular material specification exists for use with devices for use in luminaires, the resistance to heat test, as specified in Section 13 of IEC 60598-1, shall be applied at a value equal to the marked maximum surface temperature +20 K.

NOTE If certification (third party) is sought, it is not a requirement of this standard that the certification body confirm conformance to IEC 61347-1. The manufacturer should state the basis of compliance in the documentation, see Clause 36.

29.7 Thickness of encapsulant

The minimum thickness of encapsulant between an internal part and the free surface of the encapsulated assembly shall be 3 mm except that for very small encapsulations having no free surface exceeding 200 mm², a minimum thickness of 1 mm is allowed. If encapsulated in an enclosure, only the free surface is considered, not the external surface of the enclosure. If a metallic enclosure is used, the minimum thickness of the layer of encapsulating resin between the enclosure and any component or conductor shall be at least 1 mm. If a non-metallic enclosure is used, no minimum thickness of the layer between the enclosure and any component or conductor is required, provided the minimum thickness of the protective enclosure is 1 mm. If this thickness is less than 1 mm, the sum of the thicknesses of enclosure and resin shall be at least 3 mm and the material of the enclosure shall be subject to the same requirements as the encapsulating resin.

NOTE The thickness of the layer may have to be greater than the minimum stated in order to comply with 33.5.4.2.

29.8 Type tests

The type tests described in 33.5 shall be performed.

30 Supplementary requirements for energy-limited apparatus and circuits producing arcs, sparks or hot surfaces

30.1 General

To determine that the stored energy in the circuit or the operational arc or spark has insufficient energy to cause ignition under the operating conditions given in this standard, the apparatus shall be analytically assessed or type tested as specified in 33.6.

NOTE 1 The energy limitation technique is based upon the philosophy of intrinsic safety (see IEC 60079-11). To ensure that ignition cannot occur, normally sparking parts are located in circuits where the energy is sufficiently limited to prevent spark or thermal ignition. The components which restrict the energy may be part of the apparatus or may be outside.

NOTE 2 Energy-limited apparatus may be interconnected with associated energy-limited apparatus not specifically examined in combination as a system when one of the following conditions is true:

- a) where maximum voltage or current is not controlled by the energy-limited apparatus

$$U_i \geq U_o; I_i \geq I_o; C_o \geq C_i + C_{\text{cable}}; L_o \geq L_i + L_{\text{cable}}$$
- b) where maximum current is controlled by the energy-limited apparatus (I_i of the energy-limited apparatus need not be greater than the I_o of the associated energy-limited apparatus)

$$U_i \geq U_o; C_o \geq C_i + C_{\text{cable}}; L_o \geq L_i + L_{\text{cable}}$$
- c) where maximum voltage is controlled by the energy-limited apparatus (U_i of the energy-limited apparatus need not be greater than the U_o of the associated energy-limited apparatus)

$$I_i \geq I_o; C_o \geq C_i + C_{\text{cable}}; L_o \geq L_i + L_{\text{cable}}$$
- d) where maximum current and voltage are controlled by the energy-limited apparatus (neither I_i nor U_i of the energy-limited apparatus need be greater than the corresponding parameter of the associated energy-limited apparatus)

$$C_o \geq C_i + C_{\text{cable}}; L_o \geq L_i + L_{\text{cable}}$$

30.2 Associated energy-limited apparatus

The apparatus shall contain a reliable means of limiting the voltage and current available to energy storing components within the energy-limited apparatus or at the output connection facilities of energy limited circuits of the associated energy-limited apparatus and at any normally sparking contact within the energy-limited apparatus, for example by the use of Zener diodes and series resistors or active current limiting. The assessment or testing of the apparatus shall take account of the stated tolerance of such components. If the voltage is derived from the mains supply via a transformer, an upward tolerance of 10 % shall be assumed, unless other information is available.

NOTE 1 Figures A.1 and A.2 in IEC 60079-11 apply only to linear circuits. Circuits with non-linear outputs are subject to special investigation.

NOTE 2 Opening, closing, shorting and earthing of the circuit at the output terminals are considered normal.

30.3 Energy-limited apparatus

The analysis or testing of the apparatus shall take account of the non-energy-limited circuit parameters defined by the manufacturer.

30.4 Self protected energy-limited apparatus

The analysis or testing of the apparatus shall consider its included functions as energy-limited apparatus and associated energy-limited apparatus.

NOTE The associated energy-limited circuits will have to be protected by another protection method such as nA or nC. The overall apparatus should therefore be marked accordingly as nA or nC (user does not need to know if apparatus includes a sparking component; user does not need to perform a loop assessment).

30.5 Separation of conducting parts

If the apparatus does not comply with Clause 23, separation of conductive parts between

- energy-limited circuits and non-energy-limited circuits, or
- different energy-limited circuits, or
- an energy-limited circuit and earthed or isolated metallic parts if the type of protection depends on the separation,

shall comply with Table 2.

30.6 Plugs and sockets

Where energy-limited or associated energy-limited apparatus is fitted with more than one plug and socket for external connections, and interchange could adversely affect the type of protection, such plugs and sockets either shall be arranged so that interchange is not possible (for example by keying), or mating plugs and sockets shall be identified to make interchanging obvious (for example by marking or colour coding).

30.7 Protection against polarity reversal

Protection shall be provided within energy-limited apparatus to prevent invalidation of the type of protection as a result of reversal of the polarity of supplies, either to the apparatus or at connections between cells of batteries where this could occur. For this purpose a single diode is considered to be acceptable.

30.8 Requirements for components on which energy limitation depends

30.8.1 Ratings of components

Any component on which the type of protection depends, except such devices as transformers, fuses, thermal trips, relays and switches, shall either

- have a failure mode such that protection is maintained, or
- operate in normal conditions at not more than two-thirds of their maximum current, voltage and power related to the rating of the device, the mounting conditions and the temperature range specified. These maximum rated values shall be those specified by the manufacturer of the component.

