

# INTERNATIONAL STANDARD

**IEC**  
**60745-1**

Third edition  
2001-12

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## **Hand-held motor-operated electric tools – Safety –**

### **Part 1: General requirements**

*Outils électroportatifs à moteur –  
Sécurité –*

*Partie 1:  
Règles générales*



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**HAND-HELD MOTOR-OPERATED ELECTRIC TOOLS –  
SAFETY –**

**Part 1: General requirements**

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 specifications, 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 60745-1 has been prepared by sub-committee 61F: Safety of hand-held motor-operated electric tools, of IEC technical committee 61: Safety of household and similar electrical appliances.

This third edition cancels and replaces the second edition published in 1997 and constitutes a technical revision.

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

FDIS	Report on voting
61F/422/FDIS	61F/427/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.

Annexes A, B, C, D, E, F, G and I form an integral part of this standard.

Annex J is for information only.

The committee has decided that the contents of this publication will remain unchanged until 2003. At this date, the publication will be

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- withdrawn;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

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

The contents of the corrigendum of August 2003 have been included in this copy.

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**Withdrawn**

## INTRODUCTION

This part 1 is to be used in conjunction with the appropriate part 2, which contains clauses to supplement or modify the corresponding clauses in part 1 to provide the relevant requirements for each type of product.

Individual countries may wish to consider its application, so far as is reasonable, to tools not mentioned in part 2, and to tools designed on new principles.

If the functions of a tool are covered by the different parts 2 of IEC 60745, the relevant part 2 is applied to each function separately, so far as is reasonable. If applicable, the influence of one function on the other is taken into account.

Normative references to other IEC and ISO standards are given in clause 2.

NOTE In this standard, the following print types are used:

- Requirements: in roman type
- *Test specification: in italic type*
- Notes: in smaller roman type

It has been assumed in the drafting of this International Standard that the execution of its provisions is entrusted to appropriately qualified and experienced people.

A product employing materials or having forms of construction differing from those detailed in the requirements of this standard may be examined and tested according to the intention of the requirements and, if found to be substantially equivalent, may be judged to comply with the standard.

Standards dealing with non-safety aspects of hand-held tools are:

- IEC standards published by TC 59 on methods of measuring performance;
- CISPR 11 and 14 on radio interference suppression;
- IEC 61000-3-2 and IEC 61000-3-3 on electromagnetic compatibility.

# HAND-HELD MOTOR-OPERATED ELECTRIC TOOLS – SAFETY –

## Part 1: General requirements

### 1 Scope

**1.1** This International Standard deals with the safety of hand-held motor-operated or magnetically driven electric tools, the rated voltage of the tools being not more than 250 V for single-phase a.c. or d.c. tools, and 440 V for three-phase a.c. tools.

So far as is practicable, this standard deals with the common hazards presented by hand-held tools, which are encountered by all persons in the common use of the tools.

Tools with an electric heating element are within the scope of this standard. They should also comply with relevant parts of IEC 60335.

Hand-held electric tools, hereinafter referred to as tools, which can be mounted on a support for use as fixed tools without any alteration of the tool itself, are within the scope of this standard. Unless the requirement for such support is given in a relevant part 2, this standard alone will not be sufficient to ensure that the combination of tool and support is adequate.

Requirements for motors not isolated from the supply, and having basic insulation not designed for the rated voltage of the tools, are given in Annex B.

This standard does not apply to:

- hand-held tools intended to be used in the presence of explosive atmosphere (dust, vapour or gas);
- hand-held tools used for preparing and processing food;
- hand-held tools for medical purposes (IEC 60601);
- heating tools which are covered by IEC 60335-2-45.

For hand-held tools intended to be used in vehicles or on board ships or aircraft, additional requirements may be necessary.

For hand-held tools intended to be used in tropical countries, special requirements may be necessary.

**NOTE** Attention is drawn to the fact that in many countries, additional requirements are specified by the national health authorities, the national authorities responsible for the protection of labour, the national water supply authorities, etc.

### 2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 60745. 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 60745 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 60061-1:1969, *Lamp caps and holders together with gauges for the control of interchangeability and safety – Part 1: Lamp caps*  
Supplement A (1969) to amendment 26 (2001)

- IEC 60068-2-75:1997, *Environmental testing – Part 2-75: Tests – Test Eh: Hammer tests*
- IEC 60083:1997, *Plugs and socket-outlets for domestic and similar general use standardized in member countries of IEC*
- IEC 60085:1984, *Thermal evaluation and classification of electrical insulation*
- IEC 60112:1979, *Method for determining the comparative and the proof tracking indices of solid insulating materials under moist conditions*
- IEC 60127 (all parts), *Miniature fuses*
- IEC 60227 (all parts), *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V*
- IEC 60245 (all parts), *Rubber insulated cables – Rated voltages up to and including 450/750*
- IEC 60309 (all parts), *Plugs, socket-outlets and couplers for industrial purposes*
- IEC 60320 (all parts), *Appliance couplers for household and similar general purposes*
- IEC 60335-1:2001, *Safety of household and similar electrical appliances – Part 1: General requirements*
- IEC 60384-14:1993, *Fixed capacitors for use in electronic equipment – Part 14: Sectional specification: Fixed capacitors for electromagnetic interference suppression and connection to the supply mains*
- IEC 60529:1989, *Degrees of protection provided by enclosures (IP Code)*
- IEC 60695-2-2:1991, *Fire hazard testing – Part 2: Test methods – Section 2: Needle-flame test*
- IEC 60695-2-10:2000, *Fire hazard testing – Part 2-10: Glowing/hot-wire based test methods – Glow-wire apparatus and common test procedure*
- IEC 60695-2-11:2000, *Fire hazard testing – Part 2-11: Glowing/hot-wire based test methods – Glow-wire flammability test method for end-products*
- IEC 60695-2-12:2000, *Fire hazard testing – Part 2-12: Glowing/hot-wire based test methods – Glow-wire flammability test method for materials*
- IEC 60695-2-13:2000, *Fire hazard testing – Part 2-13: Glowing/hot-wire based test methods – Glow-wire ignitability test method for materials*
- IEC 60707:1999, *Flammability of solid non-metallic materials when exposed to flame sources – List of test methods*
- IEC 60730-1:1999, *Automatic electrical controls for household and similar use – Part 1: General requirements*
- IEC 60998-2-2:1991, *Connecting devices for low-voltage circuits for household and similar purposes – Part 2-2: Particular requirements for connecting devices as separate entities with screwless-type clamping units*
- IEC 60999-1:1999, *Connecting devices – Electrical copper conductors – Safety requirements for screw-type and screwless-type clamping units – Part 1: General requirements and particular requirements for clamping units for conductors from 0,2 mm<sup>2</sup> up to 35 mm<sup>2</sup> (included)*
- IEC 61058-1:2000, *Switches for appliances – Part 1: General requirements*
- IEC 61558-1:1997, *Safety of power transformers, power supply units and similar – Part 1: General requirements and tests*

