INTERNATIONAL STANDARD

IEC 61241-1-1

Second edition
1999-06

Electrical apparatus for use in the presence of combustible dust –

Part 1-1: Electrical apparatus protected by enclosures and surface temperature limitation – Specification for apparatus

Matériels électriques destinés à être utilisés en présence de poussières combustibles –

Partie 1-1: Matériels électriques protégés par enveloppes et limitation de la température de surface – Spécification pour les matériels

Reference number
IEC 61241-1-1:1999(E)

Numbering

As from 1 January 1997 all IEC publications are issued with a designation in the 60000 series.

Consolidated publications

Consolidated versions of some IEC publications including amendments are available. For example, edition numbers 1.0, 1.1 and 1.2 refer, respectively, to the base publication, the base publication incorporating amendment 1 and the base publication incorporating amendments 1 and 2.

Validity of this publication

The technical content of IEC publications is kept under constant review by the IEC, thus ensuring that the content reflects current technology.

Information relating to the date of the reconfirmation of the publication is available in the IEC catalogue.

Information on the subjects under consideration and work in progress undertaken by the technical committee which has prepared this publication, as well as the list of publications issued, is to be found at the following IEC sources:

- **IEC web site***
- **Catalogue of IEC publications**
  Published yearly with regular updates
  (On-line catalogue)*
- **IEC Bulletin**
  Available both at the IEC web site* and as a printed periodical

Terminology, graphical and letter symbols

For general terminology, readers are referred to IEC 60050: *International Electrotechnical Vocabulary* (IEV).

For graphical symbols, and letter symbols and signs approved by the IEC for general use, readers are referred to publications IEC 60027: *Letter symbols to be used in electrical technology*, IEC 60417: *Graphical symbols for use on equipment. Index, survey and compilation of the single sheets* and IEC 60617: *Graphical symbols for diagrams*.

* See web site address on title page.

INTERNATIONAL STANDARD

IEC 61241-1-1

Second edition
1999-06

Electrical apparatus for use in the presence of combustible dust –

Part 1-1: Electrical apparatus protected by enclosures and surface temperature limitation – Specification for apparatus

Matériels électriques destinés à être utilisés en présence de poussières combustibles –

Partie 1-1: Matériels électriques protégés par enveloppes et limitation de la température de surface – Spécification pour les matériels

International Electrotechnical Commission 3, rue de Varembé Geneva, Switzerland
Telefax: +41 22 919 0300 e-mail: inmail@iec.ch IEC web site http://www.iec.ch

Commission Electrotechnique Internationale
International Electrotechnical Commission
Международная Электротехническая Комиссия

PRICE CODE V

For price, see current catalogue

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ELECTRICAL APPARATUS FOR USE IN THE PRESENCE OF COMBUSTIBLE DUST –

Part 1-1: Electrical apparatus protected by enclosures and surface temperature limitation – Specification for apparatus

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.
2) The formal decisions or agreements of the IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested National Committees.
3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical reports or guides and they are accepted by the National Committees in that sense.
4) In order to promote international unification, IEC National Committees undertake to apply IEC International Standards transparently to the maximum extent possible in their national and regional standards. Any divergence between the IEC Standard and the corresponding national or regional standard shall be clearly indicated in the latter.
5) The IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with one of its standards.
6) Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. The IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 61241-1-1 has been prepared by subcommittee 31H: Apparatus for use in the presence of combustible dust, of IEC technical committee 31: Electrical apparatus for explosive atmospheres.

This second edition cancels and replaces the first edition, published in 1993, and constitutes a technical revision.

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

FDIS	Report on voting
31H/90/FDIS	31H/96/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.

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

IEC 61241 consists of the following parts under the general title: Electrical apparatus for use in the presence of combustible dust:

– Part 1: Electrical apparatus protected by enclosures and surface temperature limitation
– Part 2: Test methods
– Part 3: Classification of areas where combustible dusts are or may be present
– Part 4: Type of protection pressurization "p"[1)]
– Part 5: Intrinsically safe apparatus[1)]

1) Under consideration.

INTRODUCTION

Combustible dust can be ignited by electrical apparatus in several main ways:

- by surfaces of the apparatus that are above the minimum ignition temperature of the dust concerned. The temperature at which a type of dust ignites is a function of the properties of the dust, whether the dust is in a cloud or layer, the thickness of the layer and the geometry of the heat source;
- by arcing or sparking of electrical parts such as switches, contacts, commutators, brushes, or the like;
- by discharge of an accumulated electrostatic charge;
- by radiated energy (for example electromagnetic radiation);
- by mechanical sparking or frictional sparking or heating associated with the apparatus.

In order to avoid ignition hazards it is necessary that

- the temperature of surfaces, on which dust can be deposited, or which would be in contact with a dust cloud, is kept below the temperature limitation specified in IEC 61241-1-2;
- any electrical sparking parts, or parts having a temperature above the minimum ignition temperature of the dust
  - are contained in an enclosure which adequately prevents the ingress of dust, or
  - the energy of electrical circuits is limited so as to avoid arcs, sparks or temperatures capable of igniting combustible dust;
- any other ignition sources are avoided.

The protection specified in this standard will not provide the required level of safety unless the electrical apparatus is operated within its rating and is installed and maintained according to the relevant codes of practice or requirements, for example in respect of protection against over-currents, internal short circuits, and other electrical faults. In particular, it is essential that the severity and duration of an internal or external fault be limited to values that can be sustained by the electrical apparatus without damage.

Two different types of practice, A and B, are specified in this standard. Both are intended to provide an equivalent level of protection.

ELECTRICAL APPARATUS FOR USE IN THE PRESENCE OF COMBUSTIBLE DUST –

Part 1-1: Electrical apparatus protected by enclosures and surface temperature limitation – Specification for apparatus

1 Scope

This part of IEC 61241 is applicable to electrical apparatus protected by enclosures and surface temperature limitation for use in areas where combustible dust may be present in quantities which could lead to a fire or explosion hazard. It specifies requirements for design, construction and testing of electrical apparatus.

NOTE – IEC 61241-1-2 gives guidance on the selection, installation and maintenance of the apparatus. Apparatus within the scope of this standard may also be subject to additional requirements in other standards – for example, IEC 60079-0.

The ignition protection is based on the limitation of the maximum surface temperature of the enclosure and other surfaces which could be in contact with dust and on the restriction of dust ingress into the enclosure by the use of "dust-tight" or "dust-protected" enclosures.

The application of electrical apparatus in atmospheres which may contain explosive gas as well as combustible dust, whether simultaneously or separately, requires additional protective measures.

Where the apparatus has to meet other environmental conditions, for example, protection against ingress of water and resistance to corrosion, additional methods of protection may be necessary. The method used is not to adversely affect the integrity of the enclosure.

The principles of this standard may also be followed when combustible fibres or flyings cause a hazard.

This standard does not apply to dusts of explosives which do not require atmospheric oxygen for combustion, or to pyrophoric substances.

This standard is not applicable to electrical apparatus intended for use in underground parts of mines as well as those parts of surface installations of such mines endangered by fire damp and/or combustible dust. This standard does not take account of any risk due to an emission of flammable or toxic gas from the dust.

