

Electrical apparatus for potentially explosive atmospheres — Type of protection “n”

The European Standard EN 50021:1999 has the status of a
British Standard

ICS 29.260.20

National foreword

This British Standard is the English language version of EN50021:1999. It supersedes BS 6941:1988 and BS 5000-16:1997 which are withdrawn.

The UK participation in its preparation was entrusted by Technical Committee GEL/31, Electrical apparatus for explosive atmospheres, to Subcommittee GEL/31/14, Types of protection “e” and “n”, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep UK interests informed;
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Matériel électrique pour atmosphères explosibles —
Mode de protection type “n”

Elektrische Betriebsmittel für
explosionsgefährdete — Bereiche Zündschutzart “n”

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CENELEC

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Foreword

This European Standard was prepared by SC 31-5, Apparatus type of protection “n”, of Technical Committee CENELEC TC 31, Electrical apparatus for explosive atmospheres.

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The European Standard was prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association and covers essential requirements of the EC Directive 94/9/EC.

Annexes designated “normative” are part of the body of the standard. In this standard, annex A is normative.

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Section One: General

1 Scope

This European Standard specifies requirements for the construction, testing and marking of Group II electrical apparatus with type of protection “n”, intended for use only in areas where explosive atmospheres of gas, vapour and mist are unlikely to occur or if they do occur, are likely to do so infrequently or for a short period only.

This standard is applicable to non-sparking electrical apparatus and also to 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 atmosphere.

A non-incendive part 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.

This standard is applicable to electrical equipment and components of Group II, Category 3G. Such equipment is designed to be capable of functioning in conformity with the operating parameters established by the manufacturer and ensuring a normal level of protection.

Equipment in this category ensures the requisite level of protection during normal operation.

NOTE 1 In this standard the word “apparatus” has the same meaning as the word “equipment” used in the Directive.

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

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

NOTE 2 The application of this standard may require the exercise of engineering judgement because of the wide range of apparatus and technologies covered. If apparatus is to be certified the relevant requirements may need to be agreed between the manufacturer and the testing station.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN 50014:1997, *Electrical apparatus for potentially explosive atmospheres — General requirements*.

EN 50020:1994, *Electrical apparatus for potentially explosive atmospheres — Intrinsic safety “i”*.

EN 60034-1, *Rotating electrical machines — Part 1: Rating and performance*.

EN 60034-5, *Rotating electrical machines — Part 5: Classification of degrees of protection provided by enclosures for rotating machines*.

EN 60068-2-27:1993, *Basic environmental testing procedures — Part 2: Tests — Test Ea and guidance: Shock*.

EN 60068-2-75, *Environmental testing — Part 2: Tests — Test Eh: Hammer tests*.

EN 60081, *Double-capped fluorescent lamps — Performance specifications*.

EN 60155, *Starters for tubular fluorescent lamps*.

EN 60238, *Edison screw lampholders*.

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

EN 60400, *Lampholders for tubular fluorescent lamps and starterholders*.

EN 60529:1991, *Degrees of protection provided by enclosures (IP Code)*.

EN 60598-1:1997, *Luminaires — Part 1: General requirements and tests*.

EN 60598-2, *Luminaires — Part 2: Particular requirements*.

EN 60662, *High-pressure sodium vapour lamps*.

EN 60920, *Ballasts for tubular fluorescent lamps — General and safety requirements*.

EN 60922, *Auxiliaries for lamps — Ballasts for discharge lamps (excluding fluorescent lamps) — General and safety requirements*.

EN 60924, *D.C. supplied electric ballasts for tubular fluorescent lamps — General and safety requirements*.

EN 60926, *Auxiliaries for lamps — Starting devices (other than glow starters) — General and safety requirements*.

EN 60927, *Auxiliaries for lamps — Starting devices (other than glow starters) — Performance requirements*.

EN 60928, *Auxiliaries for lamps — A.C. supplied electronic ballasts for tubular fluorescent lamps — General and safety requirements*.

EN 60947-1, *Low-voltage switchgear and controlgear — Part 1: General rules*.

EN 61048, *Capacitors for use in tubular fluorescent and other discharge lamp circuits — General and safety requirements*.

EN 61049, *Capacitors for use in tubular fluorescent and other discharge lamp circuits — Performance requirements*.

EN 61184, *Bayonet lampholders*.