ISO 1463:1982, *Metallic and oxide coatings – Measurement of coating thickness – Microscopical method*

ISO 2178:1982, *Non-magnetic coatings on magnetic substrates – Measurement of coating thickness – Magnetic method*

### 3 Definitions

For the purpose of this International Standard, the following definitions apply.

**3.1.1** Where the terms voltage and current are used, they imply the r.m.s. values, unless otherwise specified.

**3.1.2** Where in this standard the expressions "with the aid of a tool", "without the aid of a tool", and "requires the use of a tool", the word "tool" means a screwdriver or any other object, which may be used to operate a screw or other fixing means.

#### 3.2.1

**rated voltage**

voltage assigned to the tool by the manufacturer. For three-phase supply, it is the voltage between phases

#### 3.2.2

**rated voltage range**

voltage range assigned to the tools by the manufacturer, expressed by its lower and upper limits

#### 3.2.3

**working voltage**

maximum voltage to which the part under consideration is subjected when the tool is supplied at its rated voltage and operating under normal load. When deducing the working voltage, the effect of transient voltages is ignored

#### 3.2.4

**rated input**

input in watts assigned to the tool by the manufacturer

#### 3.2.5

**rated input range**

input range in watts assigned to the tool by the manufacturer, expressed by its lower and upper limits

#### 3.2.6

**rated current**

current assigned to the tool by the manufacturer. If no current is assigned to the tool, the rated current for the purpose of this standard is the current measured when the tool is under normal load at rated voltage

#### 3.2.7

**rated frequency**

frequency assigned to the tool by the manufacturer

#### 3.2.8

**rated frequency range**

frequency range assigned to the tool by the manufacturer, expressed by its lower and upper limits

### **3.2.9**

#### **normal load**

load to be applied to a tool, to obtain rated input or rated current, any marking of short-time or intermittent operation being observed and, unless otherwise specified, heating elements, if any, being operated as in normal use. The normal load is based on the rated voltage or on the upper limit of the rated voltage range

### **3.2.9.1**

#### **no load input / current**

highest input or current obtained when a tool is operated at rated voltage and frequency with no external load (work) applied to the accessories packaged with the tool by the manufacturer and adjusted according to manufacturer's instructions, ready for use

### **3.2.10**

#### **rated no-load speed**

no-load speed at rated voltage or at the upper limit of the rated voltage range assigned to the tool by the manufacturer

### **3.3.1**

#### **detachable cord**

flexible cord, for supply, intended to be connected to the tool by means of a suitable appliance coupler

### **3.3.2**

#### **supply cord**

flexible cord, for supply purposes, which is fixed to the tool

### **3.3.3**

#### **type X attachment**

method of attachment of the supply cord so that it can easily be replaced without the aid of a special purpose tool provided by the manufacturer. The supply cord may be a specially prepared cord and only available from the manufacturer or its service agent. A specially prepared cord can also include a part of the tool.

### **3.3.4**

#### **type Y attachment**

method of attachment of the supply cord such that any replacement is intended to be made by the manufacturer, its service agent or similar qualified person. Type Y attachment may be used either with an ordinary flexible cord or with a special cord

### **3.3.5**

#### **type Z attachment**

method of attachment of the supply cord so that it cannot be replaced without breaking or destroying the tool

### **3.4.1**

#### **basic insulation**

insulation applied to live parts to provide basic protection against electric shock. Basic insulation does not necessarily include insulation used exclusively for functional purposes

### **3.4.2**

#### **supplementary insulation**

independent insulation applied in addition to the basic insulation, in order to provide protection against electric shock in the event of a failure of the basic insulation

### **3.4.3**

#### **double insulation**

insulation system comprising both basic insulation and supplementary insulation

#### 3.4.4

##### **reinforced insulation**

single insulation system applied to live parts, which provides a degree of protection against electric shock equivalent to double insulation under the conditions specified in this standard. The term "single insulation system" does not imply that the insulation is one homogeneous piece. It may comprise several layers which cannot be tested singly as supplementary or basic insulation

#### 3.4.5

##### **class I tool**

tool in which protection against electric shock does not rely on basic insulation only, but which includes an additional safety precaution in that conductive accessible parts are connected to the protective earthing conductor in the fixed wiring of the installation in such a way that conductive accessible parts cannot become live in the event of a failure of the basic insulation. For tools intended for use with a flexible cord, this provision includes a protective conductor as part of the flexible cord

#### 3.4.6

##### **class II tool**

tool in which protection against electric shock does not rely on basic insulation only, but in which additional safety precautions, such as double insulation or reinforced insulation, are provided, there being no provision for protective earthing or reliance upon installation conditions.

