

INTERNATIONAL STANDARD

IEC 60079-15

Second edition
2001-02

Electrical apparatus for explosive gas atmospheres –

Part 15: Type of protection "n"

Matériel électrique pour atmosphères explosives gazeuses –

*Partie 15:
Mode de protection «n»*



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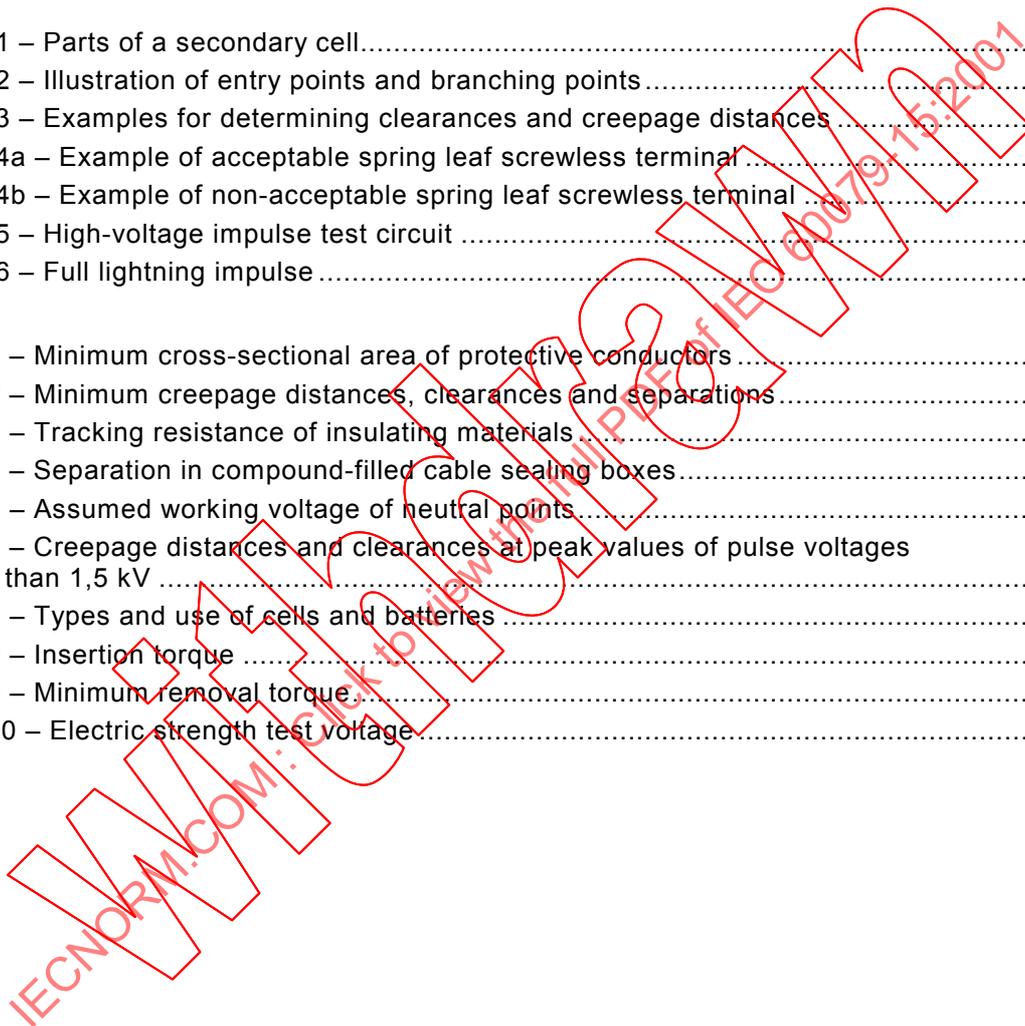
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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ELECTRICAL APPARATUS FOR EXPLOSIVE GAS ATMOSPHERES –**Part 15: Type of protection "n"**

FOREWORD

- 1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 60079-15 has been prepared by IEC technical committee 31: Electrical apparatus for explosive atmospheres.

This second edition cancels and replaces the first edition which was issued as a technical report in 1987. It constitutes a technical revision and now has the status of an International Standard.

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

FDIS	Report on voting
31/346/FDIS	31/353/RVD

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 3.

The committee has decided that the contents of this publication will remain unchanged until 2004. At this date, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

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

ELECTRICAL APPARATUS FOR EXPLOSIVE GAS ATMOSPHERES –

Part 15: Type of protection "n"

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 standard 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.

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.

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.

This standard supplements, and may enhance, the requirements for apparatus for normal industrial applications.

NOTE This standard makes several specific references to IEC 60079-0. It is not intended that apparatus with type of protection "n" should comply with IEC 60079-0 in its entirety, or that the level of protection achieved by compliance with this standard should be equal to the level of protection achieved by compliance with IEC 60079-0 and any of the types of protection listed therein.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 60079. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of IEC 60079 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid standards.

IEC 60034 (all parts), *Rotating electrical machines*

IEC 60034-1:1996, *Rotating electrical machines – Part 1: Rating and performance*¹

IEC 60034-5, *Rotating electrical machines – Part 5: Classification of degrees of protection provided by enclosures of rotating electrical machines (IP code)*

IEC 60050-411, *International Electrotechnical Vocabulary – Chapter 411: Rotating machinery*

¹ A consolidated edition 10.2 exists (1999) that includes IEC 60034-1 (1996), its amendment 1 (1997) and its amendment 2 (1999).

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

IEC 60050(486), *International Electrotechnical Vocabulary – Chapter 486: Secondary cells and batteries*

IEC 60060 (all parts), *High-voltage test techniques*

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 60079-0:1998, *Electrical apparatus for explosive gas atmospheres – Part 0: General requirements*²

IEC 60079-2, *Electrical apparatus for explosive gas atmospheres – Part 2: Electrical apparatus, type of protection "p"*³

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

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

IEC 60112, *Method for determining the comparative and the proof tracking indices of solid insulating materials under moist conditions*

IEC 60155, *Glow-starters for fluorescent lamps*

IEC 60216-1:1990, *Guide for the determination of thermal endurance properties of electrical insulating materials – Part 1: General guidelines for ageing procedures and evaluation of test results*⁴

IEC 60216-2, *Guide for the determination of thermal endurance properties of electrical insulating materials – Part 2: Choice of test criteria*

IEC 60238:1998, *Edison screw lampholders*⁵

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 starter holders*

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

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

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

IEC 60662:1992, *High-pressure sodium vapour lamps*

² A consolidated edition 3.1 exists (2000) that includes IEC 60079-0 (1998) and its amendment 1 (2000).

³ Fourth edition in preparation.

⁴ Fifth edition in preparation.

⁵ A consolidated edition 7.1 exists (2000) that includes IEC 60238 (1998) and its amendment 1 (1999).

IEC 60664-1, *Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests* ⁶

IEC 60920, *Ballasts for tubular fluorescent lamps – General and safety requirements*

IEC 60922, *Auxiliaries for lamps – Ballasts for discharge lamps (excluding tubular fluorescent lamps) – General and safety requirements*

IEC 60924, *D.C. supplied electronic ballasts for tubular fluorescent lamps – General and safety requirements*

IEC 60926, 1995, *Auxiliaries for lamps – Starting devices (other than glow starters) – General and safety requirements* ⁷

IEC 60927, 1996, *Auxiliaries for lamps – Starting devices (other than glow starters) – Performance requirements* ⁸

IEC 60928: 1995, *Auxiliaries for lamps – A.C. supplied electronic ballasts for tubular fluorescent lamps – General and safety requirements* ⁹

IEC 60998-2-4, 1991, *Connecting devices for low-voltage circuits for household and similar purposes – Part 2-4: Particular requirements for twist-on connecting devices*

IEC 61048, *Capacitors for use in tubular fluorescent and other discharge lamp circuits – General and safety requirements* ¹⁰

IEC 61049, *Capacitors for use in tubular fluorescent and other discharge lamp circuits – Performance requirements*

IEC 61184, *Bayonet lampholders*

3 Definitions

For the purpose of this part of IEC 60079, the definitions given in IEC 60079-0 as well as the following definitions apply.

NOTE Definitions marked ⁽¹⁾ differ from the equivalent definitions in IEC 60079-0. It is proposed that the definitions in IEC 60079-0 be modified to accommodate the slight differences needed for use with this standard, at which time definitions in this standard will be deleted.

3.1

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

⁶ A consolidated edition 1.1 exists (2000) that includes IEC 60664 (1992) and its amendment 1 (2000).

⁷ A consolidated edition 2.1 exists (2000) that includes IEC 60926 (1995) and its amendment 1 (1999).

⁸ A consolidated edition 2.1 exists (2000) that includes IEC 60927 (1996) and its amendment 1 (1999).

⁹ A consolidated edition 2.1 exists (1999) that includes IEC 60928 (1995) and its amendment 1 (1999).

¹⁰ A consolidated edition 1.2 exists (1999) that includes IEC 61048 (1991), its amendment 1 (1995) and its amendment 2 (1999).

3.2

(electrochemical) cell or battery

electrochemical system capable of storing in chemical form the electric energy received and which can give it back by reconversion

[IEV 486-01-01]

3.2.1

secondary cell

assembly of electrodes and electrolyte which constitutes the basic unit of a secondary battery

[IEV 486-01-02]

NOTE 1 A cell consists substantially of positive and negative plates and separators, of the items needed for assembling and connecting (plate lugs, group bars, terminal posts), of the cell container, and the electrolyte.