International Publications with references to the corresponding European publications

IEC 60050, *International Electrotechnical Vocabulary*.

IEC 60060, *High-voltage test techniques* (HD 588 S1:1991, EN 60060-2:1994).

IEC 60112, *Method for determining the comparative and the proof tracking indices of solid insulating materials under moist conditions* (HD 214 S2:1980).


Documents

Document Sharing Hub

IEC 60216-1, *Guide for the determination of thermal endurance properties of electrical insulating materials — Part 1: General guidelines for ageing procedure and evaluation of test results* (HD 611.1 S1:1992).

IEC 60216-2, *Guide for the determination of thermal endurance properties of electrical insulating materials — Part 2: Choice of test criteria* (HD 611.2 S1:1992).

IEC 60664-1, *Insulation co-ordination for equipment within low-voltage systems — Part 1: Principles, requirements and test.* (HD 625.1 S1:1996).

ISO 179, *Plastics — Determination of charpy impact strength.*

ISO 4892, *Plastics — Methods of exposure to laboratory light sources.*

3
Definitions

For the purposes of this standard, the following definitions apply.

NOTE Definitions which are identical with or technically equivalent to those given in IEC 60050, IEC 60664-1, and EN 50014 are identified as follows:

IEC 60050	1)
IEC 60664-1	2)
EN 50014	3)

3.1
electrical apparatus³⁾

items applied as a whole or in part for the utilization of electrical energy

These include, among others, items for the generation, transmission, distribution, storage, measurement, regulation, conversion, and consumption of electrical energy and items for telecommunications.

3.2
explosive gas atmosphere³⁾

mixture with air, under atmospheric conditions, of flammable substances in the form of gas, vapour or mist, in which, after ignition, combustion spreads throughout the unconsumed mixture

3.3
type of protection³⁾

specific measures applied to electrical apparatus to avoid ignition of a surrounding explosive atmosphere

3.4
type of protection “n”

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

3.5
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, e.g. operation of a motor on a duty cycle.

NOTE 2 Variation of the supply voltage within stated limits (see 4.3.1.2) and any other operational tolerance is part of normal operation.

3.6
enclosure³⁾

all the walls doors, covers, cable entries, rods, spindles, shafts, etc., which contribute to the type of protection and/or the degree of protection (IP) of the electrical apparatus

3.7
degree of protection of enclosure (IP)³⁾

a numerical classification preceded by the symbol “IP” applied to the enclosure of electrical apparatus to provide for:

- protection of persons against contact with or approach to live parts and against contact with moving parts (other than smooth rotating shafts and the like) inside the enclosure, and
- protection of the electrical apparatus against ingress of solid foreign objects, and, where indicated by the classification,
- protection of the electrical apparatus against harmful ingress of water.

NOTE The enclosure which provides the “degree of protection IP” is not necessarily identical to the apparatus enclosure for the types of protection listed in EN 50014:1997, 1.2.

3.8
non-sparking device

a device constructed to minimize the risk of occurrence of arcs, sparks or hot spots capable of creating an ignition hazard during normal use

Normal use excludes the removal or insertion of components with the circuit energized.

3.9
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

3.10
non-incendive component

component with contacts for making and breaking a potentially incendive circuit where either the contacting mechanism or the enclosure in which the contacts are housed is so constructed that ignition of the prescribed flammable gas or vapour is prevented under specified operating conditions

3.11

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, e.g. by soldering, brazing, welding or the fusion of glass to metal

3.12

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

3.13

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

3.14

restricted-breathing enclosure

enclosure that is designed to restrict the entry of gases

3.15

simplified pressurization

the 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

3.16

maximum surface temperature

the highest temperature which is attained in service under the most adverse conditions (but within the recognized tolerances) by any part or surface of an electrical apparatus, which would be able to produce an ignition of the surrounding explosive atmosphere

NOTE 1 The manufacturer will prescribe the product standard and also in his particular design he should take into account the following other conditions:

- fault conditions specified in this standard for the protection technique concerned;
- all operating conditions in any other standard specified by him, including recognized overloads;
- any other operating condition specified by him.

NOTE 2 The relevant surface temperature may be internal or external depending upon the protection technique concerned.

3.17

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

3.17.1

energy-limited apparatus

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

3.17.2

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 cannot adversely affect the energy-limited circuits.