Such a tool may be of one of the following types:

- a) a tool having a durable and substantially continuous enclosure of insulating material which envelops all metal parts, with the exception of small parts, such as nameplates, screws and rivets, which are isolated from live parts by insulation at least equivalent to reinforced insulation; such a tool is called an insulation-encased class II tool;
- b) a tool having a substantially continuous metal enclosure, in which double insulation is used throughout, except for those parts where reinforced insulation is used, because the application of double insulation is manifestly impracticable; such a tool is called a metal-encased class II tool;
- c) a tool which is a combination of the types a) and b).

The enclosure of an insulation-encased class II tool may form a part or the whole of the supplementary insulation or of the reinforced insulation.

If a tool with double insulation and/or reinforced insulation throughout has an earthing terminal or earthing contact, it is considered to be a class I tool

#### 3.4.7

##### **class II construction**

part of a tool for which protection against electric shock relies upon double insulation or reinforced insulation

#### 3.4.8

##### **class III tool**

tool in which protection against electric shock relies on supply at safety extra-low voltage, and in which voltages higher than those of safety extra-low voltages are not generated. Tools intended to be operated at safety extra-low voltage, and having internal circuits which operate at a voltage other than safety extra-low voltage, are not included in the classification, and are subject to additional requirement

#### 3.4.9

##### **class III construction**

part of a tool for which protection against electric shock relies upon safety extra-low voltage, and in which voltages higher than those of safety extra-low voltages are not generated

**3.4.10****creepage distance**

shortest path between two conductive parts, or between a conductive part and the boundary surface of the tool, measured along the surface of the insulating material

**3.4.11****clearance**

shortest distance between two conductive parts, or between a conductive part and the boundary surface of the tool, measured through air. The boundary surface of the tool is the outer surface of the enclosure, considered as though metal foil were pressed into contact with accessible surfaces of insulating material

**3.4.12****normal duty conditions of insulating material**

where there is virtually no deposition of conductive material and a long period of electrical stress; or a light deposition of conductive material and a short period of electrical stress

**3.4.13****severe duty conditions of insulating material**

where there is a light deposition of conductive material and a long period of electrical stress; or a heavy deposition of conductive material and a short period of electrical stress

**3.4.14****extra-severe duty conditions of insulating material**

where there is heavy deposition of conductive material and a long period of electrical stress; or an extra heavy deposition of conductive material and a short period of electrical stress

**3.5.1****extra-low voltage**

voltage supplied from a source within the tool and, which, when the tool is supplied at rated voltage, does not exceed 50 V between conductors and between conductors and earth

**3.5.2****safety extra-low voltage**

nominal voltage not exceeding 42 V between conductors and between conductors and earth, the no-load voltage not exceeding 50 V. When safety extra-low voltage is obtained from the supply mains, it is to be through a safety isolating transformer or a convertor with separate windings, the insulation of which complies with double or reinforced insulation requirements

NOTE The voltage limits specified are based on the assumption that the safety isolating transformer is operated at its rated supply voltage.

**3.5.3****safety isolating transformer**

transformer, the input winding of which is electrically separated from the output winding by an insulation at least equivalent to double insulation or reinforced insulation, and which is intended to supply a distribution circuit, a tool or other equipment at safety extra-low voltage

**3.6.1****hand-held tool (in this standard abbreviated to "tool")**

electric motor-operated or magnetically-driven machine intended to do mechanical work, and so designed that the motor and the machine form an assembly which can easily be brought to the place of operation, and which is held by hand or suspended during operation

NOTE Hand-held tools may be provided with a flexible shaft, the motor being either fixed or portable. Hand-held tools may also have provisions for mounting on a support. Hand-held tools include also hand-supported tools (such as paving breakers).

**3.6.2****exchange type tool**

tool which is intended not to be repaired at all, or to be repaired by the manufacturer's service organization only

**3.7.1****non-detachable part**

part which can only be removed or opened with the aid of a tool, or a part which fulfils the test of 21.22

**3.7.2****detachable part**

part which can be removed or opened without the aid of a tool, or a part which is removed in accordance with the instruction for use, even if removal requires the use of a tool.

**3.8.1****thermostat**

temperature-sensing device, the operating temperature of which may be either fixed or adjustable; and which, during normal operation, keeps the temperature of the controlled part between certain limits by automatically opening and closing a circuit

**3.8.2****temperature limiter**

temperature-sensing device, the operating temperature of which may be either fixed or adjustable, and which, during normal operation, operates by opening or closing a circuit when the temperature of the controlled part reaches a predetermined value. It does not make the reverse operation during the normal duty cycle of the tool. It may or may not require manual resetting

**3.8.3****thermal cut-out**

device which, during abnormal operation, limits the temperature of the controlled part by automatically opening the circuit, or by reducing the current, and which is so constructed that its setting cannot be altered by the user

**3.8.4****self-resetting thermal cut-out**

thermal cut-out which automatically restores the current after the relevant part of the tool has cooled down sufficiently

**3.8.5****non-self-resetting thermal cut-out**

thermal cut-out which requires a manual operation for resetting, or replacement of a part, in order to restore the current

**3.8.6****protective device**

device the operation of which prevents a hazardous situation under abnormal operation conditions

**3.8.7****thermal link**

thermal cut-out which operates only once, and then requires partial or complete replacement

**3.9.1****all-pole disconnection**

disconnection of all supply conductors except the protective earthing (grounding) conductor by a single initiating action

**3.9.2****off-position of a switching device**

stable position in which the related circuit is disconnected from the supply mains

NOTE The off-position does not imply an all-pole disconnection.