NOTE 2 A sketch illustrating various parts of a cell is given in figure 1. This sketch is included for descriptive purposes only and is not intended to imply any requirements or preference for a particular form of construction.

3.2.2

secondary battery

two or more secondary cells connected together and used as a source of electric energy

[IEV 486-01-03]

3.2.3

container (of a cell)

container for the plate pack and electrolyte of a cell made of a material impervious to attack by the electrolyte

[IEV 486-02-20]

3.2.4

(battery) container

enclosure to contain the battery

NOTE The cover is a part of the battery container.

3.2.5

battery capacity

quantity of electricity or electric charge, which a fully charged battery can deliver under specified conditions

NOTE The SI unit for electrical charge is the coulomb (1 C = 1 As) but in practice, battery capacity is usually expressed in ampere-hours (Ah).

[IEV 486-03-01]

3.2.6

plate pack

assembly of the positive and negative plate groups with separators

[IEV 486-02-15]

3.2.7

intercell connector

conductor of electricity used for carrying current between cells

[IEV 486-02-31]

3.3

clearance

shortest distance in air between two conductive parts

(IEC 60664-1)

3.4

continuous operating temperature (COT)

maximum temperature which ensures the stability and integrity of the material for the expected life of the apparatus, or part, in its intended application

3.5

creepage distance

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

3.6

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]

3.7

encapsulated device

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.

3.8

enclosed-break device

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

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

3.9.1

energy-limited apparatus

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

3.9.2

associated energy-limited apparatus

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;
- b) electrical apparatus which has an alternative type of protection listed in IEC 60079-0 for use in the appropriate explosive gas atmosphere;
- 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

3.9.3

self protected energy-limited apparatus

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

3.10

Ex component ¹⁾

part of electrical apparatus or a module (other than an Ex cable entry), marked with the symbol "U", which is not intended to be used alone and requires additional consideration when incorporated into electrical apparatus or systems for use in explosive gas atmospheres

3.11

hand-held apparatus

portable apparatus intended to be supported by one hand during normal use

3.12

hermetically-sealed device

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

3.13

maximum external capacitance, C_o

maximum capacitance in an energy-limited circuit that can be connected to the connection facilities of the apparatus

3.14

maximum external inductance, L_o

maximum value of inductance in an energy-limited circuit that can be connected to the connection facilities of the apparatus

3.15

maximum input current, I_i

maximum current (peak a.c. or d.c.) that can be safely applied in normal operation to the connection facilities of an energy-limited apparatus

3.16

maximum input power, P_i

maximum power that can be safely dissipated in normal operation within an energy-limited apparatus

3.17

maximum input voltage, U_i

maximum voltage (peak a.c. or d.c.) that can be safely applied in normal operation to the connection facilities of an energy-limited apparatus

3.18

maximum internal capacitance, C_i

total equivalent internal capacitance of the apparatus containing energy-limited circuits which is considered as appearing across the connection facilities of the apparatus in normal operation

3.19

maximum internal inductance, L_i

total equivalent internal inductance of the apparatus containing energy-limited circuits which is considered as appearing at the connection facilities of the apparatus in normal operation

3.20**maximum output current (I_o)**

maximum current (peak a.c. or d.c.) that can be taken in normal operation, including short circuit at the terminals, from the connection facilities of an apparatus connected to an energy-limited circuit

3.21**maximum output power, P_o**

maximum power that can be taken in normal operation from the connection facilities of an apparatus connected to an energy-limited circuit

3.22**maximum output voltage, U_o**

maximum voltage (peak a.c. or d.c.) that can appear in normal operation, including open circuit conditions, at the connection facilities of an apparatus connected to an energy-limited circuit

3.23**maximum r.m.s. a.c. or d.c. voltage, U_m**

maximum voltage that can be applied to the non-energy-limited connection facilities of associated energy-limited apparatus without invalidating the energy limitation

3.24**non-incendive component**

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

3.25**non-sparking device**

device constructed to minimize the risk of occurrence of arcs or sparks capable of creating an ignition hazard during conditions of use. Normal use excludes the removal or insertion of components with the circuit energized

3.26**normal operation**

operation of apparatus conforming electrically and mechanically with its design specification and used within the limits specified by the manufacturer

NOTE 1 The limits specified by the manufacturer may include persistent operational conditions, for example operation of a motor on a duty cycle.

NOTE 2 Variation of the supply voltage within stated limits and any other operational tolerance is part of normal operation.

3.27**n-pressurization**

technique of applying a protective gas to an enclosure in order to prevent the formation of an explosive atmosphere inside the enclosure by maintaining an overpressure against the surrounding atmosphere

NOTE n-pressurization is based on a limited range of techniques selected from those given in IEC 60079-2 which specifies different methods of applying purge and pressurization techniques. It does not apply to circumstances where there is an internal source of release.

3.28**portable apparatus**

apparatus intended to be carried by hand

3.29**restricted-breathing enclosure**

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

3.30**sealed device**

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

3.31**sealed gas-tight cell or battery**

cell or battery which remains closed and does not release either gas or liquid when operated within the limits of charge or temperature specified by the manufacturer

NOTE Such cells and batteries may be equipped with a safety device to prevent dangerously high internal pressure. The cell or battery does not require addition to the electrolyte and is designed to operate during its life in its original sealed state.

3.32**sealed valve regulated cell or battery**

cell or battery which is closed under normal conditions but which has an arrangement which allows the escape of gas if the internal pressure exceeds a predetermined value. The cell or battery cannot normally receive an addition to the electrolyte

3.33**separation**

shortest distance through solid insulating material between two conductive parts

3.34**stopping box**

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

3.35**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.

3.36**"U" symbol ¹⁾**

symbol used (usually as a suffix to a certificate reference) to denote an Ex component

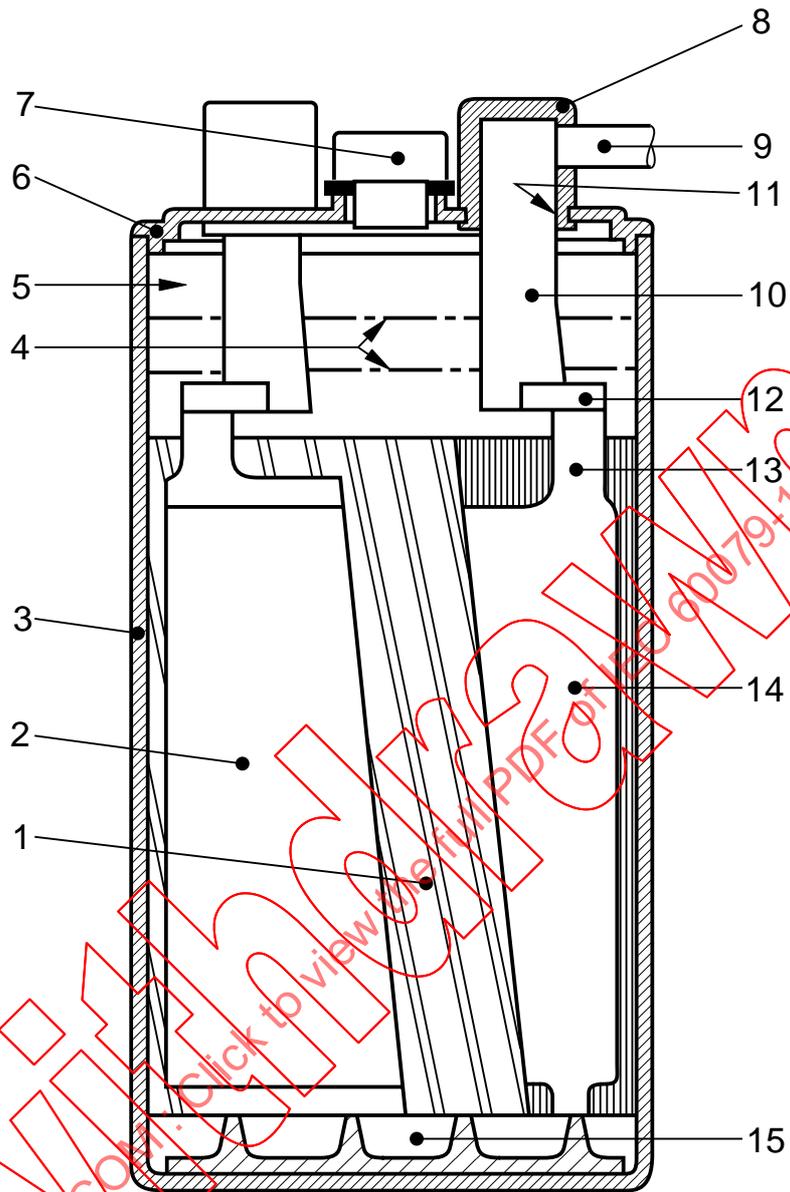
NOTE The symbols "X" and "U" should not be used together.

3.37**working voltage**

highest r.m.s. value of the a.c. or d.c. voltage which may occur (locally) across any insulation at rated supply volts, transients being disregarded, in open circuit conditions or under normal operating conditions

3.38**"X" symbol ¹⁾**

symbol used (usually as a suffix to a certificate reference) to denote special conditions for safe use



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NOTE This sketch is included for descriptive purposes only and is not intended to imply any requirements or preference for a particular form of construction.