This standard does not include other types of protection and is only applicable to protection by enclosures and surface temperature limitation.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 61241. 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 61241 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 IEC and ISO maintain registers of currently valid International Standards.

IEC 60034-5:1991, *Rotating electrical machines – Part 5: Classification of degrees of protection provided by enclosures of rotating electrical machines (IP code)*

IEC 60050(426):1990, *International Electrotechnical Vocabulary (IEV) – Chapter 426: Electrical apparatus for explosive atmospheres*

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

IEC 60079-7:1990, *Electrical apparatus for explosive gas atmospheres – Part 7: Increased safety "e"*

IEC 60079-11:1991, *Electrical apparatus for explosive gas atmospheres – Part 11: Intrinsic safety "i"*

IEC 60093:1980, *Methods of test for volume resistivity and surface resistivity of solid electrical insulating materials*

IEC 60192:1973, *Low-pressure sodium vapour lamps*

IEC 60243-1:1998, *Electrical strength of insulating materials – Test methods – Part 1: Tests at power frequencies*

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*

IEC 60216-2:1990, *Guide for the determination of thermal endurance properties of electrical insulating materials – Part 2: Choice of test criteria*

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

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

IEC 60947-3:1990, *Low-voltage switchgear and controlgear – Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units*

IEC 61241-1-2:199X, *Electrical apparatus for use in the presence of combustible dust – Part 1-2: Electrical apparatus protected by enclosures – Selection, installation and maintenance*

IEC 61241-2-1:1994, *Electrical apparatus for use in the presence of combustible dust – Part 2: Test methods – Section 1: Methods for determining the minimum ignition temperatures of dust*

IEC 61241-3:1997, *Electrical apparatus for use in the presence of combustible dust – Part 3: Classification of areas where combustible dusts are or may be present*

ISO 178:1993, *Plastics – Determination of flexural properties*

ISO 527 (all parts), *Plastics – Determination of tensile properties*

ISO 4225:1994, *Air quality – General aspects – Vocabulary*

3 Definitions

For the purpose of this part of IEC 61241, the following definitions apply:

3.1
dust
small solid particles in the atmosphere which settle out under their own weight, but which may remain suspended in air for some time (includes dust and grit as defined in ISO 4225)

3.2
combustible dust
dust, fibres or flyings that can burn or glow in air and could form explosive mixtures with air at atmospheric pressure and normal temperatures

3.3
conductive dust
dust fibres or flyings with electrical resistivity equal to or less than 10^3 Ωm

3.4
explosive dust atmosphere
mixture with air, under atmospheric conditions, of flammable substances in the form of dust or fibres in which, after ignition, combustion spreads throughout the unconsumed mixture

[IEV 426-02-04]

3.5
minimum ignition temperature of a dust layer
lowest temperature of a hot surface at which ignition occurs in a dust layer of specified thickness on this hot surface

[see 3.3 of IEC 61241-2-1, modified]

3.6
minimum ignition temperature of a dust cloud
lowest temperature of the hot inner wall of a furnace at which ignition occurs in a dust cloud in air contained therein

[see 3.5 of IEC 61241-2-1, modified]

3.7
dust ignition protection (DIP)
all relevant measures specified in this standard (for example, dust ingress protection and surface temperature limitation) applied to electrical apparatus to avoid ignition of a dust layer or cloud

3.8
dust-tight enclosure
enclosure capable of preventing the ingress of all observable dust particles

3.9
dust-protected enclosure
enclosure in which the ingress of dust is not totally prevented but does not enter in sufficient quantity to interfere with the safe operation of the equipment. Dust should not accumulate in a position within the enclosure where it is liable to cause an ignition hazard

3.10
maximum surface temperature
highest temperature which is attained by any part of the surface of electrical apparatus when tested under the defined dust-free or blanket conditions

NOTE – This temperature is attained under the test condition. Increasing the layer thickness can increase this temperature due to the thermal insulation properties of dust.

3.11
maximum permissible surface temperature
highest temperature a surface of electrical apparatus is allowed to reach in practical service to avoid ignition. The maximum permissible surface temperature will depend upon the type of dust, whether as a cloud or layer, if a layer, its thickness, and the application of a safety factor [see IEC 61241-1-2, clause 6]

3.12
zones
see 2.10 of IEC 61241-3

3.13
zone 20
see 2.11 of IEC 61241-3

3.14
zone 21
see 2.12 of IEC 61241-3

3.15
zone 22
see 2.13 of IEC 61241-3

4 Construction

4.1 Electrical apparatus for use in potentially explosive dust atmospheres shall comply with the requirements of this standard.

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

4.2 Enclosures for use in zone 20 or 21 which can be opened more quickly than the time necessary

- to allow incorporated capacitors, charged by a voltage of 200 V or more, to discharge to a value of residual energy of 0,2 mJ; or
- to allow the cooling of enclosed hot components to a surface temperature below the temperature class of the electrical apparatus

shall be marked with the following or equivalent warning:

"AFTER DE-ENERGIZING, DELAY X MINUTES BEFORE OPENING"

"X" being the value in minutes of the delay required.

Alternatively the apparatus may be marked with the warning:

"DO NOT OPEN WHEN AN EXPLOSIVE DUST ATMOSPHERE IS PRESENT".

4.3 Where the apparatus has to meet other environmental conditions, for example, protection against ingress of water and resistance to corrosion, the method of protection used shall not adversely affect the integrity of the enclosure.

5 Enclosure materials

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

The following requirements apply to non-metallic enclosures and non-metallic parts of enclosures on which the type of protection depends. In addition, the requirements of 20.4.7 apply to enclosures for use in zone 20 or 21.

5.1.1 Documents submitted to the manufacturer shall specify both the material and the manufacturing process of the enclosure or part of the enclosure.

5.1.2 The specification for plastic materials shall include

a) the name of the manufacturer;

b) the exact and complete reference of the material including its colour, percentage of fillers and any other additives if used;

c) the possible surface treatments, such as varnishes, etc.;

d) the temperature index "TI" corresponding to the 20 000 h point on the thermal endurance graph without loss of flexural strength exceeding 50 %, determined in accordance with IEC 60216-1 and IEC 60216-2 and based on the flexing property in accordance with ISO 178. If the material does not break in this test before exposure to the heat, the index shall be based on the tensile strength in accordance with ISO 527 with test bars of type 1.

The data by which these characteristics are defined shall be supplied by the manufacturer.

5.1.3 The testing station is not required to verify compliance of the material with its specification.

5.1.4 Thermal endurance

5.1.4.1 Plastic materials shall have a temperature index "TI" corresponding to the 20 000 h point of at least 20 K greater than the temperature of the hottest point of the enclosure or the part of the enclosure (see 20.4.7.1), having regard to the maximum ambient temperature in service.

5.1.4.2 The endurance to heat and to cold of the enclosures, or parts of enclosures, of plastic materials shall be satisfactory (see 20.4.7.3 and 20.4.7.4).

5.1.5 Electrostatic charges on enclosures or parts of enclosures of plastic material for use in zone 20 or 21.

5.1.5.1 The following requirements apply only to plastic enclosures, to plastic parts of 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.