### 3.9.3

#### **accessible part**

part which can be touched by means of the standard test finger in Figure 1, including, for accessible metal parts, any metal part connected to it

### 3.9.4

#### **live part**

any conductor or conductive part intended to be energized in normal use, including a neutral conductor but, by convention, not a PEN conductor.

NOTE Parts accessible or not, complying with 9.1, are not considered to be live parts.

### 3.10.1

#### **electronic component**

part in which conduction is achieved principally by electrons moving through a vacuum, gas or semiconductor

NOTE Neon indicators are not considered to be electronic components

### 3.10.2

#### **electronic circuit**

circuit incorporating at least one electronic component

### 3.10.3

#### **protective impedance**

impedance connected between live parts and accessible conductive parts, and of value so that the current, in normal use and under likely fault conditions in the tool, is limited to a safe value

### 3.11.1

#### **rated operating time**

operating time assigned to the tool by the manufacturer

### 3.11.2

#### **continuous operation**

operation under normal load for an unlimited period

### 3.11.3

#### **short-time operation**

operation under normal load for a specified period, starting from cold, the intervals between each period of operation being sufficient to allow the tool to cool down approximately to room temperature

### 3.11.4

#### **intermittent operation**

operation in a series of specified identical cycles, each cycle being composed of a period of operation under normal load followed by a rest period with the tool running idle or switched off

### 3.11.5

#### **routine servicing**

periodic servicing which requires tool disassembly as instructed by the instruction manual and performed by authorized service centre

### 3.11.6

#### **user maintenance**

any maintenance operation stated in the instructions for use or marked on the tool which the manufacturer of the tool intends the user to perform

### 3.12.1

#### **accessory**

device that is attached only to the output mechanism of the tool

### 3.12.2 attachment

device attached to the housing or other component of the tool and which may or may not be attached to the output mechanism. Attachments include tables to convert hand-held tools to bench mounted types; for example, a router table

## 4 General requirements

Tools shall be so constructed that in normal use they function safely so as to cause no danger to persons or surroundings, even in the event of carelessness that may occur in normal use.

*In general, this principle is achieved by fulfilling the relevant requirements specified in this standard, and compliance is checked by carrying out all the relevant tests.*

## 5 General conditions for the tests

5.1 Tests according to this standard are type tests.

5.2 Unless otherwise specified, the tests are made on a single tool, which shall withstand all the relevant tests. However, the tests of clauses 23 to 27 and of clause 29 may be made on separate samples

*Additional samples may be required, for example if the tool is designed for different supply voltages, or if the test of 12.6 has to be made, in this case, three samples of the motor are needed. The testing of components may necessitate the submission of additional samples of these components.*

*The cumulative stress resulting from successive tests on electronic circuits is to be avoided. It may be necessary to replace components or to use additional samples. The number of additional samples should be kept to a minimum by an evaluation of the relevant electronic circuits.*

5.3 Unless otherwise specified, the tests are carried out in the order of the clauses. If it is evident from the construction of the tool that a particular test is not applicable, the test is not made.

5.4 The tests are carried out with the tool, or any movable part of it, placed in the most unfavourable position that may occur in normal use.

5.5 Tools provided with controls or switching devices are tested with these controls or devices adjusted to their most unfavourable setting, if the setting can be altered by the user. Electronic speed control devices are set for the highest speed.

*If the adjusting means of the control is accessible without the aid of a tool, this subclause applies whether the setting can be altered by hand or with the aid of a tool. If the adjusting means is not accessible without the aid of a tool, and if the setting is not intended to be altered by the user, this subclause does not apply.*

*Adequate sealing is regarded as preventing alteration of the setting by the user.*

5.6 The tests are made in a draught-free location and, in general, at an ambient temperature of  $(20 \pm 5)$  °C.

*If the temperature attained by any part is limited by a temperature sensitive device, or is influenced by the temperature, the room temperature is, in case of doubt, maintained at  $(23 \pm 2)$  °C.*

**5.7.1** Tools for a.c. only are tested with a.c. at rated frequency, if marked, and those for a.c./d.c. are tested at the more unfavourable supply.

Tools for a.c. which are not marked with rated frequency, or marked with a frequency range of 50 Hz, are tested with either 50 Hz or 60 Hz, whichever is the more unfavourable.

**5.7.2** Tools having more than one rated voltage are tested on the basis of the most unfavourable voltage.

When it is specified for tools marked with a rated voltage range that the supply voltage is equal to the rated voltage multiplied by a factor, the supply voltage is equal to:

- the upper limit of the rated voltage range multiplied by this factor, if greater than 1;
- the lower limit of the rated voltage range multiplied by this factor, if smaller than 1.

When a factor is not specified, the supply voltage is the most unfavourable within the rated voltage range.

For tools having more than one rated voltage or rated voltage range it may be necessary to make some of the tests at the minimum, the mean, and the maximum values of the rated voltage, or the rated voltage range, in order to establish the most unfavourable voltage.

**5.7.3** For tools marked with a rated voltage range and rated input corresponding to the mean of the rated voltage range, when it is specified that the power input is equal to rated input multiplied by a factor, the input is equal to:

- the calculated input corresponding to the upper limit of the rated voltage range multiplied by this factor, if greater than 1;
- the calculated input corresponding to the lower limit of the rated voltage range multiplied by this factor, if smaller than 1.

When a factor is not specified, the input corresponds to the input at the most unfavourable rated voltages within the range.

**5.8** When alternative accessories are made available for the tool by its manufacturer, the tool is tested with those accessories which give the most unfavourable results.

**5.9** Unless otherwise specified, tools are tested with the appropriate flexible cord connected to the tool.

**5.10** If class I tools have accessible metal parts which are not connected to an earthing terminal or earthing contact, and are not separated from live parts by an intermediate metal part which is connected to an earthing terminal or earthing contact, such parts are checked for compliance with the appropriate requirements specified for class II construction.