Key

- | | |
|-------------------------------|---|
| 1 Separator | 9 Intercell connector |
| 2 Positive plate | 10 Terminal post |
| 3 Cell container | 11 Electrolyte-tight terminal post seal |
| 4 Electrolyte level (max/min) | 12 Group bar |
| 5 Headspace | 13 Plate lug |
| 6 Electrolyte-tight lid seal | 14 Negative plate |
| 7 Filler and vent plug | 15 Slurry space |
| 8 Post encapsulation | |

Figure 1 – Parts of a secondary cell

4 General

4.1 Potential ignition sources

The apparatus shall not in normal operation and in certain abnormal conditions specified by this standard:

- 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 17 to 23;
- 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 17 to 23 as appropriate, or is otherwise shown to be safe as specified in 4.3.3.

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.

4.2 Apparatus grouping

Apparatus shall be designated as group II unless specified otherwise in this standard when it shall be designated as one of the following subgroups of group II: IIA, IIB or IIC.

Where electrical apparatus is for use only in a particular gas, it shall be tested accordingly and it shall be marked with the symbol II and the name or chemical formula of the gas (see clause 28).

NOTE For the purpose of this standard, the allocation of gases is as for the apparatus groupings in IEC 60079-0.

4.3 Temperatures

4.3.1 Maximum surface temperature

Subclause 5.1.2 of IEC 60079-0 applies.

The internal parts of enclosed-break devices, restricted-breathing enclosures, hermetically sealed devices, lamps, sealed devices, n-pressurization enclosures (but see 23.3 for qualification) or components or apparatus complying with 4.3.3 need not comply with the requirements for maximum surface temperature.

4.3.2 Ambient temperatures

Subclause 5.2 of IEC 60079-0 applies.

4.3.3 Surface temperature and ignition temperature

Subclause 5.3 of IEC 60079-0 applies, including the reference to IEC 60079-11 for relaxations which may be applicable to type "n" apparatus having small components, thin wires or printed circuit tracks.

4.4 Electrical apparatus

Electrical apparatus with type of protection "n" shall comply with the requirements of this standard.

4.5 Ex components

4.5.1 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.

4.5.2 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).

4.5.3 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).

4.5.4 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.

4.6 Other requirements

Electrical apparatus and Ex components shall be constructed in accordance with the principles of good engineering practice in safety matters.

NOTE 1 If certification is sought, it is not the responsibility of the certifying body or testing station to check compliance with this requirement. The manufacturer should indicate compliance by marking the apparatus or component in accordance with clause 28 and by stating the basis of compliance in the documentation (see clause 29).

NOTE 2 If the electrical apparatus or Ex component is intended to withstand particularly adverse service conditions (for example rough handling, humidity effects, ambient temperature variations, effects of chemical agents, corrosion) these have to be specified to the manufacturer by the user. If certification is sought, it is not the responsibility of the certifying body or testing station to confirm suitability for the adverse conditions. Special precautions should be taken when vibration effects on terminals, fuse holders, lampholders and current-carrying connections in general may impair safety, unless they comply with specific standards.

5 Construction

5.1 Degree of protection

5.1.1 Unless specified elsewhere in this standard, the enclosure of the apparatus, when tested in accordance with 26.3.4 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, thermocouples) in which case the documentation (see clause 29) shall explain why and shall prescribe any special installation requirements which may be necessary and in which case the apparatus shall be marked with the symbol "X" (see clause 28):

- 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 28).

For protected apparatus, the degree of protection shall be marked according to clause 28.

NOTE For requirements for rotating electrical machines, see clause 9.

5.1.2 Where the degree of protection provided by the enclosure depends on a gasketed joint which is intended to be opened for installation or maintenance purposes, gaskets shall be attached or secured to one of the mating faces to prevent loss, damage or incorrect assembly. The gasket material shall not itself adhere to the other joint face.

NOTE An adhesive may be used for attaching a gasket to one of the mating faces.

5.1.3 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 29.

5.2 Mechanical strength

Enclosures shall be capable of satisfying the criteria for compliance of the impact test given in 26.3.3.1. Hand-held apparatus shall additionally be capable of satisfying the criteria for compliance of the drop test given in 26.3.3.2. Apparatus shall be marked with the symbol "X" when required according to the chosen level of test.

5.3 Guards for light transmitting parts

Every guard provided for the protection of a light-transmitting part shall have a mesh size of up to but not exceeding 50 mm × 50 mm.

5.4 Circulating currents

Precautions shall be taken where necessary to guard against any effect due to the presence of circulating currents caused by stray magnetic fields, for example, arcs or sparks occurring as a result of interrupting such currents, or excessive temperatures caused by such currents.

NOTE 1 Current may flow in any enclosure or in any supporting structure (internal or external to the enclosure) in the presence of stray magnetic fields, if made of conducting materials.

NOTE 2 In order to ensure reliable current transfer without risk of sparking under adverse operating conditions, such as vibration or corrosion, precautions that can be taken include:

- the provision of equipotential bonding between parts of an enclosure or structure of the apparatus.
- the provision of an adequate quantity of fasteners.

5.5 Non-metallic enclosures, non-metallic parts of enclosures

5.5.1 Non-metallic materials shall have a temperature index TI corresponding to the 20 000 h point (see IEC 60216-1 and IEC 60216-2) or a continuous operating temperature (COT) 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 according to data supplied by the material manufacturer.

5.5.2 The enclosure shall be resistant to ageing; this shall be tested in accordance with 26.3.2.1 and 26.3.2.2.

5.5.3 Where the enclosure is expected to be exposed to sunlight, or other source of UV radiation, the materials shall be resistant to light. This shall either be declared in the data provided by the manufacturer or by testing in accordance with 23.4.7.5 of IEC 60079-0. For apparatus where the enclosure does not comply with the requirements, it shall be marked with an "X" and information given in the documentation in accordance with clause 29.

5.5.4 The following requirements apply only to plastic enclosures, to plastic parts on enclosures and to other exposed plastic parts of electrical apparatus for

- non-fixed electrical apparatus,
- fixed apparatus with plastic parts that are likely to be rubbed or cleaned on site.

Enclosures of plastic material with surface area projected in any direction of more than 100 cm² shall be so designed that under normal conditions of use, maintenance and cleaning, danger of ignition due to electrostatic charges is avoided.

This requirement shall be satisfied either by suitable selection of the material so that the insulation resistance, measured according to the method given in 23.4.7.8 of IEC 60079-0, does not exceed 1 GΩ at (23 ± 2) °C and (50 ± 5) % relative humidity or, where by selection of the size, shape and layout or other protective methods, such that dangerous electrostatic charges are not likely to occur.

If, however, the danger of ignition cannot be avoided in the design, a warning label shall indicate the safety measures to be applied in service.

NOTE When selecting electrical insulating materials attention should be paid to maintaining a minimum insulation resistance to avoid problems arising from touching exposed plastic parts that are in contact with live parts.

5.5.5 Threaded holes for fasteners which secure covers intended to be opened in service for adjustment, inspection and other operational reasons may only be tapped into plastic material when the thread form is compatible with the plastic material of the enclosure.

6 Connection facilities and wiring

6.1 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 11.

6.2 Connection for external conductors

6.2.1 Electrical apparatus intended for connection to external circuits, except for electrical apparatus manufactured with a cable permanently connected to it or provided with loose leads, shall include connection facilities. The connection facilities shall effectively be protected against corrosion, and be so designed that the conductors can be connected readily to the terminals and can be clamped without reducing significantly their cross-sectional area, in such a manner that they are gripped and secured against loosening and twisting, and that 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 1 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.

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 2 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 3 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 clause 7 are the responsibility of the installer of the apparatus.

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

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

6.2.3 A facility for the connection of an earthing or equipotential bonding conductor shall be provided near the other connection facilities and inside the terminal compartment of electrical apparatus except where the installation and supply lead conditions specified (for example single-core cable connections) do not require an internal earthing conductor, in which case the connections for the protective conductor may be terminated outside the terminal compartment.

Special precautions shall be taken if one of the parts in contact consists of a material containing light metal.

NOTE One example of a means of connecting to a material containing light metal is to use an intermediate part made from steel.

6.2.4 Earthing or equipotential bonding connection facilities shall allow for the effective connection of at least one conductor with a cross-sectional area as given in table 1.

Table 1 – Minimum cross-sectional area of protective conductors

Cross-sectional area of phase conductors of the installation S	Cross-sectional area of the corresponding protective conductor Sp
mm ²	mm ²
S ≤ 16	S
16 < S ≤ 35	16
S > 35	0,5 S

In addition earthing or equipotential bonding connection facilities on the outside of electrical apparatus, if provided, shall have provision for effective connection of a conductor of at least 4 mm².

6.2.5 Earthing or equipotential bonding connection facilities are not required for electrical apparatus having double or reinforced insulation or for which supplementary earthing is not necessary. Enclosures intended to be earthed by specific forms of installation, such as with earthed metallic conduit systems shall be marked with an "X".