5.1.5.2 Enclosures of plastic material with surface area projected in any direction of more than 100 cm^2 shall be so designed that under normal conditions of use, maintenance and cleaning, danger of ignition due to electrostatic charges is avoided.

5.1.5.3 This can be achieved by the use of plastic material having one or more of the following characteristics:

- Insulation resistance $\leq 10^9$ Ω (resistance against electrostatic discharge to earth through or across the surface of insulation, measured according to the method described in IEC 60093 with an effective area of the circular electrode of 20 cm^2).
- Breakdown voltage ≤4 kV (measured across the thickness of the insulating material according to the method described in IEC 60243-1).
- Thickness ≥8 mm of the external insulation on metal parts. (External plastic layers of 8 mm and greater on metal parts such as measurement probes or similar components make propagating brush discharges unlikely to occur. When evaluating the minimum thickness of the insulation to be used or specified, it is necessary to allow for any expected wear under normal usage.)

5.1.5.4 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.

5.2 Enclosures containing light metals

5.2.1 Materials used in the construction of enclosures of electrical apparatus to be used in explosive dust atmospheres shall not contain, by weight, more than 6 % in total of magnesium and titanium.

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

6 Fasteners

6.1 Parts necessary to achieve a standard type of protection or used to prevent access to uninsulated live parts shall be capable of being released or removed only with the aid of a tool.

6.2 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 the plastic or light metal material when the thread form is compatible with the plastic or light metal material of the enclosure.

7 Interlocking devices

Interlocking devices used to maintain a type of protection shall be so constructed that their effectiveness cannot readily be defeated by the use, for example, of a screwdriver or pliers.

8 Bushings

8.1 Bushings in enclosures used as connection facilities, and which may be subjected to a torque while the connection or disconnection is being made, shall be mounted in such a way that all parts are secured against turning.

8.2 Bushings in enclosures for use in zone 20 or 21 shall comply with the relevant torque test as specified in 20.4.4.

9 Materials used for cementing

9.1 The manufacturer's documents submitted according to 20.2 of this standard shall testify that for the intended operating conditions, the materials used for cementing, and on which safety depends, have a thermal stability adequate for the minimum and maximum temperatures to which they will be subjected, within the rating of the electrical apparatus.

9.2 The thermal stability is considered adequate if the limiting values for the material are below or equal to the lowest working temperature and at least 20 K above the maximum temperature in service.

NOTE – If the cementing has to withstand adverse service conditions, appropriate measures should be agreed between user and manufacturer.

9.3 The testing station is not required to verify the characteristics listed in the documents mentioned in 9.1.

10 Connection facilities and terminal compartments

10.1 Electrical apparatus which is intended for connection to external circuits shall include connection facilities, except if the electrical apparatus is manufactured with a cable permanently connected to it. All apparatus constructed with permanently connected unterminated cables shall be marked with the symbol "X" to indicate the need for appropriate connection of the free end of the cable.

10.2 Terminal compartments and their access openings shall be dimensioned so that the conductors can be readily connected.

10.3 Terminal compartments shall be so designed that after proper connection of the conductors, the creepage distances and the clearances comply with the requirements, if any, of the specific standard for the type of apparatus concerned.

11 Connection facilities for earthing or bonding conductors

11.1 A connection facility for the connection of an earthing or equipotential bonding conductor shall be provided inside the terminal compartment of electrical apparatus and near the other connection facilities.

11.2 Electrical apparatus with a metallic enclosure shall have an additional external connection facility for an earthing or equipotential bonding conductor. This external connection facility shall be electrically in contact with the facility required in 11.1. The external connection facility is not required for electrical apparatus which is designed to be moved when energized and is supplied by a cable incorporating an earthing or equipotential bonding conductor.

NOTE – The expression "electrically in contact" does not necessarily involve the use of a conductor.

11.3 Neither an internal nor external earthing or bonding connection facility is required for electrical apparatus for which earthing (or bonding) is not required, such as electrical apparatus having double or reinforced insulation, or for which supplementary earthing is not necessary.

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

Table 1 – Minimum cross-sectional areas of protective conductors

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

11.5 In addition to meeting this requirement, earthing or bonding connection facilities on the outside of electrical apparatus shall provide for effective connection of a conductor of at least 4 mm^2.

11.6 Connection facilities shall effectively be protected against corrosion. They shall also be designed so that the conductors are secured against loosening and twisting and so that the contact pressure is maintained.

11.7 Contact pressure of electrical connections shall not be affected by dimensional changes of insulating materials in service, due to temperature or humidity, etc.

11.8 Special precautions shall be taken if one of the parts in contact consists of a material containing light metal. One example of a means of connecting to a material containing light metal is to use an intermediate part made from steel.

12 Cable and conduit entries

12.1 The manufacturer shall specify in the documents submitted according to 20.2, the entries intended for use with cable or conduit, their position on the apparatus and the maximum number permitted.

12.2 Cable and conduit entries shall be constructed and fixed so that they do not alter the specific characteristics of the type of protection of the electrical apparatus on which they are mounted. This shall apply to the whole range of cable dimensions specified by the manufacturer of the cable entries as suitable for use with those entries.

12.3 Cable and conduit entries may form an integral part of the apparatus, i.e. one major element or part forms an inseparable part of the enclosure of the apparatus. In such cases, the entries shall be tested and certified with the apparatus.

NOTE – Cable and conduit entries, which are separate from, but installed with the apparatus, are usually tested and certified separately from the apparatus but may be tested and certified together with the apparatus if the apparatus manufacturer so requests.

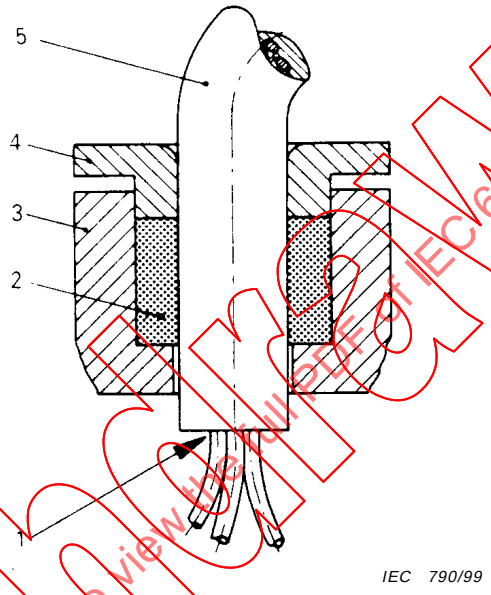
12.4 Where the design of a cable entry is such that twisting of the cable can be transmitted to the connections, then an anti-rotation device shall be fitted.

12.5 Entry by conduit or cable entries shall be either by screwing into threaded holes or by locking in plain holes

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

12.6 Blanking elements intended to close openings in the walls of electrical apparatus when they are not fitted with cable or conduit entries, shall, together with the enclosure wall of the apparatus, satisfy the requirements of the specific type of protection concerned. The means provided for this shall be such that the blanking element can be removed only with the aid of a tool.

12.7 When the temperature under rated conditions, including any manufacturer's installation requirements, 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, in order to ensure that the rated temperature of the cable is not exceeded (see figure 1).