If class I tools have accessible non-metallic parts, such parts are checked for compliance with the appropriate requirements specified for class II construction, unless these parts are separated from live parts by an intermediate metal part connected to an earthing terminal or earthing contact.

**5.11** If class I or class II tools have parts operating at safety extra-low voltage, such parts are checked for compliance with the appropriate requirements specified for class III tools.

**5.12** When testing electronic circuits, the supply is to be free from those perturbations from external sources that can influence the results of the tests.

**5.13** *If, in normal use, the heating element cannot be operated unless the motor is running, the element is tested with the motor running. If the heating element can be operated without the motor running, the element is tested with or without the motor running, whichever is the more unfavourable. Heating elements incorporated in the tool are connected to a separate supply unless otherwise specified.*

**5.14** *For accessories performing a function which is within the scope of one of the relevant parts 2, the tests are made in accordance with that part 2.*

*For other accessories, the tests are made in accordance with manufacturer's instructions; in the absence of such instructions, the tool is operated continuously at a load at which rated input or rated current is attained.*

**5.15** *If a torque is to be applied, the method of loading is chosen so as to avoid additional stresses, such as those caused by side thrust. Additional loads necessary for the correct operation of the tool are, however, taken into consideration.*

*If a brake is used for applying a load, it must be applied gradually to assure that the starting current does not affect the test. Modification of output means for purpose of loading is permitted for the connection to a brake.*

**5.16** *Tools intended to be operated at safety extra-low voltage are tested together with their supply transformer, if this is normally sold with the tool.*

## **6 Void**

## **7 Classification**

**7.1** Tools shall be of one of the following classes with respect to protection against electric shock:

**class I, class II, class III.**

*Compliance is checked by inspection and by the relevant tests.*

**7.2** Tools shall have the appropriate degree of protection against harmful ingress of water. The degrees of protection against harmful ingress of water are given in IEC 60529.

*Compliance is checked by inspection and by the relevant tests.*

## **8 Marking and instructions**

**8.1** Tools shall be marked with:

- rated voltage(s) or rated voltage range(s), in volts. Tools for star-delta connection shall be clearly marked with the two rated voltages (for example 230  $\Delta$ / 400 Y);
- symbol for nature of supply, unless the rated frequency is marked;
- rated input, in watts or rated current, in amperes. The rated input or current to be marked on the tool is the total maximum input or current that can be on circuit at the same time. If a tool has alternative components which can be selected by a control device, the rated input or rated current is that corresponding to the highest loading possible;
- name or trade mark or identification mark of the manufacturer or responsible vendor;
- model or type reference;
- symbol for class II construction, for class II tools only;

- IP number according to degree of protection against ingress of water other than IPX0. The first numeral of the IP number need not be marked on the tool;
- manufacturer's address or country of origin;
- any mandatory mark showing compliance with legislation by reference to this standard.

*Compliance is checked by inspection.*

Additional markings are allowed, provided they do not give rise to misunderstanding.

If components are marked separately, the marking of the tool and that of the components is to be such that there can be no doubt with regard to the marking of the tool itself.

**8.2** Tools for short-time operation or intermittent operation shall be marked with rated operating time, or rated operating time and rated resting time respectively, unless the operating time is limited by the construction of the tool.

The marking of short-time operation or intermittent operation shall correspond to normal use.

The marking of intermittent operation shall be such that the rated operating time precedes the rated resting time, both markings being separated by an oblique stroke.

*Compliance is checked by inspection.*

**8.3** The marking of tools intended to be operated without adjustment in a rated range of values (voltage, frequency, etc.) shall be differentiated from those intended to be operated with or without adjustment under different values of the same criteria (voltage, frequency, etc.).

The lower and upper limits of the rated range of values shall be separated by a hyphen (-).

The different rated values shall be separated by an oblique stroke (/).

Examples:

115-230 V: The tool is suitable for any value within the marked range.

115/230 V: The tool is only suitable for the marked values.

*Compliance is checked by inspection.*

**8.4** If the tool can be adjusted to suit different rated voltages, the voltage to which the tool is adjusted shall be clearly discernible.

This requirement does not apply to tools for star-delta connection.

For tools where frequent changes in voltage setting are not required, this requirement is considered to be met if the rated voltage to which the tool is adjusted can be determined from a wiring diagram fixed to the tool. The wiring diagram may be on the inside of a cover which has to be removed to connect the supply conductors. It is not to be on a label loosely attached to the tool.

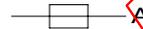
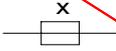
*Compliance is checked by inspection.*

**8.5** For tools marked with more than one rated voltage or with more than one rated voltage range, the rated power input for each of these voltages or ranges shall be marked.

The upper and lower limits of the rated power input shall be marked on the tool so that the relation between input and voltage appears distinctly, unless the difference between the limits of a rated voltage range does not exceed 10 % of the mean value of the range, in which case the marking for rated power input may be related to the mean value of the range.

*Compliance is checked by inspection.*

**8.6** When symbols are used, they shall be as follows:

V .....	volts
A .....	amperes
Hz .....	hertz
W .....	watts
kW .....	kilowatts
F .....	farads
$\mu$ F .....	microfarads
l .....	litres
g .....	grams
kg .....	kilograms
bar .....	bars
Pa .....	pascals
h .....	hours
min .....	minutes
s .....	seconds
$n_0$ .....	no-load speed
.../min or ...min <sup>-1</sup> .....	Revolutions or reciprocations per minute
 or d.c. ....	direct current
 or a.c. ....	Alternating current
2~ .....	two-phase alternating current
2N~ .....	two-phase alternating current with neutral
3~ .....	three-phase alternating current
3N~ .....	three-phase alternating current with neutral
 .....	rated current of the appropriate fuse-link in amperes
 .....	time-lag miniature fuse-link where X is the symbol for the time/current characteristic, as given in IEC 60127
 .....	Protective earth
 .....	class II tool
IPXX .....	IP symbol

If the first numeral for the IP numbering is omitted, the omitted numeral shall be replaced by the letter X, for example IPX5.