6.2.6 Cable entries and cable entry devices shall:

- a) be constructed and mounted so that they maintain the type of protection and the specific characteristics of the apparatus. This shall apply to the whole range of cable diameters specified by the manufacturer of the cable entries as suitable for use with those cables;
- b) provide for the passage of the cable through the wall of the enclosure without damage to the cable, and for the bonding of any metal armouring, sheath or screen where required. Cable entries shall not have sharp edges capable of damaging the cable;
- c) conform to either:
 - the appropriate standard for industrial cable entries and cable entry devices where such standards exist, or
 - the requirements of IEC 60079-0 for equivalent Ex apparatus, or
 - where necessary, provide clamping of the cable in order to prevent any pulling or twisting applied to it from being transmitted to the connections. Such clamping can be provided by a clamping device, sealing ring or filling compound. The test in 26.4 shall be applied;
- d) additionally, in the case of flexible cables, the point of entry shall include a rounded edge at an angle of at least 75°, the radius R of which is at least equal to one quarter of the diameter of the maximum admissible cable in the entry, but which need not exceed 3 mm (see figure 2).

NOTE The term "cable entry" in this standard includes devices for the entry of cables containing optical fibres into the enclosure. Multi-cable "transits" are also included.

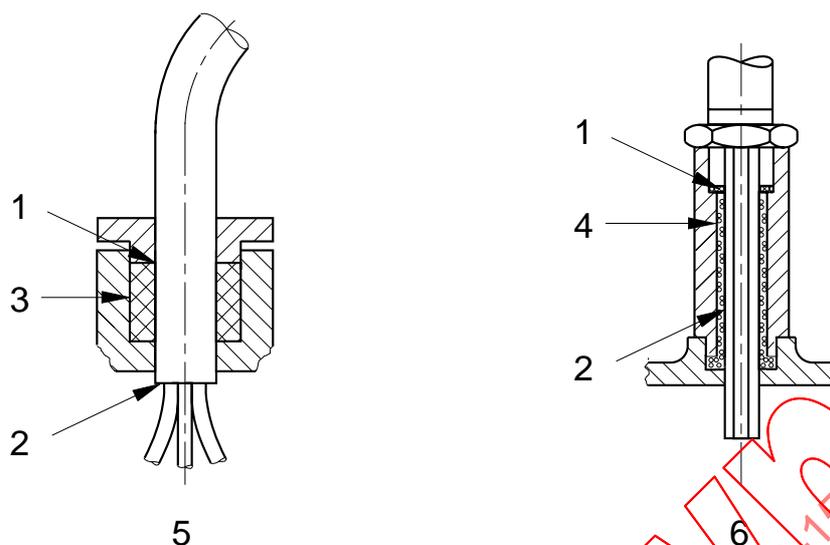
6.2.7 Conduit entries shall be constructed and mounted so that they do not alter the type of protection and the specific characteristics of the electrical apparatus on which they are mounted and shall screw into threaded holes or be locked in plain holes situated as follows:

- a) in the enclosure;
- b) in an adaptor plate designed to be fitted in or on the enclosure;
- c) in a suitable stopping box, integral with or attached to the enclosure.

6.2.8 When the temperature under rated conditions is higher than 70 °C at the cable or conduit entry point, or 80 °C at the branching point of the conductors, the outside of the electrical apparatus shall be marked as a guide for the selection by the user of the cable, or of the wiring in the conduit (see figure 2). In addition, the apparatus shall be marked with the symbol "X".

If a diversity factor is applied, in the case of multiple sources of heat, it shall be stated in the documentation (see clause 29).

6.2.9 In the case of portable apparatus any cable entry shall satisfy the appropriate clamping requirements of B.2.3.1 of IEC 60079-0.

**Key**

- 1 Entry point
- 2 Branching point
- 3 Sealing ring

- 4 Filling compound
- 5 Cable entry
- 6 Conduit entry

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Figure 2 – Illustration of entry points and branching points**7 Clearances, creepage distances and separations**

7.1 Clearances, creepage distances and separations between conductive parts at different potentials shall be as given in table 2, except in the following cases:

- a) neutral point connections of rotating electrical machines complying with 9.4;
- b) luminaires complying with 11.2.7;
- c) with regard to sealed, encapsulated or solid insulation separations only, apparatus subject to the routine electric strength test of 8.2;
- d) with regard to energy-limited apparatus, associated energy-limited apparatus and circuits (see clause 21), 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;
- e) instruments and low power apparatus complying with clause 12.

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.

7.2 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 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.

7.3 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.

7.4 A conformal coating, if applied, shall have the effect of sealing the conductors 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.

7.5 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 11.2.7 and table 6 for pulse voltages in luminaire circuits or IEC 60664-1 for additional information.

7.6 Figure 3 (examples taken from IEC 60664-1) illustrates the features to be taken into account when determining the appropriate clearances or creepage distance.

NOTE 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

- a) 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;
- b) grooves in the surface have a minimum depth of 1,5 mm and a minimum width of 1,5 mm.

NOTE 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)	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 7.4.

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.

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	$100 \leq \text{CTI} < 175$

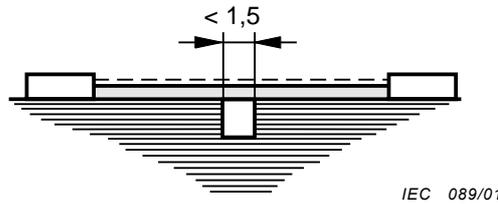
7.7 Where compound filled cable sealing boxes are used for the termination of external cables supplying apparatus with rated voltages in excess of 750 V, the construction shall be such that the creepage distances and clearances given in table 4 are obtainable for bare live parts, prior to the pouring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

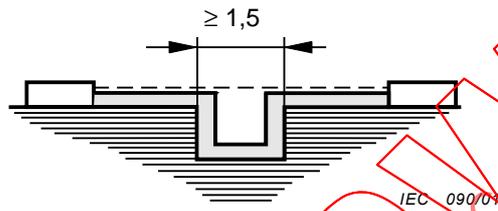
Example 1



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.

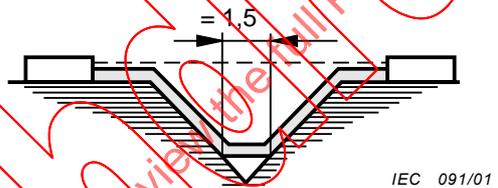
Example 2



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.

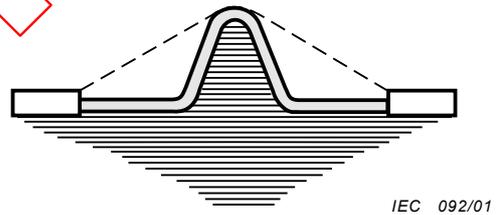
Example 3



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



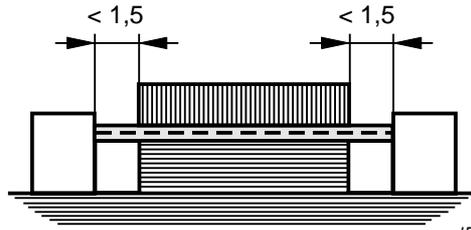
Condition: Path under consideration includes a rib.

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

--- 1

— 2

Example 5

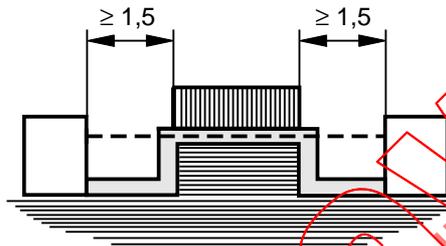


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Condition: Path under consideration includes an uncemented joint with grooves less than 1,5 mm wide on each side

Rule: Creepage and clearance path is the "line of sight" distance shown.

Example 6

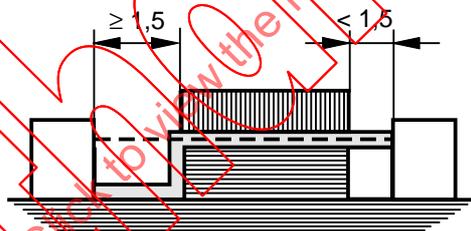


IEC 094/01

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

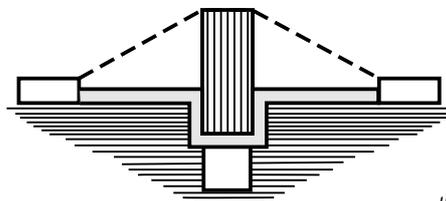


IEC 095/01

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



IEC 096/01

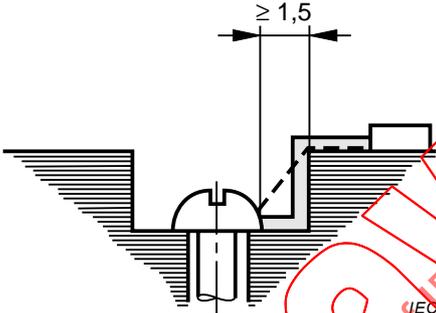
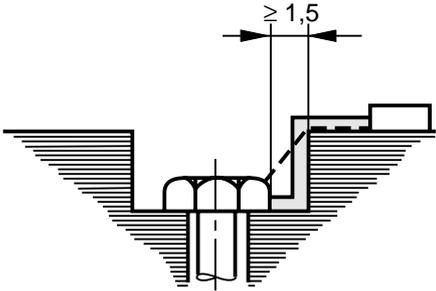
Condition: Creepage distance through uncemented joint is less than creepage distance over barrier.

Rule: Clearance is the shortest direct air path over the top of the barrier.