Key

1 Branching point of the conductors
2 Sealing ring
3 Cable entry body
4 Clamping ring with curved rim
5 Cable

Figure 1 – Illustration of entry points and branching points

13 Supplementary requirements for electrical apparatus for practice B for use in zone 20 or 21

13.1 Joints

13.1.1 Plain joints (see figure 2) shall have a minimum contact width from inside to outside of the enclosure and a maximum allowable clearance between the surfaces as shown in table 2.

Table 2 – Plain joints

Minimum contact width of the plain joint (mm), *W*	5	22
Maximum allowable clearance between the surfaces of the joint (mm), *G*	0,05	0,22
NOTE – For widths of joints between 5 mm and 22 mm the maximum clearance may be increased by 0,01 mm for each millimetre increase in joint width greater than 5 mm.		

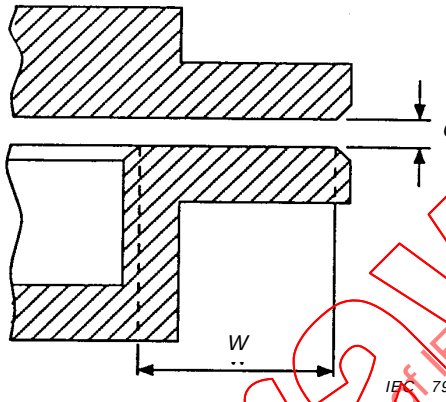


Figure 2 – Plain joints

13.1.2 Spigotted joints (see figure 3) which have axial, *L*, and radial, *W*, paths neither of which is less than 1,2 mm, may have diametrical clearances as shown for plain joints in table 2. The radial section, *W*, of the spigotted joint shall have a maximum allowable clearance, *G*, as shown for plain joints in table 2.

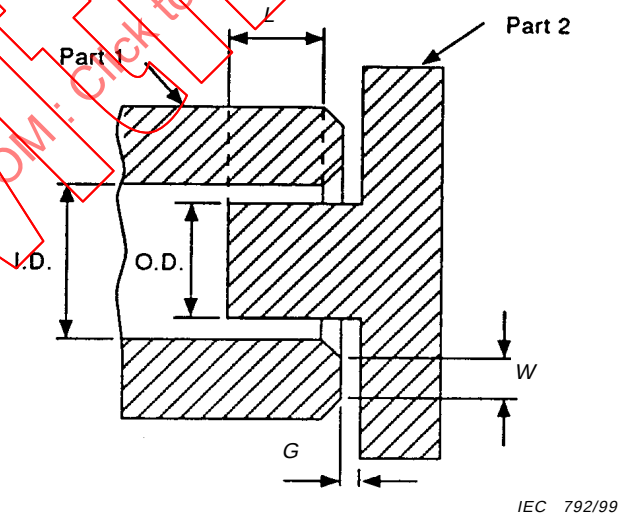


Figure 3 – Spigotted joints

13.1.3 For gasketed joints (see figure 4) requirements are given in table 3.

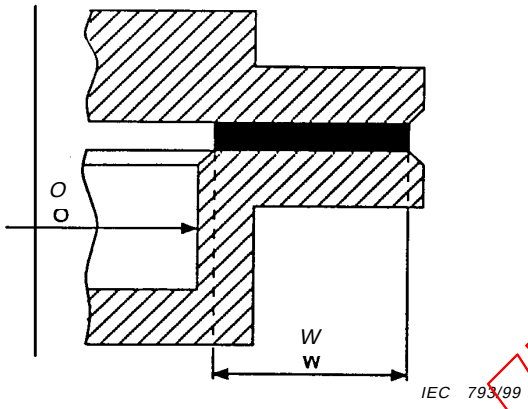


Figure 4 – Gasketed joints

Table 3 – Gasketed joints

Maximum opening dimension (mm), *O*	305	915	>915
Minimum required effective width of gasketed joint (mm), *W*	3	4,8	9,5
NOTE – For maximum opening dimensions between 305 mm and 915 mm, the effective width of the gasketed joint shall be increased by 0,003 mm for each millimetre increase in the maximum opening dimension greater than 305 mm.			

13.2 Operating rods, spindles or shafts

13.2.1 Equipment meeting the requirements of "Dust ignition protected apparatus type DIP B20 or DIP B21" and the test requirements of 20.4.3 of this standard shall not depend on running contact seals to ensure dust-tightness.

13.2.2 If running contact seals are used, the equipment shall meet the design details of table 4 and table 5 and the dust tests of 20.4.3 without the running contact seals installed.

13.2.3 Power shafts for transmitting power at rotational speeds of 100 r/min or more (see figure 5) shall meet the requirements for the length of path from the inside to the outside of the enclosure as given in table 4.

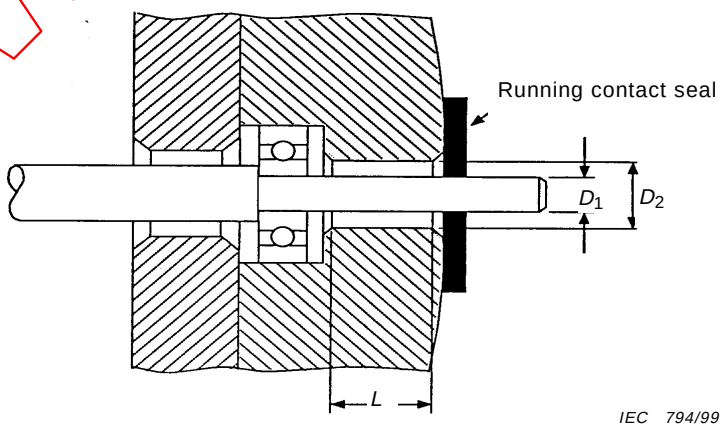


Figure 5 – Power shafts for speeds of 100 r/min. or more

Table 4 – Power shafts for speeds of 100 r/min or more

Minimum length of path for power shafts (mm), *L*	12,5	38,5
Maximum allowable diametrical clearance (mm), $D_2 - D_1$	0,26	0,57
NOTE 1 – For lengths of path for power shafts between 12,5 mm and 38,5 mm the maximum diametrical clearance may be increased by 0,012 mm for each millimetre increase in the length of path greater than 12,5 mm. NOTE 2 – The minimum length of path may include both the inner and outer lips of the bearing housing.		

13.2.4 Operating rods, spindles or shafts having rotary motion of less than 100 r/min or axial motion, shall have either a threaded joint with three full threads engaging, or have a minimum length of path from the inside to the outside of the enclosure as given in table 5.

Table 5 – Power shafts for speeds of less than 100 r/min

Minimum length of path for operating rods, spindles or shafts (mm), *L*	12,5	25,5
Maximum allowable diametrical clearance (mm), $D_2 - D_1$	0,13	0,21
NOTE – For lengths of path for operating rods, spindles or shafts between 12,5 mm and 25,5 mm, the maximum diametrical clearance may be increased by 0,006 mm for each millimetre length of path greater than 12,5 mm.		