Associated energy-limited apparatus may be either:

- a) electrical apparatus which has an alternative type of protection listed in this standard for use in the appropriate explosive gas atmosphere; or
- b) electrical apparatus which has an alternative type of protection listed in EN 50014 for use in the appropriate explosive gas atmosphere; or
- c) electrical apparatus not so protected and which therefore shall not be used within an explosive gas atmosphere, e.g. a recorder which is not of itself in an explosive atmosphere but is connected to a thermocouple situated within an explosive atmosphere where only the recorder input circuit is energy-limited.

3.17.3

self protected energy-limited apparatus

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

3.18

explosive test mixture³⁾

a specified explosive mixture used for the testing of electrical apparatus for potentially explosive atmospheres

3.19

terminal compartment³⁾

a separate compartment or part of a main enclosure, communicating or not with the main enclosure, and containing connection facilities

3.20

connection facilities³⁾

terminals, screws and other parts, used for the electrical connection of conductors of external circuits

3.21

cable entry³⁾

a device permitting the introduction of one or more electric and/or fibre optic cables into an electrical apparatus so as to maintain the relevant type of protection

3.22

conduit entry³⁾

a means of introducing a conduit into an electrical apparatus so as to maintain the relevant type of protection

3.23

stopping box

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

3.24

rated value³⁾

a quantity value assigned, generally by the manufacturer, for a specified operating condition of a component, device or apparatus

3.25

rating³⁾

the set of rated values and operating conditions

3.26

duty cycle¹⁾

variation of load with time which may or may not be repeated and in which the cycle time is too short for thermal equilibrium to be attained

3.27

creepage distance²⁾

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

NOTE A joint between two pieces of insulating material is considered part of the surface.

3.28

separation

shortest distance through solid insulating material between two conductive parts

3.29

clearance²⁾

shortest distance in air between two conductive parts

3.30

portable apparatus

apparatus that can be moved while in operation or that can easily be moved from one place to another ready for use while connected to the supply

3.31

working voltage²⁾

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

3.32

Ex component

a 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 potentially explosive atmospheres

NOTE Directive 94/9/EC defines a component as:

Any item essential to the safe functioning of equipment and protective systems but with no autonomous function.

In this standard, the words "Ex component" have the same meaning as the word "component used in the Directive".

3.33

X symbol

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

3.34

U symbol

the 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.

3.35 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

3.36 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

3.37

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

3.38

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

3.39

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

3.40

maximum input power (P_i)

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

3.41

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

3.42

maximum external capacitance (C_o)

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

3.43

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

3.44

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

3.45

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

3.46

cell or battery¹⁾

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

3.46.1

secondary cell

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

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.

3.46.2

secondary battery¹⁾

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

3.46.3

container (of a cell)¹⁾

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

3.46.4

(battery) container

enclosure to contain the battery

NOTE The cover is a part of the battery container.

3.46.5

battery capacity¹⁾

the 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 ($1C = 1As$), but in practice battery capacity is usually expressed in ampere-hours (Ah).

3.46.6

plate pack¹⁾

an assembly of the positive and negative plate groups with separators

3.46.7

intercell connector¹⁾

a conductor of electricity used for carrying current between cells

4 General requirements

4.1 Potential ignition sources

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

- 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 section four;
- 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 section four 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 European 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 purposes of this standard, the allocation of gases is as for the apparatus groupings in EN 50014.