--- 1

— 2

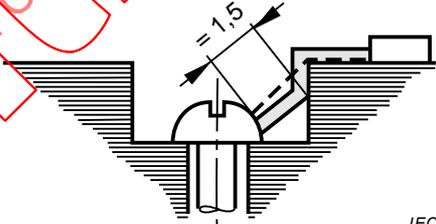
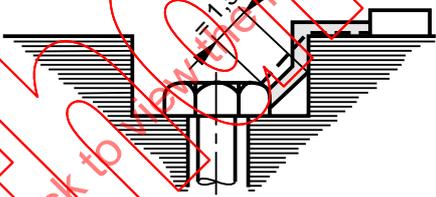
Example 9



IEC 097/01

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

Example 10



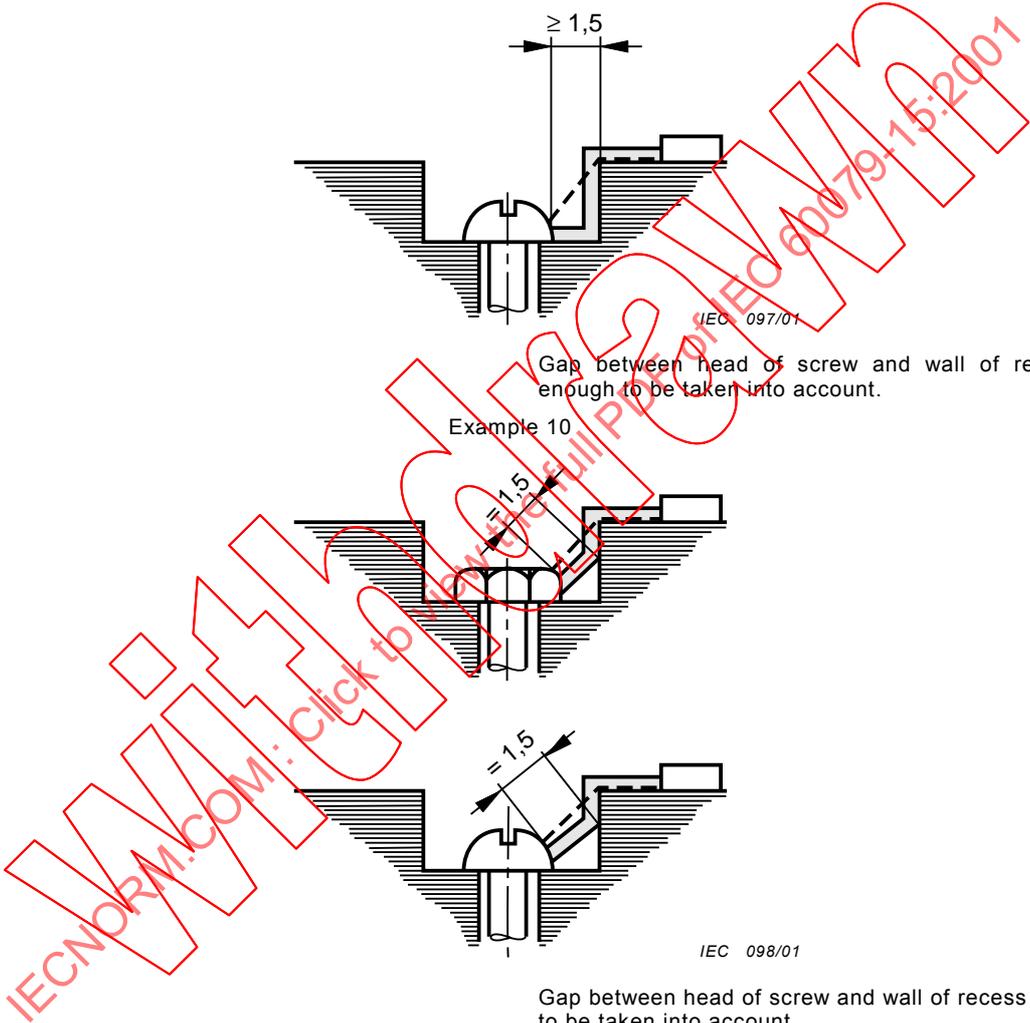
IEC 098/01

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.

--- 1

▬ 2



9 Supplementary requirements for non-sparking rotating machines

9.1 General

The requirements in this clause apply to rotating machines within the scope of IEC 60034 (all parts). 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.

NOTE 1 Pending the development of specific requirements in this standard, rotating machines should be in compliance with ENV 50269. This is of particular importance where starting may be considered as part of normal operation.

NOTE 2 When rotating machines are subject to certification to this standard, it is not intended that the testing station check compliance with IEC 60034-1 but that the manufacturer should declare compliance with that standard.

9.2 Degree of protection

NOTE The requirements of 9.2 replace those of 5.1.1.

9.2.1 Machine enclosure

Machine enclosures containing bare live parts shall provide a degree of protection not less than IP54, as determined in accordance with 26.3.4, 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.

9.2.2 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 26.3.4.

9.2.3 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 26.3.4.

9.3 Connection facilities for external conductors

The connection facilities of rotating machines shall comply with 6.2 of this standard. 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 clause need not apply if there is no requirement to disconnect and reconnect the machine during service.

9.4 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
≤ 1 100	<i>U</i>
1 100 < <i>U</i> ≤ 3 300	1 100
3 300 < <i>U</i> ≤ 6 600	3 300
6 600 < <i>U</i> ≤ 11 000	6 600
11 000 < <i>U</i> ≤ 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.

9.5 Radial air gap

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

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

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).

9.6 Ventilation systems

9.6.1 General

External shaft driven cooling fans of rotating electrical machines shall be enclosed by a fanhood which is not considered to be part of the enclosure of the electrical apparatus. Such fans and fanhoods shall comply with 9.6.2 to 9.6.5 as shall internal fans and fanhoods unless stated otherwise.

9.6.2 Ventilation openings for external fans

The degree of protection (IP) of ventilation openings for external fans of rotating electrical machines shall be at least:

- IP20 on the air inlet side;
- IP10 on the air outlet side.

NOTE This is in accordance with IEC 60034-5.

For vertical rotating machines foreign objects shall be prevented from falling into ventilation openings.

9.6.3 Construction and mounting of the ventilation system

Fans, fanhoods and ventilation screens shall be constructed so as to comply with the requirements of the resistance to impact test specified in 26.3.3.1.

9.6.4 Clearances for the ventilation system

In normal operation, the clearances taking into account design tolerances between the fan and its hood, ventilation screens and their fasteners shall be at least 1/100 of the maximum diameter of the fan, except that the clearances need not exceed 5 mm and may be reduced to 1 mm if the opposing parts are manufactured so as to have dimensional accuracy and stability. In no case shall the clearance be less than 1 mm.

9.6.5 Materials for fans and fanhoods

9.6.5.1 If any fan's peripheral speed exceeds 50 m/s, the fans, fanhoods, ventilation screens, etc. shall have an electrical resistance, when measured in accordance with 23.4.7.8 of IEC 60079-0, not exceeding 1 GΩ.

9.6.5.2 The thermal stability of plastic materials shall be considered adequate if the continuous operating temperature (COT) specified by the manufacturer of the plastic material exceeds the maximum temperature to which the material will be subjected in service (within the rating) by at least 20 K.

9.6.5.3 Fans, fanhoods and ventilation screens manufactured from materials containing light metals shall comply with the requirements of 8.1 of IEC 60079-0.

9.7 Bearing seals and shaft seals

9.7.1 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 sliding element (sleeve) bearings, this clearance shall be 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.

9.7.2 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 4.3.

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 9.7 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 new condition. Elastic seals which lift off during rotation (for example V rings) are also considered to meet the requirements.

9.8 Rotor cages

9.8.1 Rotor cages built from bars connected to end rings

Precautions shall be taken to guard against incendive 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.

NOTE The following recommendations should be observed:

- a) the bars throughout the length of the rotor core should be mechanically tight with respect to adjacent stampings;
- b) the whole rotor construction should be such as to minimize the risk of fracture of bars, joints or short-circuiting rings;
- c) where the type of construction employs impregnating varnish to provide the necessary degree of tightness, the manufacturer should employ a method achieving a high degree of penetration of the varnish, and should ensure that the grade of varnish is suitable for the design temperature and operating conditions.

9.8.2 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.

9.9 Surface temperature limitation

NOTE Calculations or tests may be accepted as evidence of compliance with 4.3 and 9.9.

9.9.1 Prevention of thermal ignition

The temperature of any external or internal surface to which the potentially explosive atmosphere has access shall not, under normal operating conditions exceed the temperature class in accordance with 4.3.

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.

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

9.9.2.1 Except as allowed in 9.9.2.2, motors supplied at varying frequency and voltage by a convertor shall be tested for this duty as a unit in association with the convertor specified in the descriptive documents according to 23.2 of IEC 60079-0.

9.9.2.2 For convertor-fed motors rated less than 1 kV, the convertor shall be designed to limit the peak voltage-to-earth to 1 kV and the du/dt to 500 V/ μ s, or less. For convertor-fed, form-wound motors rated 1 kV and above, the convertor shall be designed to limit the peak voltage-to-earth to two times rated line-to-line voltage and the du/dt to 500 V/ μ s, or less. The limitation of voltage and du/dt may be accomplished by the application of a series inductor, shunt capacitor low-pass filter located at the output of the convertor. A convertor or a convertor/filter combination that meets the peak voltage and du/dt limits may be used with any motor. Application limits for the convertor-fed motor, including the motor maximum speed and the load speed-versus-torque characteristics, shall be indicated on the motor marking plate. A convertor, or convertor-filter combination, shall be marked as suitable for application with a motor of a designated voltage and output rating.