13.3 Clearance of bolts

Bolts passing through the enclosure wall shall have a maximum diametrical clearance between the unthreaded shank of the bolt, N, and the clearance hole in the enclosure, DS-DH, of not more than 0,26 mm and a length of path, *L*, of not less than 12,5 mm (see figure 6).

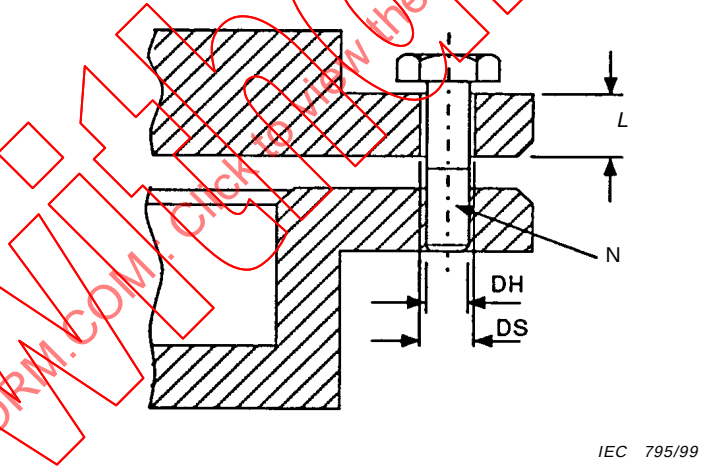


Figure 6 – Clearance of bolts

14 Rotating electrical machines

14.1 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 meet the following requirements.

14.2 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,

according to IEC 60034-5.

14.3 For vertical rotating machines for use in zone 20 or 21, foreign objects shall be prevented from falling into the ventilation openings.

14.4 Construction and mounting of the ventilating systems

Fans, fanhoods and ventilation screens shall be constructed so as to meet the requirements of the resistance to impact test according to 20.4.2.1 and the required results according to 20.4.2.3.

14.5 Clearances for the ventilating system for use in zone 20 or 21

In normal operation the clearances, taking into account design tolerances, between the external 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.

14.6 Materials for external fans and fanhoods for use in zone 20 or 21

14.6.1 External fans, fanhoods, ventilation screens, etc., shall have an electrical insulation resistance measured according to 5.1 5.3 not exceeding 10^9 Ω.

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

14.6.3 The external fans, fanhoods, ventilation screens, of rotating electrical machines, manufactured from materials containing light metals shall not contain by weight more than 6 % of magnesium.

15 Switchgear

15.1 Switchgear with contacts immersed in flammable dielectric is not permitted.

15.2 Disconnectors (which are not designed to be operated under the intended load) shall:

- be electrically or mechanically interlocked with a suitable load breaking device; or
- be marked at a place near the actuator of the disconnector, with the warning

"DO NOT OPERATE UNDER LOAD".

15.3 Where switchgear includes a disconnector, the latter shall disconnect all poles and shall be designed so that the position of the disconnector contacts is visible, or their open position is indicated in accordance with the requirements for the isolation function specified in IEC 60947-3. Any interlock between such disconnector and the cover or door of the switchgear shall allow this cover or door to be opened only when the separation of the disconnector contacts is effective.

16 Fuses

Enclosures containing fuses shall

- be interlocked so that insertion or removal of replaceable elements can be carried out only with the supply disconnected and so that the fuses cannot be energized until the enclosure is correctly closed; or
- alternatively, the apparatus shall be marked with the warning

"DO NOT OPEN WHEN ENERGIZED".

17 Plugs and sockets

17.1 Plugs and sockets shall comply with either a) or b) below:

a) 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 the plug and socket are separated; or

b) be fixed together by means of special fasteners according to 9.2 of IEC 60079-0 and the apparatus marked with the warning:

"DO NOT SEPARATE WHEN ENERGIZED".

17.2 In the case where bolted types cannot be de-energized before separation because they are connected to a battery, the marking shall then state:

"SEPARATE ONLY IN A NON-HAZARDOUS AREA".

17.3 Plugs and sockets for rated currents not exceeding 10 A and rated voltage not exceeding either 250 V a.c. or 60 V d.c. need not comply with the requirements of 17.1 if all the following conditions are complied with:

- the part which remains energized is a socket outlet;
- the plug and socket break the rated current with delayed release to permit the arc to be extinguished before separation;
- the plug and socket remain dust tight to IP6X during the arc-quenching period.

17.4 Plugs and components remaining energized when not engaged with a socket are not permitted.

18 Luminaries

18.1 The source of light of luminaires shall be protected by a light-transmitting cover which may be provided with an additional guard comprising a mesh of not greater than 50 mm squares. If mesh sizes exceed 50 mm squares then the luminaire cover shall be considered as unguarded.

18.2 The light transmitting cover and, if provided, the guard, shall be capable of passing the relevant tests according to 20.4.2.1.

18.3 The mounting of luminaires shall not depend on a single screw. A single eyebolt may be used only if this is an integral part of the luminaire, for example by being cast or welded to the enclosure, or, if threaded, the eyebolt is locked by a separate means against loosening when twisted.

18.4 Except in the case of intrinsically safe luminaries to IEC 60079-11, covers giving access to the lampholder and other internal parts of luminaries shall either

a) be interlocked with a device which automatically disconnects all poles of the lampholder as soon as the cover opening procedure begins; or

b) be marked with the warning:

"DO NOT OPEN WHEN ENERGIZED".

18.5 In the case of a) above, where it is intended that some parts other than the lampholder will remain energized after operation of the disconnecting device, then in order to minimize the risk of explosion, those energized parts shall be protected by

- clearances and creepage distances between phases (poles) and to earth in accordance with the requirements of IEC 60079-7; and
- an internal supplementary enclosure (which can be the reflector for the light source) which contains the energized parts and provides a degree of protection of at least IP30, according to IEC 60529; and
- marking on the internal supplementary enclosure with the warning:

"DO NOT OPEN WHEN ENERGIZED".

18.6 Lamps containing free metallic sodium (for example low-pressure sodium lamps in accordance with IEC 60192) are not permitted. High-pressure sodium lamps (for example, in accordance with IEC 60662) may be used.

19 Caplights, caplamps and handlamps

19.1 Leakage of the electrolyte shall be prevented in all positions of the apparatus.

NOTE – The materials used for handlamps and caplights which may be exposed to the electrolyte should be chemically resistant to the electrolyte.

19.2 Where the source of light and the source of supply are housed in separate enclosures, which are not mechanically connected other than by an electric cable, the cable entries and the connecting cable shall be tested as appropriate according to clause 24 or clause 25.

20 Verification and tests

20.1 General

20.1.1 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.

20.1.2 Table 6 indicates the party, either testing station (third party) or manufacturer, responsible for carrying out the test and the subclause to which the test refers.