4.3 Temperatures

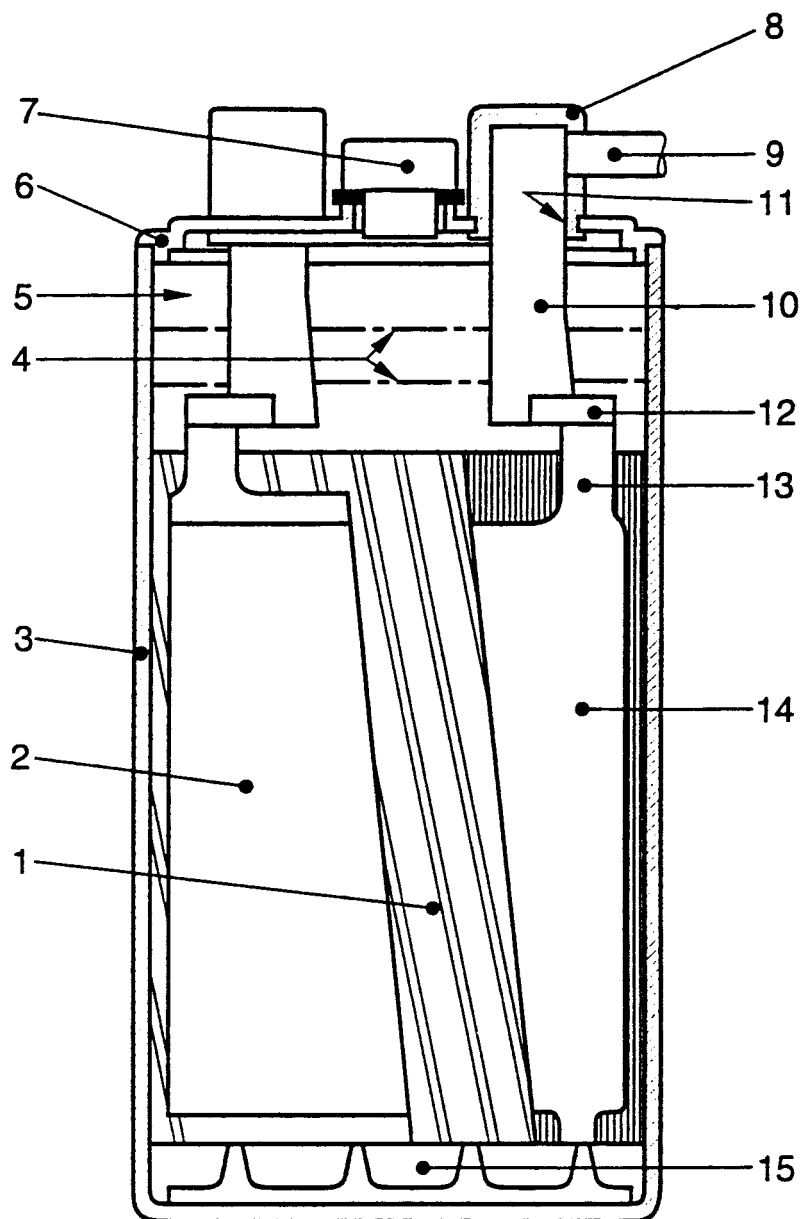
4.3.1 Maximum surface temperature

4.3.1.1 Electrical apparatus shall be either:

- classified in a temperature class given in Table 1;
- defined by the actual maximum surface temperature;
- defined by the specific gas for which it is intended.

NOTE It is preferred that the apparatus be classified in a temperature class as given in Table 1.

The apparatus shall be marked accordingly (see clause 28).



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.

- | | |
|-------------------------------|---|
| 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 cell

Table 1 — Classification of maximum surface temperatures for electrical apparatus

Temperature class	Maximum surface temperature °C
T1	450
T2	300
T3	200
T4	135
T5	100
T6	85

4.3.1.2 Except for the internal parts of enclosed-break devices, restricted-breathing enclosures, hermetically sealed devices, lamps, sealed devices or components or apparatus complying with **4.3.3**, the temperature of any external or internal surface to which the surrounding atmosphere has access shall not exceed the values stated in Table 1. The temperature shall be measured or assessed with the apparatus in the most unfavourable conditions and at the most unfavourable voltage within the range of 90 % to 110 % of rated voltage of the electrical apparatus unless other European Standards or CENELEC Harmonization Documents for normal industrial applications prescribe values different from this range. For electrical apparatus which can normally be used in different positions, the temperature in the worst case position is to be determined. When the temperature is determined for specific positions only, the apparatus shall be marked X.

The measured maximum surface temperature shall not exceed:

- for electrical apparatus where each manufactured sample is routinely submitted to the thermal test; the temperature as marked on the electrical apparatus;
- for electrical apparatus where the electrical apparatus is subjected to type testing, the marked temperature, or the temperature class, less 5 K for temperature classes T6, T5, T4 and T3, and less 10 K for temperature classes T2 and T1.

4.3.2 Ambient temperatures

Electrical apparatus shall normally be designed for use in the ambient temperature range between -20 °C and $+40\text{ °C}$; in this case, no additional marking is necessary. When the electrical apparatus is designed for use in a different range of ambient temperatures, it is considered to be special; the ambient temperature range shall then be stated by the manufacturer and specified in the documentation (see clause 29). In addition the marking shall include either the symbol T_a or T_{amb} together with the special range of ambient temperatures or, if this is impracticable, the symbol X, see Table 2.