9.9.2.3 In cases where it is not practicable to carry out the test of 9.9.2.1, the temperature class may be determined by calculation.

NOTE 1 The determination of the temperature class by calculation should be agreed between the manufacturer, the purchaser and/or the testing station, 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.

10 Supplementary requirements for non-sparking fuses and fuse assemblies

10.1 Fuse-links 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 Rupture of the fuse-link is not considered to be normal operation.

10.2 The temperature class of an apparatus shall take account of the external surface of the cartridge, including the indicator if any, of each fuse-link 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 29).

10.3 Fuse links 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 14.2.

10.4 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 label

"DO NOT REMOVE FUSE WHEN ENERGIZED".

10.5 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.

11 Supplementary requirements for non-sparking luminaires

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

11.1 General

Luminaires shall comply with the relevant section of IEC 60598-2 together with the additional requirements for luminaires where specified in this standard.

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, that is 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 When luminaires are subject to certification to this standard, it is not intended that the certification body check compliance with the relevant section of IEC 60598-2, but that the manufacturer should declare compliance with that standard.

NOTE 2 In order to reduce the time of testing and to allow for any tests that may be destructive, the manufacturer may submit 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.

NOTE 3 Information is given to the user that, as an exception to the requirements of IEC 60598-1, a type "n" luminaire should not be operated in an ambient temperature in excess of t_a even for a short time (see clause 29 e)).

11.2 Construction

11.2.1 General

The constructional requirements of the relevant section of IEC 60598-2 and also 4.3.1, 4.3.2 and 4.3.3 of this standard shall apply together with the requirements specified in 11.2.2 to 11.2.12.

11.2.2 Enclosure of lamp

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

11.2.3 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.

11.2.4 Lampholders

11.2.4.1 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 11.2.4.2, 11.2.4.3 and 11.2.4.4.

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

11.2.4.2 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.

11.2.4.3 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 26.10.

11.2.4.4 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.

11.2.5 Auxiliaries

11.2.5.1 General

When mounted in the luminaire, auxiliaries shall comply with the electrical and mechanical safety requirements of IEC 60920, IEC 60922, IEC 60924, IEC 60926, IEC 60928, IEC 61048, IEC 61049, IEC 60662 or IEC 60155, as applicable or of other appropriate standards.

11.2.5.2 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 canister; the canister does not have to be hermetically sealed).

11.2.5.3 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 60926 and IEC 60927 respectively and shall be non-sparking devices. 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 comply with the relevant requirements specified in 26.13 and additionally shall comply with the relevant requirements specified in 26.6.

NOTE 1 The requirements of 26.6 and 26.13 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 26.13).

11.2.5.4 Starter holders

Starter holders shall be of the non-sparking type (see 3.25) 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 26.11.

11.2.5.5 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 11.2.10.3.2 of this standard).

Electronic ballasts according to IEC 60924 and IEC 60928, shall not produce temperatures in excess of the temperature class when subjected to the abnormal conditions given in those standards.

For printed boards of electronic ballasts, the requirements for creepage and clearance distances of table 1A of IEC 60928 apply without the exemptions permitted in that standard.

In all cases where the circuit includes ignitors that subject the ballast to high-voltage impulses, the ballast shall withstand the test specified in 26.12.

NOTE This requirement is more onerous than the equivalent requirement in IEC 60922.

11.2.6 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.

11.2.7 Creepage distances and clearances

The creepage distance and clearance requirements of the relevant sections 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 6 except for creepage distances and clearances within an encapsulated device or sealed device or within a ballast complying with the requirements of 26.12.

Table 6 – 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 Up to 2,8	Above 2,8 Up to 5,0	Above 1,5 Up to 2,8	Above 2,8 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 ¹ that are subject to the pulsed voltage of the ignitor	8	12	6	9

¹ Unless the component itself is an encapsulated device or a sealed device

11.2.8 Terminals

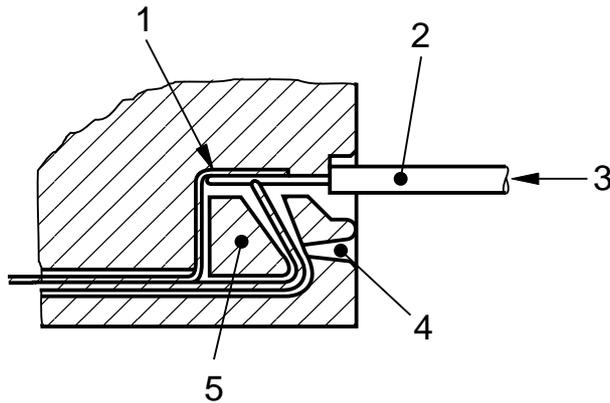
11.2.8.1 The terminal requirements of the relevant section of IEC 60598-2 shall apply together with the requirements specified in 11.2.8.2 to 11.2.8.4 of this standard.

11.2.8.2 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:

- a) 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;
- b) 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;
- c) other terminals complying with 6.1 and 6.2.1 to 6.2.3.

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

- a) terminals as described in 11.2.8.2;
- b) pinch screw terminals if ferrules are fitted on the conductor;
- c) screwless terminals of the following types:
 - 1) those in accordance with section 15 of IEC 60598-1 except for spring-leaf terminals of the type shown as type a) in figure 18 of that standard reproduced as the not acceptable type in figure 4 b) of this standard;
 - 2) the "acceptable" type of spring-leaf terminal with the conductor clamped between metal surfaces as shown in figure 4 a) 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;
 - 3) twist-on connecting devices meeting the requirements of IEC 60998-2-4;
 - 4) insulated crimped connectors.

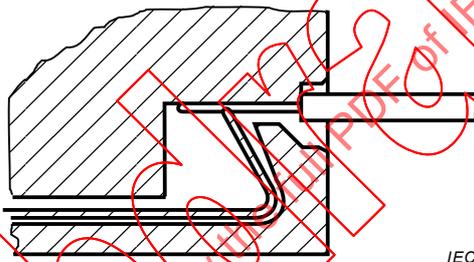


IEC 100/01

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 4a – Example of acceptable spring leaf screwless terminal



IEC 101/01

Figure 4b – Example of non-acceptable spring leaf screwless terminal

11.2.8.4 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.

11.2.9 External and internal wiring

The external and internal wiring requirements of the relevant section 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 26.14.

11.2.10 Endurance tests and thermal tests

11.2.10.1 General

The endurance and thermal test requirements of the relevant section of IEC 60598-2 shall apply together with the requirements specified in 11.2.10.2 to 11.2.10.4 of this standard.

11.2.10.2 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.

11.2.10.3 Thermal test (abnormal conditions)

11.2.10.3.1 Except for windings (see 11.2.10.3.2), 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.

11.2.10.3.2 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.

11.2.10.4 Surface temperatures

11.2.10.4.1 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.

11.2.10.4.2 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.

11.2.10.4.3 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.

11.2.11 Resistance to dust and moisture

The resistance to dust and moisture requirements of the relevant section 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 28.

11.2.12 Insulation resistance and electric strength

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

11.3 Other apparatus containing light sources

Light sources mounted within other apparatus shall comply with the relevant requirements of clause 11.

12 Supplementary requirements for non-sparking instruments and low power apparatus

Electronic and allied low power apparatus (typically less than or equal to 20 W) used, for example, for measurement, control or communication purposes and which does not comply with clauses 7 and 8 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) The rated voltage of the apparatus or the part of the apparatus being considered shall not exceed 60 V a.c. or 75 V d.c.;
- c) Provision shall be made, either in the apparatus or external to the apparatus, to prevent the rated voltage being exceeded by transient disturbances of more than 40 %. Where the means is to be provided externally the apparatus shall be marked with the symbol "X" (see clause 28) and the information shall be given in the documentation (see clause 29).

13 Supplementary requirements for non-sparking current transformers

Where the secondary circuit of a current transformer extends outside the apparatus, the latter shall be marked with the symbol "X" and 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 at the apparatus of any possible disconnection of either set of transformers.

14 Supplementary requirements for non-sparking plugs and sockets

14.1 Plugs and sockets for external connections shall comply with either a) or 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 following warning

"DO NOT SEPARATE WHEN ENERGIZED."

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 protection for the plug and/or socket.

14.2 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 1,5 kgf 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 kgf) shall not be less than 10 times the mass of the component.

NOTE 1 kgf equals 9,81 N.

14.3 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.

15 Supplementary requirements for non-sparking cells and batteries

15.1 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 7.

15.1.1 Type 1 – Cells and batteries 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 15.2 and 15.3 and the verification and tests in 15.6.

15.1.2 Type 2 – Cells and batteries 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 17 to 23 of this standard.

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 15.2 and 15.4 and the verification and tests are given in 15.6.

15.1.3 Type 3 – Cells and batteries 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 15.5 and the verification and tests are given in 15.6.

Table 7 – 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 ¹	Yes Only apparatus without arcs or sparks	Apparatus with sparks or arcs shall be located in a separate compartment
3	No restriction	Yes	No ¹	No	–

¹ For charging in hazardous areas, special precautions are required.

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

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

15.2.2 Batteries shall not contain both primary and secondary cells. Only cells from the same manufacturer shall be used to form batteries. They shall be of the same construction, design, rated capacity and electrochemical system.

15.2.3 Primary cells shall not be charged.

15.2.4 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.