30.8.2 Fuses

Fuses may be used to protect other components and to limit the current flowing in energy-limited circuits. Where fuses are used for this purpose, $1,7 I_n$ shall be assumed to flow continuously where I_n is the rated current of the fuse. The fuse time-current characteristic shall ensure that the transient ratings of protected components are not exceeded.

User replaceable fuses used to protect components shall be replaceable only by opening the enclosure. The type designation and I_n or the characteristics important for energy limitation shall be marked on the apparatus.

Fuses need not meet the requirements of Table 2 but must have a rated voltage of at least U_m within associated energy-limited apparatus (or U_i within energy-limited circuits or apparatus).

Fuses in associated apparatus shall be capable of interrupting 1 500 A, unless additional current-limiting devices are fitted. These devices shall be protective components in accordance with 30.8.1.

30.8.3 Shunt safety components

Unless their failure is apparent in the operation of the apparatus, integral shunt safety components such as diodes and voltage-limiting devices shall be connected close to the protected component in such a manner that they are not likely to become disconnected.

30.9 Battery powered apparatus

Battery powered apparatus shall be considered at

- the maximum open circuit voltage in Tables 6 and 7 of IEC 60079-0 for spark ignition, and
- the nominal voltage in Tables 6 and 7 of IEC 60079-0 for temperature purposes.

30.10 Marking and documentation

The apparatus shall be marked according to Clause 35 and the documentation (see Clause 36) shall give all relevant details to enable the installer to use the apparatus safely. This shall include at least the maximum values of voltage, current, power, inductance and capacitance (including cable inductance and capacitance), which may be connected as applicable.

31 Supplementary requirements for restricted-breathing enclosures protecting apparatus producing arcs, sparks or hot surfaces

31.1 General

Protection by restricted-breathing enclosures may be applied under the following two circumstances with differing test requirements and provision for maintenance according to the particular type:

- a) Enclosures containing sparking contacts but with a limitation in dissipated power such that the average air temperature within the enclosure does not exceed the external ambient temperature by more than 10 K. However, the internal air temperature may exceed the external ambient temperature by up to 20 K if the rate of temperature decay, when the apparatus is de-energized, is limited to not more than 10 K/h.
- b) Enclosures of apparatus without internal sparking contacts and otherwise compliant with this standard except for surface temperatures of internal parts, and where only limitation of external surface temperature is necessary.

NOTE 1 The use of a restricted-breathing enclosure to protect against ignition from sparking contacts is not allowed where, because of high internal air temperatures, there is an increased risk of drawing the hazardous atmosphere into the enclosure when the apparatus is de-energized.

NOTE 2 The effects of the sun's direct heating on the exterior of the enclosure should be taken into account. This can cause a larger internal temperature change than the 10 K allowed.

NOTE 3 Restricted breathing is not suitable for apparatus operated on a short time duty cycle because of the increased probability that the apparatus might be de-energized when flammable gas or vapour surrounds the enclosure.

31.2 Test point for restricted-breathing apparatus

Apparatus of the type described in item a) of 31.1 shall be provided with a test point to enable routine testing of the restricted breathing properties to be carried out after installation and during routine maintenance. It shall be subject to the type test of 33.7.1

31.3 Test point exemption

Apparatus of the type described in item b) of 31.1 shall either have a test point fitted and be tested the same as apparatus described in item a) of 31.1, or shall be exempted from having a test point fitted and be subject to the type test of 33.7.2.

31.4 Gasket and seal requirements

Resilient gasket seals shall be positioned so that they are not subject to mechanical damage under normal operating conditions and they shall retain their sealing properties over the expected life of the device. Alternatively, the manufacturers shall recommend a nominated replacement frequency and this shall be included in the documentation. See Clause 36.

31.5 Non-resilient seals

Encapsulating compounds and non-resilient seals for apparatus described in item a) of 31.1 shall have a continuous operating temperature (COT) at least 10 K higher than that occurring when operating in the most onerous rated service conditions.

Encapsulating compounds and non-resilient seals for apparatus described in 31.1 b) shall have a continuous operating temperature (COT) at least 20 K higher than that occurring when operating in the most onerous rated service conditions.

31.6 Maintenance considerations

Restricted-breathing enclosures without the provision for carrying out checks after installation or maintenance shall be type tested, including the cable gland.

NOTE The installation instructions provided with the apparatus should contain information on the selection of entry devices and cables.

31.7 Internal fans

If internal fans are fitted, the suction shall not induce a depression at a potential source of leakage.

32 General information on verification and tests

The order of testing should be: any endurance test specified in this standard or the relevant product standard, followed by impact testing and then IP tests and, where appropriate, the restricted-breathing test.

33 Type tests

33.1 Representative samples

Representative samples shall be tested in accordance with the requirements for type tests of this standard.

33.2 Test configuration

Each test shall be made in that configuration of the apparatus which is considered to be the most unfavourable by the person making the test.

33.3 Tests for enclosures on which the type of protection depends

33.3.1 Order of tests

33.3.1.1 Non-metallic enclosures and non-metallic parts of enclosures (other than glass and ceramic)

Tests shall be made on four samples which shall be submitted first to the tests of thermal endurance to heat (see 33.3.2.1), then to the tests of thermal endurance to cold (see 33.3.2.2), then to the mechanical tests (see 33.3.3), then to the tests for degrees of protection (IP) (see 33.3.4) and then the tests for restricted breathing, if necessary (see 33.7) and finally, to any other tests specified in this standard.

33.3.1.2 Metallic enclosures, metallic parts of enclosures and glass and ceramic parts of enclosures

Tests shall be made on the number of samples specified for each test, first the mechanical tests (see 33.3.3), then to the tests for degrees of protection (IP) (see 33.3.4) and the tests for restricted breathing, if necessary (see 33.7) and finally any other tests specified in this standard.