Table 2 — Ambient temperatures in service and additional marking

Electrical apparatus	Ambient temperature in service	Additional marking
Normal	Maximum: $+40\text{ °C}$ Minimum: -20 °C	None
Special	Special range stated by the manufacturer and specified in the documentation	T_a or T_{amb} with the special range, for example “ $-30\text{ °C} \leq T_a \leq +40\text{ °C}$ ” or the symbol X

4.3.3 Surface temperature and ignition temperature

The maximum surface temperature shall be lower than the lowest ignition temperature of the explosive atmospheres concerned.

Temperatures higher than that of the marked temperature class are permitted for small components, for example transistors, wire or resistors, if it can be shown by tests or experimental evidence that there is no risk of ignition and that any deterioration or deformation by such higher temperatures does not impair the type of protection.

Where components comply with one of the requirements of Table 3, no test need be carried out for T4 classification.

Table 3 — Assessment for T4 classification according to component size and ambient temperature

Total surface area excluding lead wires	Requirement for T4 classification
$< 20\text{ mm}^2$	Surface temperature $\leq 275\text{ °C}$
$\geq 20\text{ mm}^2$	Power dissipation $\leq 1,3\text{ W}^{1)}$
$\geq 20\text{ mm}^2 < 10\text{ cm}^2$	Surface temperature $\leq 200\text{ °C}$
¹⁾ Reduced to 1,2 W with 60 °C ambient temperature or 1,0 W with 80 °C ambient temperature.	

In addition components with a smaller surface area than 10 cm^2 (excluding lead wires) may be classified as T5 if their surface temperature does not exceed 150 °C .

NOTE For potentiometers, the surface to be considered is that of the resistance element and not the external surface of the component. Temperature is measured with current flowing in 10 % of the track resistance value.

4.3.4 Wiring within apparatus

The maximum permissible current corresponding to the maximum wire temperature due to the effect of self-heating cable can be taken from Table 4 for copper wires or can be calculated from the formula for metals in general.

Table 4 — Temperature class of copper wiring
(maximum ambient temperature = 40 °C)

Diameter (see note 4) mm	Cross-sectional area (see note 4) mm ²	Maximum permissible current for temperature class		
		T1-T4 A	T5 A	T6 A
0,035	0,000962	0,53	0,48	0,43
0,05	0,00196	1,04	0,93	0,84
0,1	0,00785	2,1	1,9	1,7
0,2	0,0314	3,7	3,3	3,0
0,35	0,0962	6,4	5,6	5,0
0,5	0,196	7,7	6,9	6,7
NOTE 1 The value given for maximum permissible current is the r.m.s. a.c. or d.c. value.				
NOTE 2 For stranded conductors the cross-sectional area is taken as the total area of all strands of the conductor.				
NOTE 3 The table also applies to flexible flat conductors, such as in ribbon cable, but not to printed circuit conductors.				
NOTE 4 Diameter and cross-sectional area are the nominal dimensions specified by the wire manufacturer.				
NOTE 5 Where P_i does not exceed 1,3 W the wiring can be awarded a temperature class of T4.				

The maximum current in insulated wiring shall not exceed the wire manufacturer's rating.

A formula for calculating the maximum permissible current causing self-heating of a metal wire is:

$$I = I_f \left[\frac{t(1 + aT)}{T(1 + at)} \right]^{1/2}$$

where

- a is the resistance temperature coefficient of the material of the wire (0,004265 K⁻¹ for copper);
- I is the maximum permissible current r.m.s. a.c. or d.c. (A);
- I_f is the current at which the wire melts (A);
- T is the temperature at which the wire melts (1 083 °C for copper);
- t is the wire temperature due to self-heating and ambient temperature (°C).

4.3.5 Printed circuit wiring

Where P_i does not exceed 1,3 W, the printed circuit wiring shall be allocated a temperature class of T4.

For other applications, the temperature class of conductive wiring of printed circuit boards shall be determined from Table 5. For the purposes of this European Standard, copper is the reference material for conductive tracks. Conductive tracks of material for which the conductivity characteristics are not at least equivalent to copper shall be thermally tested.