15.2.5 The type of battery used shall be clearly shown in the marking.

15.2.6 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.

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

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

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

15.2.10 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.

15.2.11 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.

15.2.12 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.

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

15.2.14 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.

15.2.15 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.

15.2.16 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.

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

15.3 Charging of type 1 cells and batteries

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

15.3.2 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.

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

15.3.4 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.

15.3.5 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.

15.4 Charging of type 2 cells and batteries

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

15.4.2 If the 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.

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

15.4.2.2 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.

15.4.2.3 The charging system should not normally cause gassing. However, if gassing does occur the construction of the battery container shall be such that the H₂ level in it shall not exceed 2 % V/V after 48 h.

The test to verify this shall be that a H₂ 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.

15.4.2.4 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 shall be within the limits specified by the manufacturer of the apparatus.

15.5 Requirements for type 3 secondary batteries

15.5.1 Types of permissible batteries

These 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 15.6.

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

15.5.2 Battery containers

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

15.5.2.2 Battery containers including covers shall be designed so as to withstand the mechanical stresses in use including those due to transit and handling. They shall be protected against short circuits in service.

15.5.2.3 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.

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

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

15.5.2.6 The extraction of liquid which may have entered battery containers without drain holes shall be possible without the removal of the cells.

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

15.5.2.8 Plugs and sockets shall comply with the requirements of clause 14. This does not apply to plugs and sockets which can only be separated with the use of a tool and which bear a warning label:

"SEPARATE ONLY IN A NON-HAZARDOUS AREA."

Where there are single-pole positive and negative plugs and sockets, they shall not be interchangeable.

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

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

15.5.2.11 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.

15.5.3 Cells

15.5.3.1 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.

15.5.3.2 The positive and negative plates shall be supported effectively.

15.5.3.3 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.

15.5.3.4 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.

15.5.3.5 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.

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

15.5.4 Connections

15.5.4.1 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 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.

15.5.4.2 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.

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

15.6 Verification and tests

NOTE These type tests apply to batteries to which the additional requirements of 15.5 apply.

15.6.1 Insulation resistance

The test conditions are given in 26.16.

15.6.2 Shock test

Batteries which are subject to mechanical shocks in normal service shall be submitted to the test of 26.15. Other batteries need not be submitted to this test but their marking shall include the symbol "X".

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.

16 Other electrical apparatus

Electrical apparatus which is not specifically mentioned in clauses 9 to 15 shall comply with the requirements in clauses 4 to 8 together with any relevant requirements, as agreed between the manufacturer, purchaser and testing station as appropriate, of clauses 9 to 15.

17 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 18);
- b) non-incendive component (see clause 18);
- c) hermetically-sealed device (see clause 19);
- d) sealed device (see clause 20);
- e) encapsulated device (see clause 20);
- f) energy-limited apparatus and circuits (see clause 21);
- g) restricted-breathing enclosure (see clause 22);
- h) n-pressurization (see clause 23).

Except for category 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 (see 28.2 m)).

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

18.1 Type testing

Enclosed-break devices and non-incendive components shall be subjected to the type test specified in 26.5. After the test the device or component shall show no visible signs of damage, and no external ignition shall occur and there shall be no failure to clear the arc when the switch contacts are opened.

18.2 Ratings

18.2.1 Enclosed-break devices shall be limited to a maximum rating of 690 V and 16 A.

NOTE An enclosed-break device prevents flame transmission to the external atmosphere under the test conditions of 26.5 by the closeness of fit of its parts which, because of the construction, form an assembly that prevents external ignition of the explosive mixture.

18.2.2 Non-incendive components shall be limited to a maximum rating of 254 V and 16 A.

NOTE The contact arrangements of a non-incendive component quench an incipient flame and thereby prevent ignition 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.

18.3 Construction of enclosed-break devices

18.3.1 The free internal volume shall not exceed 20 cm³.

18.3.2 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.

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

19 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.

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

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

20.1 Sealed devices or encapsulated devices other than for luminaires

NOTE An encapsulated device is considered to be a sealed device.

20.1.1 Sealed devices shall be so constructed that they cannot be opened in normal service, they 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.

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

20.1.3 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.

20.1.4 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.

20.1.5 The type tests described in 26.6 shall be performed on five samples of each device selected at random.

20.2 Encapsulated devices for luminaires

20.2.1 The encapsulant resin shall have a continuous operating temperature (COT) of at least 20 K higher than the marked maximum surface temperature.

20.2.2 The manufacturer shall provide a material specification to substantiate the continuous operating temperature (COT). Where no particular material specification exists, 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.

20.2.3 The encapsulation shall have no deliberate voids, except that components such as relays and switches may 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 voids contain switching contacts without additional inorganic housing, the rated current of each contact should not exceed 6 A.

20.2.4 All parts of the device, excluding the termination facilities for external connection, shall be encapsulated.

20.2.5 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 a canister, only the free surface is considered, not the external surface of the canister.

If a metallic canister is used, the minimum thickness of the layer of encapsulating resin between the housing and any component or conductor shall be at least 1 mm. If a non-metallic canister is used, no minimum thickness of the layer between the housing and any component or conductor is required provided the minimum thickness of the protective housing is 1 mm, but if this thickness is less than 1 mm, the sum of the thicknesses of housing and resin shall be at least 3 mm and the material of the housing 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 26.6.3.2.

20.2.6 These encapsulated devices shall be tested in accordance with 26.6.3.

20.3 Sealed devices for luminaires

Sealed devices for luminaires shall comply with the requirements of 20.1.1 to 20.1.4 and shall be tested in accordance with 26.6.4.

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

21.1 General

NOTE 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 appropriate circuits. The components which restrict the energy may be part of the apparatus or may be outside.

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 26.7.

21.2 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 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. 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.

21.3 Energy-limited apparatus

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

The apparatus shall be marked according to 28.2 m) and the documentation (see clause 29) 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.

21.4 Self protected energy-limited apparatus

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

21.5 Separation of conducting parts

If the apparatus does not comply with clause 12, separation of conductive parts between

- energy-limited circuits and non-energy-limited circuits;
- 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.

21.6 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).

21.7 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 to that apparatus or at connections between cells of batteries where this could occur. For this purpose a single diode is considered to be acceptable.

21.8 Requirements for components on which energy limitation depends

21.8.1 Ratings of components

Any component on which the type of protection depends, except such devices as transformers, fuses, thermal trips, relays and switches, shall not operate in normal conditions at 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.

NOTE 1 Normal operation may include open-circuit, short-circuit and earth fault conditions at the field terminals.

NOTE 2 It is not intended that components which are stressed infrequently shall be restricted to two-thirds rating. For example, a diode used to suppress the spark energy caused by manual or infrequent switching of a solenoid valve need only be rated for the normal current in the circuit.

21.8.2 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 in accordance with 21.8.1.

21.8.3 Shunt safety components

Unless their failure is apparent in the operation of the apparatus, 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.

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

NOTE Restricted breathing is not suitable for equipment 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.

22.1 Protection by restricted-breathing enclosures may be applied in the following circumstances:

- a) enclosures containing sparking contacts but with a limitation in dissipated power such that the averaged 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 not containing sparking contacts with limitation only in external surface temperature.

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.

22.2 Restricted-breathing enclosures shall comply with 26.8.1. Provision shall be made for carrying out checks to ensure that the requirements for restricted-breathing enclosures are complied with after installation or after maintenance.

22.3 Restricted-breathing enclosures shall comply with the appropriate test of 26.8. Any gasket or special part necessary to comply with the criteria shall be supplied with the enclosure and shall be subjected to the preconditioning described in 26.6.2.2 before being subjected to the test specified in 26.8.

22.4 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.

22.5 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.

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

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

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

23 Supplementary requirements for n-pressurization protecting apparatus producing arcs, sparks or hot surfaces

NOTE Since the application of these supplementary requirements provides protection against ignition from arcs, sparks and hot surfaces, it is implicit that the requirements in clause 6 to 16 need not apply to the internal parts of a pressurized enclosure, provided that all such parts are intended to be unenergized when the pressurization technique is inactive. This does not preclude the option of having some parts remain energized in the absence of pressurization, in which case the relevant requirements of clauses 6 to 16 (possibly supplemented by clauses 17 to 22) do apply.

23.1 Forms of n-pressurization

Apparatus is subject to purging and

- a) leakage compensation; or
- b) static pressurization.

23.2 Requirements for n-pressurization enclosures

23.2.1 Degree of protection of enclosure

The enclosure, ducts, cable entry devices, etc. shall provide a degree of protection of at least IP44 when tested in accordance with 26.3.4.

NOTE 1 These requirements replace those of 5.1.1.

NOTE 2 For effective static pressurization, a higher degree of protection will normally be required.

23.2.2 Doors and covers

The requirements of 5.3 of IEC 60079-2 apply.

23.2.3 Mechanical strength

In addition to the requirements of 5.2, the enclosure, ducts, etc. shall withstand the overpressure test, or shall be fitted with a safety device or marked "X" accordingly, as required by 5.4 of IEC 60079-2.

23.2.4 Apertures, partitions and internal components

The requirements of 5.5 of IEC 60079-2 apply.

23.2.5 Spark and particle barriers

A spark and particle barrier shall be provided for any normally open vent when there is a risk of incandescent particles being produced according to the criteria given in 5.8 of IEC 60079-2.