Table 6 – Electrical apparatus testing and responsibility

Test	Subclause	Apparatus for use in zone 20 or 21	Apparatus for use in zone 22
Verification of documents	20.2	TS [1)]	MF [2)] or TS
Compliance	20.3	TS	MF or TS
Type tests	20.4		
– General	20.4.1	TS	MF or TS
– Mechanical tests	20.4.2		
– Resistance to impact	20.4.2.1	TS	RAS [3)]
– Drop test	20.4.2.2	TS	RAS
– Required results	20.4.2.3	TS	RAS
– Degree of protection	20.4.3	TS	MF or TS
– Torque test for bushings	20.4.4	TS	N/A [4)]
– Thermal tests	20.4.5	TS	MF or TS
– Thermal shock	20.4.6	TS	MF or TS
– Non-metallic enclosure	20.4.7	TS	N/A
Routine tests	21	MF	MF
Responsibility	22	MF	MF
Modification	23	TS	MF or TS
Clamping of non-armoured cables	24	TS	MF or TS
Clamping of armoured cables	25	TS	MF or TS

[1)] TS = Testing station (third party)
[2)] MF = Manufacturer
[3)] RAS = relevant apparatus standard
[4)] N/A = Not applicable

NOTE – In the case of repairs to electrical apparatus affecting the dust ignition protection, the parts which have been repaired should be subjected to new routine verifications and tests which need not necessarily be made by the manufacturer.

20.2 Verification of documents

20.2.1 It shall be verified that documents submitted by the manufacturer give a full and correct specification of the safety aspects of the electrical apparatus.

20.2.2 It shall also be verified that in the design of the electrical apparatus, the requirements of this standard and of the specific standards for the types of protection concerned have been observed.

20.3 Compliance of prototype or sample with documents

It shall be verified that the prototype or sample of the electrical apparatus submitted for the type tests complies with the manufacturer's documents referred to above.

20.4 Type tests

20.4.1 General

The prototype or sample shall be tested in accordance with the requirements for type tests of this standard. However, the responsible party

- may omit certain tests judged to be unnecessary. A record of all tests carried out and the justification for those omitted shall be kept;
- shall not conduct the tests which have already been carried out on a DIP component.

For tests required to be carried out by a testing station, the tests shall be made either in the laboratory of the testing station or, subject to agreement between the testing station and the manufacturer, elsewhere under the supervision of the testing station, for example at the manufacturer's works.

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

20.4.2 Mechanical tests

20.4.2.1 Test for resistance to impact for zone 20 or 21 enclosures

In this test the electrical apparatus is submitted to the effect of test mass of 1 kg falling vertically from a height (h). The height (h) is dependent on the impact energy (E) which is specified in table 7 according to the application of the electrical apparatus ($h = E/10$ where h is in metres and E is in joules). The test mass shall be fitted with an impact head in hardened steel in the form of a hemisphere 25 mm in diameter.

Before each test, it is necessary to check that the surface of the impact head is in good condition.

Normally, the resistance to impact test is made on apparatus which is completely assembled and ready for use; however, if this is not possible (for example, for light-transmitting parts) the test is made with the relevant parts removed but fixed in their mounting or an equivalent frame. Tests on an empty enclosure are permitted only if there has been prior agreement between the manufacturer and testing station.

For light-transmitting parts made of glass, the test shall be made on three samples but only once on each. In all other cases, the test shall be made on two samples, at two separate places on each sample.

The points of impact shall be the places considered by the testing station to be the weakest. The electrical apparatus shall be mounted on a steel base so that the direction of the impact is normal to the surface being tested if it is flat, or normal to the tangent to the surface at the point of impact if it is not flat. The base shall have a mass of at least 20 kg or be rigidly fixed or inserted in the floor (secured in concrete, for example).

Table 7 – Tests of resistance to impact

Risk of mechanical danger		Impact energy J	
		High	Low
1	Guards, protective covers, fanhoods, cable entries	7	4
2	Plastic enclosures	7	4
3	Light metal or cast metal enclosures	7	4
4	Enclosures of materials not included in 3 with wall thickness less than 1 mm	7	4
5	Light-transmitting parts without guard	4	2
6	Light transmitting parts with guard (tested without guard)	2	1

When an electrical apparatus is submitted to tests corresponding to the low risk of mechanical danger, it shall be marked with the symbol "X" according to 26.2.2.1 or 26.2.3.1.

Normally the test is carried out at an ambient temperature of (20 ± 5) °C, except where the material data shows it to have a reduction in resistance to impact at lower temperatures within the specified ambient range, in which case the test shall be performed at the lowest temperature within the specified range.

When the electrical apparatus has an enclosure or a part of an enclosure in plastic material, including plastic fanhoods and ventilation screens in rotating electrical machines, the test shall be carried out at the upper and lower temperatures according to 20.4.7.1.

20.4.2.2 Drop test for zone 20 or 21 enclosures

In addition to being submitted to the resistance to impact test according to 20.4.2.1, handheld electrical apparatus or electrical apparatus carried on the person, ready for use, shall be dropped four times from a height of 1 m onto a horizontal concrete surface. The position of the sample for the drop test shall be selected by the testing station.

For apparatus with an enclosure in other than plastic material the test shall be carried out at a temperature of (20 ± 5) °C, except where the material data shows it to have a reduction in resistance to impact at lower temperatures within the specified ambient range, in which case the test shall be performed at the lowest temperature within the specified range.

For electrical apparatus which has enclosures or parts of enclosures made of plastic material, the tests shall be carried out at the lower ambient temperature according to 20.4.7.1.

20.4.2.3 Required results

The resistance to impact and drop tests shall not produce damage invalidating the type of protection of the electrical apparatus.

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

External fanhoods and ventilation screens shall resist the tests without displacement or deformation causing rubbing by the moving parts.

20.4.3 Tests for dust exclusion by enclosures

20.4.3.1 General

Depending on the environmental conditions likely to be encountered (such as area classification and conductivity of dust) two levels of dust exclusion efficiency have been adopted: “dust-tight” and “dust-protected” enclosures.

NOTE – For the required degree of dust exclusion efficiency, see IEC 61241-1-2.

For the purpose of these tests, a non-combustible dust may be used. In making an assessment for the acceptance of the apparatus following the tests, the effect of the presence of a combustible dust shall be taken into consideration.

The precautions that shall be taken where a combustible dust is used for the tests is left to the discretion of the testing authority or others concerned.

20.4.3.2 Dust-tight apparatus for practice A

Enclosures shall satisfy the requirements for IP6X, as specified in IEC 60529, excluding rotating machines which shall be tested under conditions described for the first numeral 5 in IEC 60034-5, acceptance conditions being those indicated for the first numeral 6 in IEC 60529.

20.4.3.3 Dust-protected apparatus for practice A

Enclosures shall satisfy the test and acceptance requirements of IP5X, as specified in IEC 60529, and IEC 60034-5 as regards rotating machines.

20.4.3.4 Dust-tight apparatus for practice B

20.4.3.4.1 Heat cycling test

a) The apparatus shall be mounted in a test chamber of sufficient size to permit free circulation of the dust-air mixture around the sample during the test. A mixture of suitable dust and air shall be circulated by auxiliary equipment and introduced continuously into the test chamber during the entire test period. The particle size of the dust shall be such that it passes through a No. 100 ASTM sieve (approximately 0,15 mm mesh width) with approximately 22 % passing through a No. 200 ASTM sieve (approximately 0,075 mm mesh width).

b) For the test specified above, the apparatus shall be operated at rated load until maximum temperatures are reached and then disconnected from the supply until it has cooled to approximately room temperature. The number of cycles of heating and cooling shall be at least six and shall last for a minimum of 30 h.