Track lengths of 10 mm or less may be disregarded for temperature class purposes.

Manufacturing tolerances on the thickness of printed circuit boards and conductive tracks, and on the width of conductive tracks, are acceptable provided they do not reduce the values stated in this clause by more than 10 % or 1 mm, whichever is the smaller.

Table 5 — Temperature class
of printed board wiring
(maximum ambient temperature = 40 °C)

Minimum track width mm	Maximum permissible current for temperature class A		
	T1-T4	T5	T6
0,15	1,2	1,0	0,9
0,2	1,8	1,45	1,3
0,3	2,8	2,25	1,95
0,4	3,6	2,9	2,5
0,5	4,4	3,5	3,0
0,7	5,7	4,6	3,1
1,0	7,5	6,05	5,4
1,5	9,8	8,1	6,9
2,0	12,0	9,7	8,4
2,5	13,5	11,5	9,6
3,0	16,1	13,1	11,5
4,0	19,5	16,1	14,3
5,0	22,7	18,9	16,6
6,0	25,8	21,8	18,9
NOTE 1 The value given for maximum permissible current is the r.m.s. a.c. or d.c. value.			
NOTE 2 This table applies to printed boards 1,6 mm or thicker with a single layer of copper of 35 µm thickness.			
NOTE 3 For boards with thickness > 0,5 mm and < 1,6 mm divide the maximum current specified by 1,2.			
NOTE 4 For boards with conducting tracks on both sides, divide the maximum current specified by 1,5.			
NOTE 5 For multilayer boards for the track layer under consideration divide the maximum current specified by 2.			
NOTE 6 For 18 µm copper thickness divide the maximum current specified by 1,5.			
NOTE 7 For 70 µm copper thickness multiply the maximum current specified by 1,3.			
NOTE 8 Where passing under components dissipating 0,25 W or more, divide the maximum current specified by 1,5.			
NOTE 9 At terminations of components dissipating 0,25 W or more, and for 1,00 mm along the conductor either multiply the track width by 3 or divide the maximum current specified by 2. If the track goes under the component apply the factor specified in note 8 to this table in addition.			

Section Two: Requirements for all electrical apparatus

5 General

5.1 Electrical apparatus

Electrical apparatus with type of protection “n” shall comply with the requirements of this European Standard.

5.2 Ex components

5.2.1 Ex components with type of protection “n” shall comply with the relevant requirements of this European Standard and may be:

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

5.2.2 Ex components may be mounted:

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

5.2.3 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 (e.g. surface temperature, creepage distance and clearance, and other conditions dependent upon mounting when the component is mounted).

5.2.4 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 type of protection “n”.

5.3 Other requirements

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

If certification is sought, it is not the intention that the certifying body or testing station should check compliance with this requirement, but that 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 If the electrical apparatus or Ex component has to withstand particularly adverse service conditions (e.g. 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.

6 Construction

6.1 Degree of protection

6.1.1 With the exceptions as specified in 6.1.2, the enclosure of the apparatus, when tested in accordance with 26.12 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).

6.1.2 A higher degree of protection shall apply and a lower degree of protection may apply to specific types of apparatus where indicated in this standard.

NOTE For requirements for rotating electrical machines, see Clause 10.

6.1.3 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.

6.1.4 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.

6.2 Mechanical strength

Enclosures shall be capable of satisfying the criteria for compliance of the impact test given in 26.3. Portable apparatus shall additionally be capable of satisfying the criteria for compliance of the drop test given in 26.3.2. Electrical apparatus complying with a low risk mechanical damage test in Table 13 shall be marked with the symbol X.

6.3 Guards

Every guard provided for the protection of a light-transmitting part or window shall have a maximum mesh size of 50 mm × 50 mm.

6.4 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 of sufficient/adequate amount and cross-section between parts of an enclosure or structure;
- the provision of an adequate quantity of fasteners.

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

6.5.1 The non-metallic materials shall have a temperature index TI corresponding to the 20 000 hour-point (see IEC 60216-1 and IEC 60216-2) or continuous operating temperature (COT) of at least 10 K greater than the temperature of the hottest point of the enclosure having regard to the maximum ambient temperature in service according to data supplied by the material manufacturer.

NOTE COT is a temperature which ensures the stability and integrity of the material for the expected life of the apparatus, or part, in its intended application.

6.5.2 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 to **26.3.4.3**.