33.3.2 Thermal endurance tests

33.3.2.1 Thermal endurance to heat

The thermal endurance to heat is determined by submitting the enclosure or parts of enclosures in non-metallic materials to continuous storage for four weeks in an ambience of $(90 \pm 5) \%$ relative humidity and at a temperature of $(10 \pm 2) \text{ K}$ above the maximum temperature in rated service.

In the case of a maximum service temperature above $85 \text{ }^{\circ}\text{C}$, the period of four weeks specified above will be replaced by a period of two weeks at $(95 \pm 2) \text{ }^{\circ}\text{C}$ and $(90 \pm 5) \%$ relative humidity followed by a period of two weeks at a temperature of $(10 \pm 2) \text{ K}$ higher than the maximum temperature in rated service.

33.3.2.2 Thermal endurance to cold

Tests shall be carried out in accordance with 26.9 of IEC 60079-0.

33.3.3 Mechanical strength tests

33.3.3.1 Tests for resistance to impact

Tests shall be carried out in accordance with 26.4.2 of IEC 60079-0.

33.3.3.2 Drop test for hand held apparatus

In addition to the test of 33.3.3.1, hand-held electrical apparatus shall be tested in accordance with 26.4.3 of IEC 60079-0.

NOTE For hand-held luminaires, the lamp filament need not remain intact after the drop test.

33.3.3.3 Criteria for compliance

When examined after the test, the enclosure shall show no significant damage. Any deformation caused by the tests shall not affect the safe operation of the electrical apparatus nor shall it reduce the clearances and creepage distances below the minimum values specified in this standard or the degree of protection of the enclosure. Any battery compartment shall remain closed and any battery block shall not be separated from the apparatus.

Superficial damage, chipping to paintwork, breakage of cooling fins or other similar parts of the electrical apparatus and small dents shall be ignored.

External fanhoods and screens may be deformed but displacement or deformation shall not cause rubbing by the moving parts.

Restricted-breathing enclosures shall be capable of passing the type tests in accordance with 33.7 after passing the type tests of this clause.

33.3.4 Tests for degree of protection (IP code) by enclosures

33.3.4.1 Test

33.3.4.1.1 General

The test procedures and acceptance criteria shall be in accordance with IEC 60529, except for electrical machines covered by Clause 17 of this standard, which shall be in accordance with IEC 60034-5.

NOTE IEC 60529 contains requirements for protection against access to hazardous parts, entry of solid foreign objects and entry of water.

For the purposes of acceptance criteria in accordance with IEC 60034-5, all dusts shall be considered to be conductive

33.3.4.1.2 Mounting

The apparatus shall be mounted in the attitude for which it was designed to operate. If there is more than one such attitude, the most onerous condition shall be chosen, which shall be noted in the test report.

33.3.4.1.3 Category determination

Where IEC 60529 is applied, apparatus shall be considered to be in category 1 as specified in 13.4 of that standard.

33.3.4.1.4 Test conditions

When tested in accordance with IEC 60529, the apparatus shall not be energized or in operation.

33.3.4.1.5 Dielectric strength test

Where no electric strength value for the test to determine adequate clearance for high-voltage apparatus (rated voltages exceeding 1 000 V a.c. or 1 200 V d.c.) is specified in a relevant product standard, the dielectric test specified in 12.3.2 of IEC 60529 shall be carried out at $(2 U_n + 1\,000) \pm 10\%$ V r.m.s. applied between 10 s and 12 s, where U_n is the maximum rated or internal voltage of the apparatus.

33.3.4.1.6 Drain holes and ventilation openings

In the case of drain holes and ventilation openings, for compliance with the acceptance criteria for IP3X and IP4X, the wire or rod shall not enter the free space of the enclosure.

33.3.4.2 Criteria for compliance supplementary to IEC 60529**33.3.4.2.1 Dust ingress**

Unless there is a more onerous requirement in a relevant product standard the criteria for compliance for IP5X, dust entry, shall be as follows:

At the conclusion of the test, talcum powder shall not have accumulated in any quantity or location such that either it or any other dust, including conducting dusts, could interfere with the correct operation, mechanical and/or electrical, of the apparatus.

33.3.4.2.2 Water ingress

Unless there is a more onerous requirement in a relevant product standard the criteria for compliance for IPXX (where the second numeral can be 1 to 7 inclusive), water ingress, shall be as follows:

At the conclusion of the test, the interior of the enclosure shall be inspected for any signs of the ingress of water. If water has entered it shall not

- a) be sufficient to interfere with the satisfactory mechanical and/or electrical operation of the apparatus,
- b) reach live parts or windings not designed to operate when wet,
- c) accumulate near to a cable entry or enter a cable.

NOTE 1 Condensation should not be mistaken for ingress of water.

NOTE 2 Wetness of rotating mechanical parts should not be regarded as failure of the test if such wetness cannot be transferred to other parts of the apparatus during rotation.

NOTE 3 Accumulated water which could be thrown up by the mechanical parts when the apparatus is operated should be assessed under a), b), or c).

NOTE 4 The preceding criteria and notes are compatible with the appropriate clauses of IEC 60034-5 and IEC 60529.

33.4 Test for enclosed-break devices and non-incendive components

33.4.1 Preparation of enclosed-break device samples

Any elastomeric or thermoplastic material which is used for the purpose of sealing a cover which is intended to be opened in service, or which is unprotected against mechanical or environmental damage, shall be removed wholly or partially before the device or component is subjected to the type test when such removal will result in a more onerous test.

NOTE Any remaining non-metallic parts of the enclosure will have been subjected to the conditioning test described in 33.3.2.

33.4.2 Preparation of non-incendive component samples

For non-incendive components, the contacts shall be preconditioned by 6 000 cycles of operations at a rate of approximately six times per minute when carrying the specified electrical load.

The component shall be arranged to ensure that the test atmosphere has access to the contacts and that a resulting explosion will be detected. This may be achieved by

- a) removing the housing adjacent to the contacts, or
- b) drilling at least two holes in the enclosure, or
- c) drawing a vacuum, then filling the test chamber with the test mixture, using a pressure detection device to detect an ignition.