The symbol for nature of supply shall be placed next to the marking for rated voltage.

The dimensions for the symbol for class II tools shall be such that the length of the sides of the outer square is about twice the length of the sides of the inner square. The length of the sides of the outer square shall not be less than 5 mm, unless the largest dimension of the tool does not exceed 15 cm, in which case the dimensions of the symbol may be reduced, but the length of the sides of the outer square shall not be less than 3 mm.

The symbol for class II tools shall be so placed that it will be obvious that it is a part of the technical information, and is unlikely to be confused with any other marking.

When other units are used, the units and their symbols shall be those of the international standardized system.

Multiple or submultiple units are also allowed. Additional symbols are allowed, provided they do not give rise to misunderstanding.

*Compliance is checked by inspection and measurement.*

**8.7** Tools to be connected to more than two supply conductors shall be provided with a connection diagram, fixed to the tool, unless the correct mode of connection is obvious.

The correct mode of connection is deemed to be obvious if the terminals for the supply conductors are indicated by arrows pointing towards the terminals. The earthing conductor is not a supply conductor. For tools for star-delta connection, the wiring diagram should show how the windings are to be connected.

*Compliance is checked by inspection.*

NOTE The connector diagram may be that referred to in 8.4.

**8.8** Except for type Z attachments, terminals shall be indicated as follows:

– Terminals intended exclusively for the neutral conductor shall be indicated by the letter N.

– Earthing terminals shall be indicated by the symbol 

These indications shall not be placed on screws, removable washers or other parts which might be removed when conductors are being connected.

*Compliance is checked by inspection.*

**8.9** Unless it is obviously unnecessary, switches which may give rise to a hazard when operated shall be marked, or so placed as to indicate clearly which part of the tool they control.

Indications used for this purpose shall, wherever practicable, be comprehensible without a knowledge of languages, national standards, etc.

*Compliance is checked by inspection.*

**8.10** For tools which might cause danger when started unexpectedly, the "off" position of the mains switch shall be indicated, unless this position is obvious; the indication, if required, shall be the figure O.

The figure O shall not be used for any other indication.

The position of the moving contacts of the mains switch shall correspond to the indications for the different positions of its operating means.

NOTE The figure O may, for example, also be used on a digital programming keyboard.

*Compliance is checked by inspection.*

**8.11** Regulating devices and the like, intended to be adjusted during operation, shall be provided with an indication for the direction of adjustment to increase or to decrease the value of the characteristic being adjusted.

The requirement does not apply to regulating devices provided with an adjusting means, if its "fully-on" position is opposite to its "off" position.

If figures are used for indicating the different positions, the "off" position shall be indicated by the figure O and the position of a greater output, input, speed, etc., shall be indicated by a higher figure.

An indication of + and – is considered to be sufficient.

The indication for the different positions of the operating means of a control device need not to be placed on the device itself.

*Compliance is checked by inspection.*

**8.12** An instruction manual and general safety instructions shall be provided with the tool and packaged in such a way that is obvious when the tool is removed from the packaging. The general safety instructions may be separate from the instruction manual. They shall be written in the official language(s) of the country in which the tool is sold.

Instructions shall be legible and contrast with the background.

The instruction manual shall include the name and address of the manufacturer or supplier of branded product.

The subjects are as follows:

**8.12.1** General Safety Instructions. Safety Rules if in English shall be verbatim and in the exact order as given and in any other official language to be equivalent.

Format of General Safety Instructions must differentiate, by font highlighting or similar means, the context of clauses as illustrated below.

The order of the warning statements shall be: as required by part 1, as required by the applicable part 2, and any optional warning statements deemed necessary by the manufacturer.

### **General Safety Rules**

**WARNING!** Read all instructions *Failure to follow all instructions listed below may result in electric shock, fire and/or serious injury. The term "power tool" in all of the warnings listed below refers to your mains-operated (corded) power tool or battery-operated (cordless) power tool.*

SAVE THESE INSTRUCTIONS

#### **1) Work area**

- a) **Keep work area clean and well lit.** *Cluttered and dark areas invite accidents.*
- b) **Do not operate power tools in explosive atmospheres, such as in the presence of flammable liquids, gases or dust.** *Power tools create sparks which may ignite the dust or fumes.*

- c) **Keep children and bystanders away while operating a power tool.** *Distractions can cause you to lose control*

## 2) Electrical safety

- a) **Power tool plugs must match the outlet. Never modify the plug in any way. Do not use any adapter plugs with earthed (grounded) power tools.** *Unmodified plugs and matching outlets will reduce risk of electric shock*
- b) **Avoid body contact with earthed or grounded surfaces such as pipes, radiators, ranges and refrigerators.** *There is an increased risk of electric shock if your body is earthed or grounded.*
- c) **Do not expose power tools to rain or wet conditions.** *Water entering a power tool will increase the risk of electric shock.*
- d) **Do not abuse the cord. Never use the cord for carrying, pulling or unplugging the power tool. Keep cord away from heat, oil, sharp edges or moving parts.** *Damaged or entangled cords increase the risk of electric shock.*
- e) **When operating a power tool outdoors, use an extension cord suitable for outdoor use.** *Use of a cord suitable for outdoor use reduces the risk of electric shock.*