For apparatus where the enclosure does not comply with this requirement, it shall be marked with an X and information given in the instructions.

6.5.3 The following requirements apply only to plastics enclosures, to plastics parts on enclosures and to other exposed plastics parts of electrical apparatus for:

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

Enclosures of plastics 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 by suitable selection of the material so that the insulation resistance, measured according to the method given in **23.4.7.8** of EN 50014:1997 does not exceed 1 GΩ at (23 ± 2) °C and (50 ± 5) % relative humidity, or by virtue 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 plastics parts that are in contact with live parts.

7 Connection facilities and wiring

7.1 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.

NOTE Connection facilities for luminaires are specified in clause 12.

7.2 Connection for external conductors

7.2.1 Except for electrical apparatus which is manufactured with a cable permanently connected to it, electrical apparatus which is intended for connection to external circuits 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 (e.g. in-line crimp connector) 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 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 8 are the responsibility of the installer of the apparatus.

7.2.2 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.

7.2.3 A connection 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 (e.g. 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.

7.2.4 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 6 below.

Table 6 — Minimum cross-sectional area of protective conductors

Cross-sectional area of phase conductors of the installation S mm ²	Cross-sectional area of the corresponding protective conductor S_p mm ²
$S \leq 16$	S
$16 < S \leq 35$	16
$S > 35$	$0,5S$

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.

7.2.5 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, such as apparatus with metallic enclosures used with metallic conduit systems.

7.2.6 Cable entries and cable entry devices shall:

- 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;
- 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 European Standard for industrial cable entries and cable entry devices where such standards exist, or
- the requirements of EN 50014 for equivalent EEx 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 connection. Such clamping can be provided by a clamping device, sealing ring or filling compound. The test in 26.14 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.

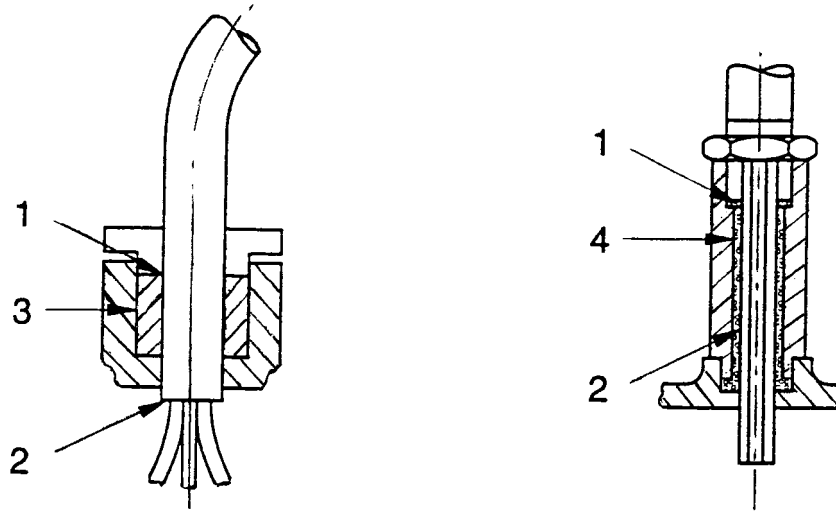
7.2.7 Conduit entries shall be constructed and mounted so that they do not alter the type of protection and the specific characteristics of the electrical apparatus on which they are mounted and shall screw into threaded holes or be locked in plain holes situated as follows:

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

7.2.8 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).

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

7.2.9 In the case of portable apparatus any cable entry shall satisfy the appropriate clamping requirements of EN 50014.



Cable entry

- 1 Entry point
- 2 Branching point

Conduit entry

- 3 Sealing ring
- 4 Filling compound

Figure 2 — Illustration of entry points and branching points

8 Clearances, creepage distances and separations

8.1 Clearances, creepage distances and separations between conductive parts at different potentials shall be as given in Table 7, except in the following cases:

- a) neutral point connections of rotating electrical machines complying with 10.4;
- b) luminaires complying with 12.2.7;
- c) with regard to sealed, encapsulated or solid insulation separations only, apparatus subject to the routine electric strength test of 9.2;
- 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 13.

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.

8.2 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.

8.3 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, e.g. 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 7 shall apply, taking account of the comparative tracking index (CTI) applicable to both insulation and conformal coating.