33.4.3 Test conditions for enclosed-break devices and non-incendive components

33.4.3.1 General

The device or component, which shall be arranged to have the most adverse dimensions permitted by the construction drawings, shall be filled with and surrounded by an explosive mixture according to the stated group of the apparatus, as follows:

- Group IIA: (6,5 ± 0,5) % ethylene/air at atmospheric pressure;
- Group IIB: (27,5 ± 1,5) % hydrogen/air at atmospheric pressure;
- Group IIC: (34 ± 2) % hydrogen, (17 ± 1) % oxygen and the remainder nitrogen at atmospheric pressure or alternatively (27,5 ± 1,5) % hydrogen/air at an overpressure of 500 mbar.

33.4.3.2 Enclosed-break devices

For enclosed-break devices, the explosive mixture within the device shall be ignited by the operation of the enclosed contacts when connected to the maximum rated source of energy and power, and maximum load, in terms of voltage, current, frequency and power factor. A make and break test shall be repeated 10 times with a fresh explosive mixture for each test and the explosive mixture surrounding the device shall not be ignited.

33.4.3.3 Non-incendive components

For non-incendive components, the contacts shall be operated 50 times at 100 % of the normal load when the component is filled with and surrounded by the explosive mixture. This make and break test shall be repeated three times with a fresh gas mixture for each test and the explosive mixture surrounding the device shall not be ignited.

NOTE "Specified electrical load" means the current and voltage under normal operating conditions of the circuit in which the component is used or for which safety has been verified.

33.5 Tests for sealed devices and encapsulated devices

33.5.1 Conditioning

The device shall be conditioned energized at rated voltage in an air oven for 7 days at a temperature at least 10 K higher than $T_{\text{amb max}}$, or at a temperature which achieves $T_c + 10$ K or un-energized at $(80 \pm 2)^\circ\text{C}$, whichever is the greater, followed by 1 day at 10 K lower than the minimum rated service temperature.

NOTE The conditioning in accordance with 7.2 may be substituted.

33.5.2 Voltage test

The terminals of the device are connected together and a sinusoidal voltage applied for 1 min between the terminals and the outer surface of the device. The r.m.s. value is not less than V_{pk} or $(2U + 1\,000)$ V whichever is the greater, where V_{pk} is the maximum peak output voltage of the device and U is the working voltage. Where the working voltage is 42 V or less, the test voltage is 500 V instead of $(2U + 1\,000)$ V. Metal foil is placed around the outer surface of the case if the latter is made of plastics material.

Compliance shall be checked as follows: the voltage test shall not produce electrical breakdown or dangerous discharge; the sample shall be subjected to visual examination. No damage of the encapsulation that could impair the type of protection shall be evident, such as cracks in the resin or exposure of encapsulated parts.

33.5.3 Tests on devices with free space

Sealed devices and encapsulated devices with free space shall be additionally subjected to the following leakage tests.

33.5.3.1 Apparatus for leakage test on sealed devices

A container of transparent material and of sufficient volume to allow for the complete immersion of the test sample. The container shall have the following additional features according to whether method 1 or method 2 is specified by the manufacturer. Test fluid, either tap water or de-ionized water.

a) Method 1

The container shall allow heating of the test fluid to the temperature required by 33.5.3.2 a) with provision for stirring to maintain a uniform bath temperature over a long period and for the insertion of a suitable temperature measuring device.

b) Method 2

The container shall allow connection to a vacuum pump capable of reducing the pressure over the surface of the liquid and maintaining it at the required value for a minimum duration of 2 min.

33.5.3.2 Leakage test on sealed devices

- a) With the test samples at an initial temperature of $(25 \pm 2) ^\circ\text{C}$, they are suddenly immersed in water at a temperature of $(65 \pm 2) ^\circ\text{C}$ to a depth of 25 mm for 1 min. If no bubbles emerge from the samples during this test, they are considered to be "sealed" for the purposes of this standard.
- b) The test samples are immersed to a depth of 75 mm in water contained in an enclosure that can be partially evacuated. The air pressure within the enclosure is reduced by the equivalent of 120 mm Hg (16 kPa). There shall be no evidence of leakage from the interior of the device.
- c) Any other test that shows that the devices leak at a rate not greater than 10^{-5} ml of air per second at a pressure differential of 1 atmosphere (101,325 Pa).

33.5.4 Test for encapsulated devices for luminaires

33.5.4.1 Thermal cycling test

A thermal cycling test shall be made on the encapsulated device as follows:

- a) At room temperature, energize the device at normal load until the surface temperature of the device has stabilized (using the rate of rise criterion of 1 K/h).
- b) Raise the ambient temperature slowly until the surface temperature of the device is at least 10 K above the value of the maximum marked surface temperature. Maintain until the surface temperature of the device has again stabilized (using the rate of rise criterion of 1 K/h).
- c) De-energize the device and allow it to cool to room temperature.
- d) Lower the ambient temperature to $(-10 \pm 2) ^\circ\text{C}$ and allow the surface temperature to stabilize.
- e) Remove the device from the low ambient temperature and immediately energize at normal load and continue the test until the surface temperature of the device has again stabilized.

The test is completed after three cycles.

After the thermal cycling test, the voltage test described in 33.5.4.2 shall be carried out.

33.5.4.2 Dielectric withstand test

The terminals of the device are connected together and a sinusoidal voltage applied for 1 min between the terminals and the outer surface of the device. The r.m.s. value is not less than V_{pk} or $(2 U + 1\,000) \text{ V}$ whichever is the greater, where V_{pk} is the maximum peak output voltage of the device and U is the working voltage. Where the working voltage is 42 V or less, the test voltage is 500 V instead of $(2 U + 1\,000) \text{ V}$. Metal foil is placed around the outer surface of the case if the latter is made of plastics material.