23.3 Temperature limits

The temperature classification shall be based on the hottest external surface temperature of the enclosure, unless there is any part of the apparatus which is internal to the enclosure and which is protected by another type of protection and is intended to remain energized when the apparatus is not subject to pressurization.

23.4 Safety provisions and safety devices (except for static pressurization)

The requirements of clause 7 of IEC 60079-2 for pressurization type pz apply.

23.5 Safety provisions and safety devices for static pressurization

The requirements of clause 8 of IEC 60079-2 apply.

23.6 Supply of protective gas

The requirements of clause 9 of IEC 60079-2 apply.

24 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.

The type verifications and tests are intended to verify that a prototype or sample of the electrical apparatus complies with the relevant requirements of this standard. The testing station is not required to verify compliance of the material with its definition.

Certain tests may be omitted if the parties concerned agree that they are not applicable to certain types of apparatus in which case justification for such omission shall be given in the documentation (see clause 29).

For manufacturer's responsibility regarding testing refer to clause 30.

25 Specification documentation

25.1 The manufacturer shall prepare documentation which gives a full and correct specification of the explosion safety aspects of the electrical apparatus and shall include verification that, in the design of the electrical apparatus, the requirements of this standard have been observed.

25.2 The manufacturer may submit this documentation, along with other information and samples as may be required, to a testing station (certification body) for issue of a certificate confirming compliance with the requirements of this standard.

25.3 Where independent certification is not sought or provided, the manufacturer shall prepare a declaration of compliance with this standard, summarizing the full documentation and which is suitable for supplying in accordance with clause 29 a).

26 Type tests

26.1 General

The representative sample shall be tested in accordance with the requirements for type tests of this standard.

26.2 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.

26.3 Tests for enclosures

26.3.1 Order of tests

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

Tests shall be made on two samples which shall be submitted first to the tests of thermal endurance to heat (see 26.3.2.1), then to the tests of thermal endurance to cold (see 26.3.2.2), then to the mechanical tests (see 26.3.3), then to the tests for degrees of protection (IP) (see 26.3.4) and finally, when necessary, to any other test specified in this standard or any product standard.

26.3.1.2 Metallic enclosures, metallic parts of enclosures and glass parts of enclosures

Tests shall be made on the number of samples specified for each test, first the mechanical tests (26.3.3), then the tests for degrees of protection (IP) (26.3.4) and finally, when necessary, any other test specified in this standard or any product standard.

26.3.2 Thermal endurance tests

26.3.2.1 Thermal endurance to heat (plastic materials)

The thermal endurance to heat is determined by submitting the enclosure or parts of enclosures in plastic materials on which the integrity of the type of protection depends to continuous storage for two weeks in an ambience of (90 ± 5) % relative humidity and at a temperature of (10 ± 2) 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 two weeks specified above will be replaced by a period of one week at $(95 \pm 2)\text{ }^{\circ}\text{C}$ and (90 ± 5) % relative humidity followed by a period of one week at a temperature of (10 ± 2) K higher than the maximum temperature in rated service.

26.3.2.2 Thermal endurance to cold (plastic materials)

Tests shall be carried out in accordance with 23.4.7.4 of IEC 60079-0.

26.3.3 Mechanical strength tests

26.3.3.1 Tests for resistance to impact

Tests shall be carried out in accordance with 23.4.3.1 of IEC 60079-0, with the exception that where IEC 60079-0 requires agreement between the manufacturer and the test house, this may be by agreement between the manufacturer and the purchaser if there is no involvement of a test house. When an electrical apparatus is submitted only to tests according to the low risk of mechanical danger given in table 4 of IEC 60079-0, it shall be marked with the symbol "X" in accordance with clause 28.

26.3.3.2 Drop test

In addition to the test of 26.3.4.1, hand-held electrical apparatus shall be tested in accordance with 23.4.3.2 of IEC 60079-0.

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

26.3.3.3 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 26.8 after passing the type tests of this clause.

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

26.3.4.1 Test

26.3.4.1.1 The test procedures and acceptance criteria shall be in accordance with IEC 60529, except for rotating electrical machines which shall be in accordance with IEC 60034-5.

26.3.4.1.2 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.

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

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

26.3.4.1.5 Where no electric strength value for the test to determine adequate clearance for high-voltage equipment (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.

26.3.4.1.6 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.

26.3.4.2 Criteria for compliance

26.3.4.2.1 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.

26.3.4.2.2 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.

26.4 Test for cable entry clamping method

The cable entry and device shall withstand a pull-test with the following forces (in newtons):

- 10 times the value in millimetres of the diameter of the mandrel or cable, with a minimum of 100 N, when the cable entry is designed for circular cable; or
- three times the value in millimetres of the perimeter of the cable, with a minimum of 100 N, when the cable entry is designed for non-circular cable.

The test will be satisfied when any slippage of the cable over a test period of 6 h does not exceed 6 mm.

Where more than one cable passes through the device, the test shall be applied simultaneously to all cables.

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

26.5.1 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.

Other gaskets or seals shall be removed, conditioned as described in 26.6.2.2 and then replaced.

26.5.2 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.

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

26.5.3.1 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 over-pressure of 500 mbar.

26.5.3.2 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.

26.5.3.3 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.

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.

26.6 Tests for sealed devices and encapsulated devices

With the exception of luminaires, the tests for which are specified in 26.6.3 and 26.6.4, sealed devices and encapsulated devices shall be tested in accordance with 26.6.1.

26.6.1 Apparatus

26.6.1.1 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.

a) Method 1

The container shall allow heating of the test fluid to the temperature required by 26.6.2.3 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 an absolute pressure of not greater than 5 kPa for a minimum duration of 2 min.

26.6.1.2 Test fluid, either tap water or de-ionized water.

26.6.2 Procedure

26.6.2.1 Five samples of each device, selected at random, shall be conditioned as described in 26.6.2.2 if appropriate and shall then be tested as described in 26.6.2.3 a) or b).

26.6.2.2 If the device contains a gasket or seal of thermoplastic or elastomeric material the device shall be conditioned in an air oven for 7 days at a temperature at least 10 K higher than the temperature of the gasket or seal in the most onerous rated service conditions or $(80 \pm 2) ^\circ\text{C}$ whichever is the greater.

26.6.2.3 The test procedure shall be that given in a) or b) according to whether method 1 or method 2 is specified by the manufacturer.

a) Method 1 – Immersion in heated fluid

The test sample, at a temperature between $15 ^\circ\text{C}$ and $35 ^\circ\text{C}$, is immersed in the test fluid maintained at a temperature in the range $75 ^\circ\text{C}$ to $85 ^\circ\text{C}$ to a depth of at least 50 mm above the uppermost portion of the enclosure of the test sample for a duration of at least 2 min.

For the duration of immersion, a close visual observation is made for evidence of leakage in the form of a stream of bubbles lasting for at least 20 s or for an initial large burst of bubbles, both of which are an indication of an unsatisfactory seal.

b) Method 2 – Immersion at reduced pressure

The test sample at a temperature between $15 ^\circ\text{C}$ and $35 ^\circ\text{C}$ is immersed in the test fluid at a temperature between $15 ^\circ\text{C}$ and $35 ^\circ\text{C}$ and the pressure above the level of the fluid is reduced to a value of not more than 5 kPa (absolute). This partial vacuum is maintained for a minimum of 2 min whilst maintaining a close visual observation for evidence of leakage.

26.6.3 Test for encapsulated devices for luminaires

26.6.3.1 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 to that value which it is predicted would make the surface temperature of the device 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 °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 26.6.3.2 is carried out.

26.6.3.2 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:

- 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.

26.6.4 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 °C for 1 h. The device is then heated to a temperature of 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 10 K above that occurring when the device is operating under maximum rated service conditions as determined by the test house 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 ± 2) °C, they are suddenly immersed in water at a temperature of (50 ± 2) °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 to 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).

26.7 Assessment and test of energy-limited apparatus and circuits

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

26.7.2 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 12 of this standard, only switching contacts, or plugs and sockets not complying with clause 14 of this standard, shall be subject to assessment or test.

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

26.8 Tests for restricted-breathing enclosures

26.8.1 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.

26.8.2 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 26.8.1 or 26.8.2, 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.

26.8.3 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 (*V*) shall not exceed 0,125.

26.9 Test for apparatus with n-pressurization

26.9.1 Maximum overpressure test

The test shall be performed in accordance with 16.1 of IEC 60079-2.

26.9.2 Leakage test

The test shall be performed in accordance with 16.2 of IEC 60079-2.

26.9.3 Purging test for leakage compensation and filling procedure for static pressurization

The test shall be performed in accordance with 16.3 of IEC 60079-2.

26.9.4 Verification of minimum overpressure

The test shall be performed in accordance with 16.5 of IEC 60079-2.

26.9.5 Verification of the ability of the n-pressurization enclosure to limit internal pressure

The test shall be performed in accordance with 16.8 of IEC 60079-2.

26.10 Test for screw lampholders

NOTE These insertion and withdrawal tests need not 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 8.

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).

Table 8 – Insertion torque

Lamp cap	Torque Nm
E14/E13	1,0 ± 0,1
E27/E26	1,5 ± 0,1
E40/E39	3,0 ± 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 9.

Table 9 – Minimum removal torque

Lamp cap	Torque Nm
E14/E13	0,3
E27/E26	0,5
E40/E39	1,0

NOTE Where vibration is severe, special mounting should be provided for the luminaires.

26.11 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 ± 2) °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.