8.4 Clearances between bare conductive parts at different potentials shall be as given in Table 7 with a minimum value for external connections of 1,5 mm.

Clearances 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.

NOTE In determining the clearances, Examples 1 to 11 inclusive illustrate the features to be taken into account and the appropriate clearances. These examples are identical with those given in IEC 60664-1.

Table 7 — Minimum creepage distances, clearances and separations

Working voltage U , a.c. r.m.s or d.c (note 1) V	Minimum creepage distance mm				Minimum clearances and separations mm		
	Material group				In air	Sealed (note 2)	Encapsulated or solid insulation (note 3)
	I	II	IIIa	IIIb			
≤ 10	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	—		—		8	5,8	1,7
≤ 1 250	—		—		11	—	—
≤ 1 600	—		—		14	—	—
≤ 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, based on the R10 series, values for creepage distances are derived from IEC 60665. Up to 800 V, creepage distances are based on Pollution degree 3. Above that voltage, creepage distances are based on Pollution degree 2. 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 Sealed by a conformal coating. See 8.3.

NOTE 3 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.

8.5 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 8 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 12.2.7 and Table 11 for pulse voltages in luminaire circuits or IEC 60664-1 for additional information).

8.6 Creepage distances between bare conductive parts at different potentials shall be as given in Table 7, with a minimum value for external connections of 1,5 mm and shall be determined as a function of the working voltage specified by the manufacturer of the apparatus.

8.7 In determining the creepage distances, examples 1 to 11 illustrate the features to be taken into account and the appropriate creepage distance.

NOTE 1 Cement within a joint would normally be considered as obstructing a creepage or clearance path.

The effect of ribs and 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 2 Projections above or depressions below the surface are considered as being either ribs or grooves, irrespective of their geometric form.

Table 8 — 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	$100 \leq \text{CTI} < 175$

Table 9 — 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

¹⁾ *U* is the higher of the rated supply voltage or the maximum voltage occurring within the apparatus.

8.8 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 9 are obtainable for bare live parts, prior to the pouring of the compound.

NOTE The requirements in Table 9 differ from those in Table 7 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.

9 Electric strength

9.1 Insulation from earth or frame

Where the electrical circuits within the apparatus are not connected directly to the frame of the apparatus or not intended to be connected to the frame in service, the insulation or separation distance used shall withstand without breakdown the following test voltages for 60 + 3, –0 s:

- a) for apparatus supplied with voltages not exceeding 90 V peak or in which internal voltages not exceeding 90 V peak are present, 500 V r.m.s. (+25, –0) V r.m.s;
- b) for other apparatus, or where internal voltages in excess of 90 V peak are present, $(1\,000 + 2U^{1/2}) + 75, -0$ V r.m.s. or $(1\,500 + 75, -0)$ V r.m.s., whichever is the greater.

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

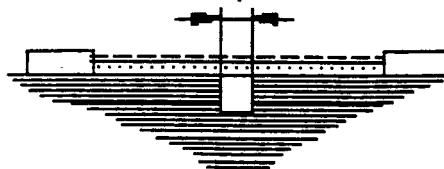
9.2 Insulation between conductive parts

In the case of apparatus subject to the exception of 8.1c) with regard to sealed, encapsulated or solid insulation separations, and where breakdown could cause an ignition capable arc, spark or hot surface, the insulation or separation between relevant conductive parts shall be subjected to a routine electric strength test carried out in accordance with 9.1.

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

Example 1

$< 1,5$

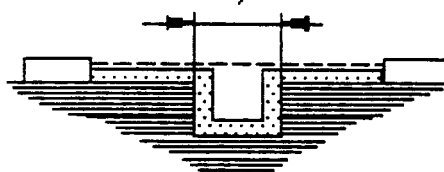


Condition Path under consideration includes a parallel or converging sided groove of any depth with a width less than 1,5 mm.

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

Example 2

$\geq 1,5$

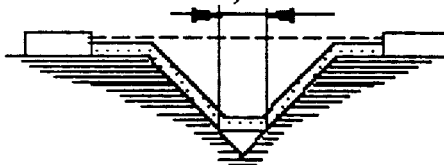


Condition Path under consideration includes a parallel-sided groove of any depth d equal to or more than 1,5 mm.

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

Example 3

$= 1,5$



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.

--- 1
Clearance

..... 2
Creepage