Compliance shall be checked as follows:

- a) the voltage test shall not produce electrical breakdown or dangerous discharge;
- b) the sample shall be subjected to visual examination. No damage of the encapsulation that could impair the type of protection shall be evident, such as cracks in the resin or exposure of encapsulated parts.

33.5.5 Test for sealed devices for luminaires

If the device contains a poured seal or encapsulating compound in thermosetting material, the device shall be placed in a temperature cabinet and cooled to $-10\text{ }^{\circ}\text{C}$ or lower for 1 h. The device is then heated to a temperature of at least 10 K above the maximum case temperature of the device for 1 h.

If the device contains a gasket or seal of thermoplastic or elastomeric material it is heated in an air oven for 7 days at a temperature of at least 10 K above that occurring when the device is operating under maximum rated service conditions as determined by the testing laboratory or declared by the manufacturer.

The test samples shall then be subjected to one of the following leakage tests:

- a) with the test samples at an initial temperature of $(25 \pm 2)\text{ }^{\circ}\text{C}$, they are suddenly immersed in water at a temperature of $(50 \pm 2)\text{ }^{\circ}\text{C}$ to a depth of 25 mm for 1 min. If no bubbles emerge from the samples during this test, they are considered to be "sealed" for the purposes of this standard;
- b) the test samples are immersed to a depth of 75 mm in water contained in an enclosure that can be partially evacuated. The air pressure within the enclosure is reduced by the equivalent of 120 mm Hg (16 kPa). There shall be no evidence of leakage from the interior of the device;
- c) any other test that shows that the devices leak at a rate not greater than 10^{-5} ml of air per second at a pressure differential of 1 atmosphere (101,325 kPa).

33.6 Assessment and test of energy-limited apparatus and circuits

33.6.1 General

Apparatus and circuits shall be assessed or tested using the methods given in 10.1 to 10.4 of IEC 60079-11.

NOTE Figures A.1 and A.2 in IEC 60079-11 apply only to linear circuits. Circuits with non-linear outputs are subject to special investigation.

33.6.2 Test conditions

References to fault conditions and safety factors in 10.1.1 and 10.4 of IEC 60079-11 shall be ignored. The assessment or test shall relate only to the apparatus and circuit in normal operation. In 10.1.2 of IEC 60079-11, reference to Table 4 of IEC 60079-11 shall be substituted by Table 2 of this standard. For apparatus complying with Clause 23 of this standard, only switching contacts, or plugs and sockets not complying with Clause 20, shall be subjected to assessment or test.

33.6.3 Variable components

Circuits having variable components shall be tested with the components in the conditions which create the most incensive sparking.

33.7 Tests for restricted-breathing enclosures

33.7.1 Apparatus with provision for routine checking of restricted-breathing properties

Under constant temperature conditions, the time interval required for an internal pressure of 300 Pa (30 mm water gauge) below atmospheric to change to 150 Pa (15 mm water gauge) below atmospheric shall be not less than 80 s.

33.7.2 Apparatus without provision for routine checking of restricted-breathing properties

Under constant temperature conditions, the time interval required for an internal pressure of 3 kPa (300 mm water gauge) below atmospheric to change to 1,5 kPa (150 mm water gauge) below atmospheric shall be not less than 3 min.

NOTE For the tests of 33.7.1 or 33.7.2, if the design of the enclosure is such that the rate of breathing is independent of the direction of the pressure the test may alternatively be performed with a positive pressure within the enclosure.

33.7.3 Apparatus where the nominal volume of the enclosure changes due to pressure

The enclosure shall be pressurized with air maintained at an overpressure of 400 Pa. The rate of supply of air in litres per hour (l/h) required to maintain this overpressure shall be measured. The value divided by the net enclosure volume in litres (l) shall not exceed 0,125.

33.8 Test for screw lampholders

NOTE 1 These insertion and withdrawal tests do not have to be carried out with E10 lampholders.

For E14, E27 and E40 lampholders, a test cap with dimensions complying with IEC 60238 shall be fully inserted into a sample lampholder applying a torque according to the type of lampholder, as given in Table 11.

For E13, E26 and E39 lampholders, an equivalent test shall be performed based on the dimensional requirements of IEC 60238, modified for differences between related lamp caps given in IEC 60061 (all parts).

NOTE 2 If certification (third party) is sought, it is not a requirement of this standard that the certification body confirm conformance to IEC 60238. The manufacturer should state the basis of compliance in the documentation, see Clause 36.

Table 11 – Insertion torque

Lamp cap	Torque Nm
E14/E13	$1,0 \pm 0,1$
E27/E26	$1,5 \pm 0,1$
E40/E39	$2,25 \pm 0,1$

The test cap shall then be partly withdrawn by rotating through 15°

The minimum torque then required to remove the cap shall be not less than that given in Table 12.

Table 12 – Minimum removal torque

Lamp cap	Torque Nm
E14/E13	0,3
E27/E26	0,5
E40/E39	0,75
NOTE Where vibration is severe, special mounting should be provided for the luminaires.	

33.9 Test for starter holders for luminaires

Three samples of the starter holder are placed in a heating cabinet in which the ambient temperature is maintained at $(85 \pm 2)^\circ\text{C}$

After a total of 72 h, the starter holders are removed from the heating cabinet and allowed to cool for 24 h. The contact pressure is then measured by means of a device made according to the dimension of the gauge detailed in IEC 60400.

The contact force shall be not less than 5 N.

NOTE If certification (third party) is sought, it is not a requirement of this standard that the certification body confirm conformance to IEC 60400. The manufacturer should state the basis of compliance in the documentation, see Clause 36.

33.10 Tests for electronic starters for tubular fluorescent lamps and for ignitors for high pressure sodium or metal halide lamps

33.10.1 General

Ignitors are categorized according to the following alternative features:

- the peak pulse voltage (V_{pk}) generated at the lamp does not exceed 1,5 kV, 2,8 kV or 5,0 kV;
- the ignitor may or may not be fitted with a cut-out device to inhibit repeated starting attempts should the associated lamp either fail to start or fail during operation;
- the ignitor may or may not cause the peak pulse voltage to be applied to the luminaire ballast winding.