## 3) Personal safety

- a) **Stay alert, watch what you are doing and use common sense when operating a power tool. Do not use a power tool while you are tired or under the influence of drugs, alcohol or medication.** *A moment of inattention while operating power tools may result in serious personal injury.*
- b) **Use safety equipment. Always wear eye protection.** *Safety equipment such as dust mask, non-skid safety shoes, hard hat, or hearing protection used for appropriate conditions will reduce personal injuries.*
- c) **Avoid accidental starting. Ensure the switch is in the off-position before plugging in.** *Carrying power tools with your finger on the switch or plugging in power tools that have the switch on invites accidents.*
- d) **Remove any adjusting key or wrench before turning the power tool on.** *A wrench or a key left attached to a rotating part of the power tool may result in personal injury.*
- e) **Do not overreach. Keep proper footing and balance at all times.** *This enables better control of the power tool in unexpected situations.*
- f) **Dress properly. Do not wear loose clothing or jewellery. Keep your hair, clothing and gloves away from moving parts.** *Loose clothes, jewellery or long hair can be caught in moving parts.*
- g) **If devices are provided for the connection of dust extraction and collection facilities, ensure these are connected and properly used.** *Use of these devices can reduce dust-related hazards.*

## 4) Power tool use and care

- a) **Do not force the power tool. Use the correct power tool for your application.** *The correct power tool will do the job better and safer at the rate for which it was designed.*
- b) **Do not use the power tool if the switch does not turn it on and off.** *Any power tool that cannot be controlled with the switch is dangerous and must be repaired.*
- c) **Disconnect the plug from the power source before making any adjustments, changing accessories, or storing power tools.** *Such preventive safety measures reduce the risk of starting the power tool accidentally.*
- d) **Store idle power tools out of the reach of children and do not allow persons unfamiliar with the power tool or these instructions to operate the power tool.** *Power tools are dangerous in the hands of untrained users.*

- e) **Maintain power tools. Check for misalignment or binding of moving parts, breakage of parts and any other condition that may affect the power tools operation. If damaged, have the power tool repaired before use. Many accidents are caused by poorly maintained power tools.**
- f) **Keep cutting tools sharp and clean. Properly maintained cutting tools with sharp cutting edges are less likely to bind and are easier to control.**
- g) **Use the power tool, accessories and tool bits etc., in accordance with these instructions and in the manner intended for the particular type of power tool, taking into account the working conditions and the work to be performed. Use of the power tool for operations different from intended could result in a hazardous situation.**

#### 5) Service

- a) **Have your power tool serviced by a qualified repair person using only identical replacement parts. This will ensure that the safety of the power tool is maintained.**

#### 8.12.2 Additional information shall be provided, if appropriate.

- a) Instructions for putting into use
  - 1) Setting-up or fixing power tool in a stable position as appropriate for power tools which can be mounted on a support
  - 2) Assembly
  - 3) Connection to power supply, cabling, fusing, socket type and earthing requirements
  - 4) Illustrated description of functions
  - 5) Limitations on ambient conditions
  - 6) List of contents
- b) Operating instructions
  - 1) Setting and testing
  - 2) Tool changing
  - 3) Clamping of work
  - 4) Limits on size of work piece
  - 5) General instructions for use
- c) Maintenance and servicing
  - 1) Regular cleaning, maintenance, and lubrication
  - 2) Servicing by manufacturer or agent; list of addresses
  - 3) List of user-replaceable parts
  - 4) Special tools which may be required
  - 5) For power tools with type X attachment, where a specially prepared cord is needed to replace the cord: if the supply cord of this power tool is damaged, it must be replaced by a specially prepared cord available through the service organization.
  - 6) For power tools with type Y attachment: if the replacement of the supply cord is necessary, this has to be done by the manufacturer or his agent in order to avoid a safety hazard
  - 7) For power tools with type Z attachment: the supply cord of this power tool cannot be replaced, and the power tool shall be scrapped.

**8.13** Markings required by the standard shall be easily legible and durable.

*Compliance is checked by inspection and by rubbing the marking by hand for 15 s with a piece of cloth soaked with water and again for 15 s with a piece of cloth soaked with petroleum spirit.*

*After all the tests of this standard, the marking shall be easily legible, it shall not be easily possible to remove marking plates, and they shall show no curling.*

*In considering the durability of the marking, the effect of normal use is taken into account. Thus, for example, marking by means of paint or enamel other than vitreous enamel on containers that are likely to be cleaned frequently is not considered to be durable.*

*The petroleum spirit to be used for the test is aliphatic solvent hexane having a maximum aromatics content of 0,1 % by volume, a kauributanol value of 29, an initial boiling point of approximately 65 °C, a dry point of approximately 69 °C and a specific mass of approximately 0,689 kg/l.*

**8.14** Markings specified in 8.1 to 8.5 shall be on a main part of the tool.

Markings on the tool shall be clearly discernible from the outside of the tool, but after removal of a cover, if necessary. It shall be possible to remove or open this cover without the aid of a tool.

Indications for switches and controls shall be placed on or in the vicinity of these components; they shall not be placed on parts which can be repositioned, or positioned in such a way that the marking is misleading.

*Compliance is checked by inspection.*

**8.15** If compliance with this standard depends upon the operation of a replaceable thermal link or fuse-link, the reference number or other means for identifying the link shall be marked on the link, or in a place that it is clearly visible after the link has failed, when the tool has been dismantled to the extent necessary for replacing the link.

This requirement does not apply to links which can only be replaced together with a part of the tool.

*Compliance is checked by inspection.*

## **9 Protection against access to live parts**

Tools shall be so constructed and enclosed that there is adequate protection against accidental contact with live parts.

*Compliance is checked by inspection, and by the tests of 9.2 to 9.4, as applicable.*

**9.1** An accessible part is not considered to be live if:

- the part is supplied with safety extra-low voltage, provided that
  - for a.c., the peak value of the voltage does not exceed 42 V;
  - for d.c., the voltage does not exceed 42 V;
- or
- the part is separated from live parts by protective impedance.