NOTE 1 – The maximum temperature under load may be obtained by other means than running at rated load. For an enclosure such as a junction box without any appreciable heating effect (for example a switch), the effect of changes in barometric pressure may be simulated to produce the desired “breathing” effect.

NOTE 2 – Heating the chamber to 40 °C and maintaining this temperature for approximately 1 h and subsequently cooling the chamber to 20 °C and maintaining this temperature for 1 h has been found to be a satisfactory method for simulating changes in barometric pressure.

When the required number of heating and cooling cycles has been completed, the equipment for producing the dust-air atmosphere shall be shut off and the accumulated dust shall be removed from the exterior surfaces of the enclosures by gently brushing, wiping or shaking, with care being taken to avoid the introduction of additional dust into the enclosures.

Under no circumstances shall the dust be removed by an air blast or by vacuum cleaning.

The enclosure shall then be opened and carefully examined for the degree of dust penetration if any.

20.4.3.4.2 Acceptance criteria

No visible dust shall have entered the enclosure. Dust in joints shall not be considered a failure.

20.4.3.4.3 Verification of joints

The apparatus shall be checked for compliance with clause 13 of this standard with regard to methods of making joints.

20.4.3.5 Dust protected apparatus for practice B

Heat cycling test

Proceed as described in 20.4.3.4 except the number of cycles of heating and cooling shall be at least two and for a minimum period of 10 h.

Acceptance criteria

No visible dust shall have entered the enclosure. Dust in joints shall not be considered a failure.

20.4.4 Torque test for bushings in enclosures for use in zone 20 or 21

Bushings used for connection facilities and which are subjected to torque during connection or disconnection of conductors shall be tested for resistance to torque.

Neither the stem in the bushing nor the bushing when mounted shall turn when the stem is subjected to a torque of the value given in table 8.

Table 8 – Torque to be applied to the stem of bushing used for connection facilities

Diameter of the stem of the bushings	Torque Nm
M4	2,0
M5	3,2
M6	5
M8	10
M10	16
M12	25
M16	50
M20	85
M24	130
NOTE – Torque values for sizes other than those specified above may be determined from a graph, plotted using these values. In addition, the graph may be extrapolated to allow torque values to be determined for bushings larger than those specified.	

20.4.5 Thermal tests

20.4.5.1 Temperature measurement

The thermal tests shall be made at the rating of the electrical apparatus at an ambient temperature between 10 °C and 40 °C and with the most unfavourable voltage between 90 % and 110 % of the rated voltage of the electrical apparatus, unless other IEC publications prescribe other tolerances for equivalent industrial electrical apparatus.

The test shall be made under the most adverse conditions, including overloads and recognized abnormal conditions that may be specified in an IEC standard giving specific requirements for the electrical apparatus concerned. Adverse conditions may also arise from the use of electrical apparatus on inverter supplies, frequent starting, etc.

The measurement of the surface temperatures shall be made with the electrical apparatus mounted in its normal service position.

For electrical apparatus which can be normally used in different positions, the temperature in each position shall be determined and the highest temperature considered. When the temperature is determined for certain positions only this shall be specified in the test report and the electrical apparatus shall be marked accordingly.

The measuring devices (thermometers, thermocouple, etc.) and the connecting cables shall be selected and so arranged that they do not significantly affect the thermal behaviour of the electrical apparatus.

The final temperature is considered to have been reached when the rate of rise of temperature does not exceed 2 K/h.

20.4.5.2 Temperature control

Some apparatus may require the provision of integral temperature sensitive devices. For example some electric motors, fluorescent luminaries, etc. This protection shall not be defeated during the thermal tests of 20.4.5.

20.4.5.3 Ambient temperature range

Electrical apparatus for use in the presence of combustible dust shall normally be designed for operation in an ambient temperature range from –20 °C to +40 °C. Where the electrical apparatus is suitable for a temperature range which differs from this, the range shall be marked accordingly.

20.4.5.4 Apparatus for practice A

20.4.5.4.1 Dust-free test

This test shall be carried out in accordance with 20.4.5.1 through 20.4.5.3 without dust layers on the enclosure.

20.4.5.4.2 Maximum surface temperature of the enclosure T_A

The maximum surface temperature is that measured in the tests of 20.4.5.1 and shall be corrected to 40 °C ambient temperature.

20.4.5.5 Apparatus for practice B

20.4.5.5.1 Dust blanket test

This test shall be carried out in accordance with 20.4.5.1 through 20.4.5.3 with the additional requirement that the apparatus shall be covered with the maximum amount of dust that it can retain. As an alternative, a 12,5 mm thick layer of dust paste may be put on top of the apparatus (top 90° quadrant) to simulate the build-up conditions.

NOTE – The paste should consist of 45 % dust (e.g. wheat flour) and 55 % water by weight. The temperature value should be measured after the paste has dried.

20.4.5.5.2 Maximum surface temperature of the enclosure T_B

The maximum surface temperature is that measured in the tests of 20.4.5.1 and shall be corrected to 40 °C ambient temperature.

20.4.6 Thermal shock test

Glass parts of luminaries and windows of electrical apparatus shall withstand, without breaking, a thermal shock caused by a jet of water of about 1 mm diameter at a temperature (10 ± 5) °C sprayed on them when they are at maximum service temperature.

20.4.7 Tests of non-metallic enclosures or of non-metallic parts of enclosures for use in zone 20 or 21

20.4.7.1 Ambient temperatures during tests

When, according to this standard, tests have to be made as a function of the permissible upper and lower ambient temperature values, these ambient temperatures shall be

- for the upper ambient temperature, the maximum ambient temperature in service increased by at least 10 K but at most 15 K;
- for the lower ambient temperature, the minimum ambient temperature in service reduced by at least 5 K but at most 10 K.

20.4.7.2 Tests of enclosures or parts of enclosures in plastic materials

These tests shall be made on two samples which shall be submitted to the tests of thermal endurance to heat (see 20.4.7.3), thermal endurance to cold (see 20.4.7.4) and mechanical tests (see 20.4.7.5) and finally to the tests specific to the type of protection concerned.

20.4.7.3 Thermal endurance to heat

Thermal endurance to heat is determined by submitting the enclosures or parts of enclosures in plastic materials on which the integrity of the type of protection depends to continuous storage for four weeks in an ambiance of (90 ± 5) % relative humidity and at a temperature of (20 ± 2) K above the maximum service temperature, but at least 80 °C.

In the case of a maximum service temperature above 75 °C, the period of four weeks specified above shall be replaced by a period of two weeks at (95 ± 2) °C and (90 ± 5) % relative humidity followed by a period of two weeks at a temperature of (20 ± 2) K higher than the maximum service temperature.

20.4.7.4 Thermal endurance to cold

Thermal endurance to cold is determined by submitting the enclosures and parts of enclosures in plastic materials on which the type of protection depends to storage for 24 h in an ambient temperature corresponding to the minimum service temperature reduced according to 20.4.7.1.