33.10.2 Moisture resistance, insulation and electric strength test

Electronic starters and ignitors shall comply with IEC 61347-1 with respect to moisture resistance, insulation and electric strength. The duration of humidity conditioning shall be 168 h.

NOTE If certification (third party) is sought, it is not a requirement of this standard that the certification body confirm conformance to IEC 61347-1. The manufacturer should state the basis of compliance in the documentation, see Clause 36.

33.10.3 Cut-out device test

Where an electronic starter or ignitor is fitted with a cut-out device, three individual units shall be tested at air temperatures of $(-25 \pm 2) ^\circ\text{C}$, $(25 \pm 2) ^\circ\text{C}$ and a temperature that is at least the maximum stated permissible case temperature $+10 \text{ K}$ (unless operating temperature limits are explicitly stated otherwise) Compliance shall be checked as follows:

- a) on starters for tubular fluorescent lamps, the starter is energized on ten successive occasions with 15 s allowed between starting attempts. The cut-out device shall operate on lamp failure (failed discharge but intact cathodes, simulated by removing lamp from circuit and replacing with dummy cathode resistors) within 10 s to prevent further lamp starting attempts;
- b) on ignitors for high pressure sodium lamps and metal/mercury halide lamps, the ignitor is operated on ten successive occasions until the cut out operates on each occasion. The cut-out device shall operate on lamp failure (failed discharge or non-ignition in cold conditions simulated by removing lamp from circuit) within 125 % of the rated time shown on the ignitor.

If all three individual units comply with the requirements, the ignitor shall be classified as "with cut-out device". If any of the three individual units fail to comply, the ignitor shall be classified as "without cut-out device" and subsequent tests shall be carried out on samples with the cut-out device isolated or removed so as to render the device inoperative and the ignitor deemed unsuitable for use where the ignitor stresses the ballast winding.

33.10.4 Life test (failed lamp)

33.10.4.1 Ignitor thermal endurance test

A further three individual ignitors shall pass the following thermal endurance test:

- a) Ignitors without a cut-out device
 - 1) Energize at the maximum rated operating voltage, at highest operating frequency (or lowest if this produces the highest temperature rise within the ignitor) in a circuit simulating the failed lamp condition.
 - 2) Raise the ambient temperature in a draught-free oven or enclosure to $60 ^\circ\text{C}$.
 - 3) Leave the ignitor in a stable state for 60 days.
 - 4) De-energize, remove the ignitor from the oven or enclosure and cool to room temperature.

b) Ignitors with a cut-out device

- 1) Raise the ambient temperature in a draught-free oven or enclosure to 60 °C.
- 2) Energize at the maximum stated operating voltage, at the highest operating frequency (or lowest if this produces highest temperature rise within ignitor), in a circuit simulating the failed lamp condition for a nominal 30 min on 30 min off cycle.
- 3) Continue the test until 500 cycles are complete.
- 4) De-energize, remove the ignitor from the oven or enclosure and cool to room temperature.

33.10.4.2 Evaluation criteria

The electronic starter/ignitor shall be re-examined and shall either:

- a) operate within the stated electrical operating characteristics and temperature classification (if assigned) and shall exhibit no mechanical or structural defect so as to render the unit unsafe or likely to generate an ignition hazard; or
- b) have failed to a "safe" condition without passing through an incandive or sparking mode and without exhibiting any mechanical or structural defect.

33.11 Test for wiring of luminaires subject to high-voltage impulses from ignitors

The test voltage at a nominal frequency of 50 Hz or 60 Hz is applied for 1 min between the conductor and a metal foil of width 25 mm wrapped around the external surfaces of the test sample insulation but not nearer than 25 mm to the bare conductors. The test sample is at least 500 mm long

The voltage is 3 kV r.m.s. in circuits using ignitors marked with 2,8 kV, or 5 kV r.m.s. in circuits using ignitors marked 5,0 kV.

No flashover or breakdown shall occur during the test.

33.12 Mechanical shock test for batteries

33.12.1 General

The test shall be carried out on a sample, comprising at least four new and fully charged cells in a 2 × 2 formation complete with internal connectors. The sample shall be in ready-for-use condition.

The sample shall be mounted in its normal operating attitude and by its normal means of attachment, either directly or by means of a rigid fixture, to the mounting surface of the shock machine. The mounting shall satisfy the requirements of 4.3 of IEC 60068-2-27.

The shock machine shall generate a half-sine pulse as shown in Figure 2 of IEC 60068-2-27. The velocity change tolerance, transverse motion and measuring system shall satisfy the requirements of 4.1.2, 4.1.3 and 4.2 respectively of IEC 60068-2-27. The peak acceleration value shall be 5 g_n as defined in Table I of IEC 60068-2-27.

33.12.2 Test procedure

The test procedure shall be as follows:

- a) the capacity of the sample is determined;
- b) a constant 5 h discharge current flows during the test;
- c) 15 independent shocks are applied to the sample as follows:
 - 1) three successive shocks in the vertically upwards direction,
 - 2) three successive shocks in each direction along two perpendicular axes in the horizontal plane. These axes are chosen so as to reveal possible weaknesses.
- d) after recharging, the capacity is again determined.

33.12.3 Evaluation criteria

The three following conditions shall be satisfied:

- a) no abrupt change in voltage during the test;
- b) no visible damage or deformation;
- c) no reduction in capacity of more than 5 %.

33.13 Insulation resistance test for batteries

33.13.1 Test conditions

The test conditions are as follows:

- a) the measuring voltage of the ohmmeter shall be at least 100 V;
- b) all connections between the battery and the external circuits and, where fitted, the battery container shall be disconnected;
- c) the cells shall be filled with electrolyte up to the maximum permissible level.

33.13.2 Evaluation criteria

The insulation resistance is considered satisfactory if the measured value is at least equal to the value specified in 22.5.2.11

33.14 Additional ignition tests for large or high-voltage machines

33.14.1 Test for cage rotor construction

33.14.1.1 General

The test shall be carried out using a machine having a stator and rotor that are representative of a finished machine in terms of the stator core and windings, and the rotor core and cage. This shall include ducts, centring rings, rings under the end rings and balance discs, where appropriate.

33.14.1.2 Rotor cage ageing process

The rotor cage shall be subject to an ageing process comprising a minimum of five locked rotor tests. The maximum temperature of the cage shall cycle between the maximum design temperature and less than 70 °C. The applied voltage shall be not less than 50 % of the rated voltage.

33.14.1.3 Ignition test

After the ageing process of 33.14.1.2 the machine shall be filled with, or immersed in, an explosive gas mixture comprised of $(21 \pm 5) \%$ hydrogen-in-air, v/v. Motors shall be subjected to 10 direct-on-line uncoupled starts or 10 locked rotor tests. These tests shall have a duration of at least 1 s.

During the tests, the terminal voltage shall not fall below 90 % of the rated voltage. The concentration of hydrogen shall be confirmed after each test.

No explosion shall occur.

NOTE Compliance with this test does not guarantee that the motor may not produce sparks under severe environmental and operation conditions. See 17.9.1.

33.14.2 Test for stator winding insulation system incandivity**33.14.2.1 General**

The tests shall be carried out on any of the following:

- one complete stator;
- one stator with motor enclosure;
- one motor;
- a partially wound stator;
- a group of coils.

In all cases, the test model shall be representative of a complete stator with, where appropriate, corona shield, stress grading, packing and bracing, impregnation and conductive parts such as the stator core. All exposed conductive parts shall be earthed.

33.14.2.2 Test conditions

Typical stator connection cables arrangements shall be tested either on one complete stator or in a representative model. Particular care shall be taken with the spacing of the cables, both from each other and from adjacent conductive parts. All such exposed conductive parts shall be earthed.

33.14.2.3 Steady state ignition test

Insulation systems and connection cables shall be tested in an explosive gas mixture comprised of $(21 \pm 5) \%$ hydrogen-in-air, v/v with a sinusoidal voltage of 1,5 times the rated r.m.s. line voltage for 3 min. The maximum rate of voltage rise shall be 0,5 kV/s. The voltage shall be applied between one phase and earth with the other phases earthed.

No explosion shall occur.

NOTE Compliance with this test does not guarantee that the motor may not produce sparks under severe environmental and operation conditions. See 17.9.1.

33.14.2.4 Impulse ignition test

Insulation systems and connecting cables shall be tested in an explosive gas mixture comprised of $(21 \pm 5) \%$ hydrogen-in-air, v/v. They shall be subjected to 10 voltage impulses of three times peak phase voltage, with a tolerance of $\pm 3 \%$ and with a voltage rise time between $0,2 \mu\text{s}$ and $0,5 \mu\text{s}$, and with a time to half value which is at least $20 \mu\text{s}$ but normally not exceeding $30 \mu\text{s}$. The impulses shall be applied phase-to-phase and separately phase-to-earth.

NOTE This is a non-standard waveform but it is believed that it is necessary to use a short rise time to initiate discharge with a sufficient length to contain enough energy for ignition. This is based on the results of experiments conducted by Physikalisch-Technische Bundesanstalt (PTB), in Germany.

No explosion shall occur

34 Routine verifications and tests

34.1 General

The manufacturer shall make the routine verifications and tests necessary to ensure that the electrical apparatus produced complies with the apparatus specification in accordance with the requirements of IEC 60079-0. The manufacturer shall also make any relevant routine tests given in 34.2.

34.2 Specific routine tests

34.2.1 Electric strength test

A dielectric strength test shall be carried out in accordance with 6.8.1. Alternatively, the test shall be carried out at 1,2 times the test voltage, but shall be maintained for at least 100 ms.

NOTE In some cases, the actual test period could be significantly longer than 100 ms as a sample with a large distributed capacitance may take some additional time to reach the actual test voltage.

34.2.2 Alternate dielectric strength test

For apparatus subject to the exception of 6.7.1, the test of 6.8.2 shall be performed as a routine test. Alternatively, a test shall be carried out at 1,2 times the test voltage, but shall be maintained for at least 100 ms.

34.2.3 Restricted-breathing routine test

For restricted-breathing enclosures without a means of checking restricted breathing after installation, the test of 33.7.2 shall be performed as a routine test. This test may be shortened by checking that the time taken for the pressure change of 3 kPa (300 mm water gauge) to 2,7 kPa (270 mm water gauge) is greater than 27 s.

34.2.4 Routine tests for electronic starters and ignitors

For electronic starters for tubular fluorescent lamps and for ignitors for high pressure sodium or metal halide lamps, a routine test is carried out in accordance with the voltage type test of 33.10.3 but for a period of 3 s.

35 Marking

35.1 General

Marking shall include the required elements of IEC 60079-0, and also any other marking required by this standard and other relevant standards with which the apparatus complies. The marking shall also include any marking normally required by the standards for construction of the electrical apparatus.

Gas groups shall be marked for apparatus protected by types of protection energy-limited, associated energy-limited and enclosed break devices.

Where it is necessary to include marking from one of the other methods of protection listed in IEC 60079-0, the marking required by this part of the standard shall occur first.

NOTE This is to avoid possible confusion over the suitability of the apparatus for a specific location.

For non-incendive components and energy-limited apparatus and components, marking shall include all the electrical parameters concerning explosion safety (for example: voltage, current, inductance and capacitance) as applicable.

35.2 Additional marking for batteries

For batteries the following marking shall be indicated:

- the type of construction of cells;
- number of cells and nominal voltage;
- rated capacity with the corresponding duration of discharge.

If no safety measures are applied then the battery container or battery pack shall carry the warning given in item d) of Table 13.

If it is possible to insert both primary and secondary cells in the apparatus or battery container when these are only designed for secondary cells, shall carry the warning given in item e) of Table 13.