20.4.7.5 Mechanical tests

The mechanical tests specified in 20.4.2 shall be carried out on the enclosures and, additionally, in the case of plastic enclosures, according to 20.4.7.2.

The following detailed conditions shall be observed.

a) Test for resistance to impact

The places of impact shall be on the external parts exposed to impact. If the enclosure of non-metallic material is protected by another enclosure, only the external parts of the assembly shall be subjected to the resistance to impact tests.

The test shall first be made at the highest temperature, then at the lowest temperature, according to 20.4.7.1.

b) Drop test

The drop test for electrical apparatus which is held in the hand or carried on the person, shall be made at the lowest temperatures, according to 20.4.7.1.

20.4.7.6 Insulation resistance test

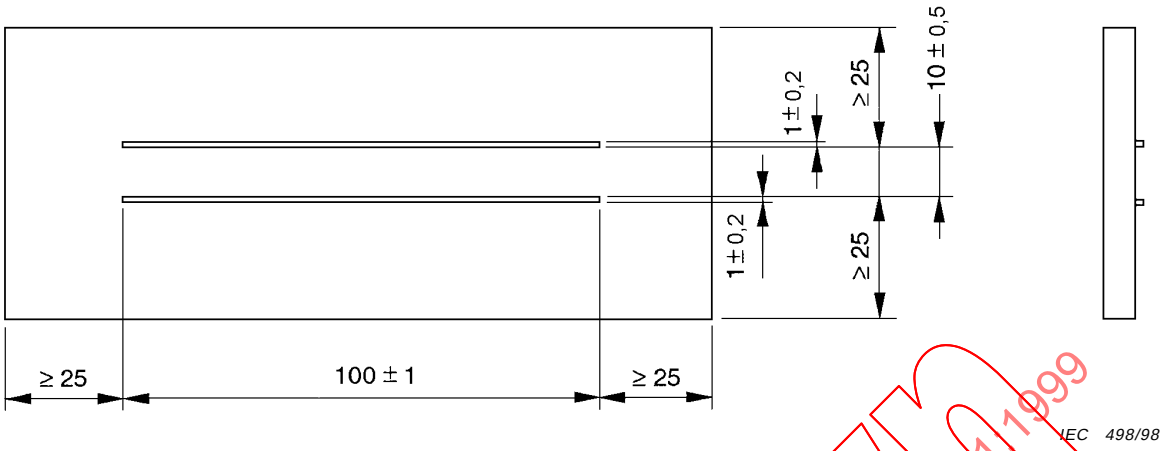
The resistance is tested on the parts of enclosures if size permits, or on a test piece comprising a rectangular plate with dimensions in accordance with figure 6, on which two parallel electrodes are painted on the surface using a conducting paint with a solvent which has no significant effect on the insulation resistance.

The test piece shall have an intact surface and shall be cleaned with distilled water, then with isopropyl alcohol (or any other solvent that can be mixed with water and will not affect the material of the test piece), then once more with distilled water before being dried. Untouched by bare hands, it shall then be conditioned for 24 h at the temperature and humidity according to 20.4.5.3. The test shall be carried out under ambient conditions.

The direct voltage applied for 1 min between the electrodes shall be equal to (500 ± 10) V.

During the test, the voltage shall be sufficiently steady so that the charging current due to voltage fluctuation is negligible compared with the current flowing through the test piece.

The insulation resistance is the quotient of the direct voltage applied at the electrodes to the total current flowing between them when the voltage has been applied for 1 min.



Dimensions in millimetres

Figure 7 – Test piece with painted electrodes

21 Routine verifications and tests

The manufacturer shall make the routine verifications and tests necessary to ensure that the electrical apparatus produced complies with the specification submitted to the testing station together with the prototype or sample.

22 Manufacturer's responsibility

By marking the electrical apparatus in accordance with clause 26, the manufacturer attests on his own responsibility that

- the electrical apparatus has been constructed in accordance with the applicable requirements of the relevant standards in safety matters;
- the routine verifications and tests in clause 21 have been successfully completed and that the product complies with the specification submitted to the testing station.

23 Verifications and tests on modified or repaired electrical apparatus

Modifications made on the electrical apparatus affecting the integrity of the type of protection or the temperature of the apparatus shall be permitted only if the modified apparatus is re-submitted to a testing station.

NOTE – In the case of repairs to electrical apparatus affecting the type of protection, the parts which have been repaired should be subjected to new routine verifications and tests which need not necessarily be made by the manufacturer.

24 Clamping tests of non-armoured and braided cables

24.1 Cable entries with clamping by the sealing ring

24.1.1 Clamping tests shall be carried out using for each type of cable entry, two sealing rings; one equal to the smallest admissible size and the other equal to the greatest admissible size.

24.1.2 In the case of elastomeric sealing rings for circular cables, each ring is mounted on a clean, dry, polished cylindrical mild steel mandrel equal to the smallest cable diameter allowable in the ring and specified by the manufacturer of the cable entry.

24.1.3 For non-circular cables, the ring shall be mounted on a sample of dry, clean cable of dimensions equal to the size specified by the manufacturer of the cable entry.

24.1.4 In the case of metallic sealing rings, each ring is mounted on a sample of clean, dry cable of a diameter equal to the smallest diameter allowable in the ring and specified by the manufacturer of the cable entry.

24.1.5 The sealing ring with the mandrel or cable, as appropriate, is fitted into the cable entry. A torque is then applied to the screws (in the case of a flanged compression element fitted with screws) or to the nut (in the case of a screwed compression element) in order to obtain the compression of the sealing ring and prevent slipping of the mandrel or cable when the force applied to it is of a value, in Newtons, equal to

- 20 times the value in millimetres of the diameter of the mandrel or cable when the cable entry is designed for round cable; or
- 6 times the value in millimetres of the perimeter of the cable when the cable entry is designed for non-circular cable.

24.1.6 For test conditions and acceptance criteria, see 24.4.

NOTE – The torque figures referred to above may be determined experimentally prior to the tests or they may be supplied by the manufacturer of the cable entry.

24.2 Cable entries with clamping by filling compound

24.2.1 Clamping tests shall be carried out using two samples of clean, dry cable; one equal to the smallest admissible size and the other equal to the greatest admissible size.

24.2.2 The filling compound, prepared as stated by the manufacturer of the cable entry, is filled into the available space and the entry is submitted to the tests after the compound has hardened in accordance with the manufacturer's instructions.

24.2.3 The filling compound shall prevent slippage of the cable when the force applied to it is of a value, in Newtons, equal to

- 20 times the value in millimetres of the diameter of the cable sample when the cable entry is designed for circular cable; or
- 6 times the value in millimetres of the perimeter of the cable sample when the cable entry is designed for non-circular cable.

24.2.4 For test conditions and acceptance criteria see 24.4.

24.3 Cable entries with clamping by means of a clamping device

24.3.1 The clamping test shall be carried out using for each type of cable, entry clamping devices of different permitted sizes.

24.3.2 Each device is mounted on a sample of clean, dry cable of a diameter allowable in the device and specified by the manufacturer of the cable entry. For non-circular cables, the ring shall be mounted on the sheath of a sample of dry cable of dimensions equal to the size specified for use with the sealing ring.