NOTE Instructions for use (instructions for maintenance), for display in the battery charging station, should be supplied with each battery. These should include all instructions necessary for charging, use and maintenance.

The instructions for use should include at least the following information:

- the name of the manufacturer or supplier or his registered trade mark,
- the manufacturer's type identification,
- the number of cells and the nominal voltage of the battery,
- the rated capacity with the corresponding duration of discharge,
- the charging instructions,
- any other conditions concerning the safe operation of the battery, for example the lifting of the cover during charging, the minimum time before closing the cover because of the release of gas after termination of charging, the checking of the electrolyte level, the specifications for the electrolyte water for topping up.

35.3 Examples of marking³

NOTE These examples do not include the marking normally required by the standards for construction of the apparatus.

- Example 1: Non-sparking apparatus incorporating a flameproof lighting fitting for ambient temperature range $-20\text{ }^{\circ}\text{C}$ to $+60\text{ }^{\circ}\text{C}$, with special conditions for safe use and without third-party certification.

ABC Industries Ltd

Type HXR

Ex nA d IIB T3

$-20\text{ }^{\circ}\text{C} \leq T_a \leq +60\text{ }^{\circ}\text{C}$

Certificate number: 045673X

- Example 2: An apparatus with restricted-breathing enclosure as a component without third-party certification.

XYZ Ltd

Type 1456

Ex nR II

Certificate number: 986U

- Example 3: A self protected energy limited apparatus for gas of subdivision C and ignition temperature less than $135\text{ }^{\circ}\text{C}$ and suitable for mounting in a hazardous area.

G. Schwarz A.G.

Model FUb69

Ex nA nL IIC T4

IECEX-04.3412

- Example 4: A limited energy apparatus gas of subdivision B and a surface temperature less than $100\text{ }^{\circ}\text{C}$. Includes the input parameters for the apparatus.

G. Smith Inc

1 000 CV transmitter

Ex nL IIB T5

$U_i = 30\text{ V}$; $I_i = 20\text{ mA}$; $P_i = 1\text{ W}$; $C_i = 30\text{ nF}$; $L_i = 1\text{ mH}$

Certificate No. Ex 04.16542

- Example 5: A non-sparking apparatus with non-sparking associated energy apparatus with energy limited output for gas of subdivision C and a surface temperature of less than $100\text{ }^{\circ}\text{C}$. Includes the output parameters for the energy limited apparatus and cable.

K Chambers LLC

PSU Type 54

Ex nA [nL] IIC T5

$U_o = 30\text{ V}$; $I_o = 20\text{ mA}$; $P_o = 1\text{ W}$; $C_o = 100\text{ nF}$; $L_o = 10\text{ mH}$

Certificate No. IECEX 05.9876

³ Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

35.3.1 Warning markings

Where any of the following markings are required on the apparatus, the text as described in Table 13, following the word "WARNING", may be replaced by technically equivalent text. Multiple warnings may be combined into one equivalent warning.

Table 13 – Text of warning markings

	Reference	Warning marking
a	19.4	WARNING – DO NOT REMOVE OR REPLACE FUSE WHEN ENERGIZED
b*	20.1(b)	WARNING – DO NOT SEPARATE WHEN ENERGIZED
c*	22.5.2.8	WARNING – SEPARATE ONLY IN A NON-HAZARDOUS AREA
d	35.2	WARNING – DO NOT CHARGE IN A HAZARDOUS AREA
e	35.2	WARNING – DO NOT USE PRIMARY CELLS
* Identical to the warning markings in IEC 60079-0.		

36 Documentation

Documentation in addition to that required in Clause 24 and Clause 25 of IEC 60079-0 shall be provided when specified in this standard. Additional documentation required includes:

- information on reduced ingress protection for components (see 6.6.1);
- the degree of protection when it is provided by the installation (see 6.6.2);
- the basis of compliance of rotating machines to IEC 60034 (see 17.1);
- information where special measures are to be employed to ensure that the enclosure of a large rotating machine rated over 100 kW does not contain an explosive gas atmosphere at the time of starting (see 17.7.3);
- information on the permitted starting frequency, the recommended time between major overhauls (disassembly and cleaning) and the intended environmental conditions of rotating electrical machines rated over 1 kV (see 17.9.1.3);
- information on special measures employed to ensure the enclosure of a rotating electrical machine rated over 1 kV does not contain an explosive gas atmosphere at the time of starting (see item b) of 17.9.2);
- information concerning the basis of compliance of luminaires to the relevant subclauses of IEC 60598-2 (see 21.1);
- information where external transient limiting means are to be provided for non-sparking low power apparatus (see Clause 23);
- information for the safe installation and use of energy limited apparatus, including at least the maximum values of voltage, current, power, inductance and capacitance (including cable inductance and capacitance) which may be connected (see 30.10);
- information on the replacement frequency for gaskets of restrictive-breathing enclosures (see 31.4).

37 Instructions

Instructions shall be provided in accordance with Clause 30 of IEC 60079-0.

BIS is a statutory institution established under the *Bureau of Indian Standards Act, 1986* to promote harmonious development of the activities of standardization, marking and quality certification of goods and attending to connected matters in the country.

BIS has the copyright of all its publications. No part of these publications may be reproduced in any form without the prior permission in writing of BIS. This does not preclude the free use, in the course of implementing the standard, of necessary details, such as symbols and sizes, type or grade designations. Enquiries relating to copyright be addressed to the Director (Publications), BIS.

Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of 'BIS Catalogue' and 'Standards: Monthly Additions'.

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

Branches : AHMEDABAD. BANGALORE. BHOPAL. BHUBANESHWAR. COIMBATORE. FARIDABAD. GHAZIABAD. GUWAHATI. HYDERABAD. JAIPUR. KANPUR. LUCKNOW. NAGPUR. PARWANOO. PATNA. PUNE. RAJKOT. THIRUVANANTHAPURAM. VISAKHAPATNAM.