In the case of protective impedance, the current between the part and the supply source shall not exceed 2 mA for d.c., and its peak value shall not exceed 0,7 mA for a.c., and moreover:

- for voltages having a peak value over 42 V up to and including 450 V, the capacitance shall not exceed 0,1  $\mu\text{F}$ ;
- for voltages having a peak value over 450 V up to and including 15 kV, the discharge shall not exceed 45  $\mu\text{C}$ .

*Compliance is checked by operating the tool at rated voltage. Voltages and currents are measured between the relevant parts and either pole of the supply source. Discharges are measured immediately after the interruption of the supply.*

**9.2** *The requirement of 9.1 applies for all positions of the tool when it is operated as in normal use, even after removal of detachable parts.*

*Lamps located behind a detachable cover are not removed, provided the tool can be isolated from the supply by means of a plug or an all-pole switch. However, during insertion or removal of lamps which are located behind a detachable cover, protection against contact with live parts of the lamp cap shall be ensured.*

*This excludes the use of screw type fuses and screw-type miniature circuit breakers which are accessible without the aid of a tool.*

*The test finger of Figure 1 is applied without appreciable force, the tool being in every possible position.*

*Through openings, the test finger is applied to any depth that the finger will permit, and it is rotated or angled before, during, and after insertion to any position.*

*If the opening does not allow the entry of the finger, the force on the finger in the straight position is increased to 20 N and the test with the finger bent repeated.*

*It shall not be possible to touch with the test finger live parts or live parts protected only by lacquer, enamel, ordinary paper, cotton, oxide film, beads or sealing compound.*

*Lacquer, enamel, ordinary paper, cotton, oxide film on metal parts, beads and sealing compound, except self-hardening resins, are not considered to give the required protection against contact with live parts.*

**9.3** *For openings in class II tools or class II constructions, except for those giving access to lamp caps or live parts in socket-outlets of class I tools, the test pin of Figure 2 is applied without appreciable force. It shall not be possible to touch live parts with the test pin.*

**9.4** In addition, class II tools and class II constructions shall be so constructed and enclosed that there is adequate protection against accidental contact with basic insulation, and metal parts separated from live parts by basic insulation only.

Parts which are not separated from live parts by double insulation or reinforced insulation shall not be accessible.

*Compliance is checked by inspection and by applying the test finger of Figure 1.*

*This requirement applies for all positions of the tool when it is operated as in normal use, even after removal of detachable parts.*

## 10 Starting

**10.1** Motors shall start under all normal voltage conditions which may occur in use.

*Compliance is checked by operating the tool with no load 10 times at a voltage equal to 0,85 times rated voltage, regulating devices, if any, being set as in normal use.*

*In all cases, the tool shall function safely and correctly.*

**10.2** Centrifugal and other automatic starting switches shall operate reliably, and without contact chattering.

*Tools provided with a centrifugal or other automatic starting switch are, in addition, operated 10 times at a voltage equal to 1,1 times rated voltage. The interval between consecutive starts is made sufficiently long to prevent undue heating.*

*In all cases, the tool shall function safely and correctly.*

**10.3** Overload protection devices shall not operate under normal starting conditions.

*The tests of 10.1 and 10.2 check compliance with this requirement.*

## 11 Input and current

**11.1** The rated power input or rated current shall be at least 110 % of the measured no-load input or current.

For tools marked with one or more rated voltage ranges, the test is made at both the upper and lower limits of the ranges, unless the marking or the rated power input is related to the mean value of the relevant voltage range, in which case the test is made at a voltage equal to the mean value of that range.

*Compliance is checked by measuring the power input or current of the tool when stabilized while all circuits which can operate simultaneously are in operation.*

## 12 Heating

**12.1** Tools shall not attain excessive temperatures under normal load.

*Compliance is checked by determining the temperature rise of the various parts under the conditions specified in 12.2 to 12.5 immediately followed by the test of clause 13 with the tool in the "on" position and under the following conditions:*

*For single-phase tools and for three-phase tools to be tested as single-phase tools:  
S1 of Figure 3 in the "on" position.*

*For three-phase tools not suitable for single-phase supply:  
a, b and c in Figure 4 in the "on" position.*

*For heating elements, the measurements are repeated with each of the switches a, b and c open in turn, the other two switches being closed.*

**12.2** *The tool is operated in still air under normal load until thermal stabilization. While the torque is maintained, the voltage is then adjusted to 0,94 times the rated voltage or 1,06 times the rated voltage, or the mean of the rated voltage range, whichever is the most unfavourable.*

*Heating elements, if any, are operated under the conditions specified in clause 11 of IEC 60335-1, when the tool is operated at a voltage equal to 1,06 times rated voltage.*

**12.3** *Temperature rises, other than those of windings, are determined by means of fine-wire thermocouples so chosen and positioned that they have the minimum effect on the temperature of the part under test.*

*The temperature rise of electrical insulation, other than that of windings, is determined on the surface of insulation, at places where failure could cause a short circuit, contact between live parts and accessible metal parts, bridging of insulation, or reduction of creepage distances or clearances below the values specified in 28.1.*

*Temperature rises of windings are determined by the resistance method, unless the windings are non-uniform, or the method involves severe complications to make the necessary connections for the resistance measurement. In that case, the measurement is made by thermocouples.*

*Such temperature rises are determined by means of fine-wire thermocouples so chosen and positioned that they have the minimum effect on the temperature of the part under test.*

*In determining the temperature rises of handles, knobs, grips and the like, consideration is given to all parts which are gripped in normal use, and, if of insulating material, to those parts in contact with hot metal.*

NOTE 1 If it is necessary to dismantle the tool to position thermocouples, the power input is measured again to check that the tool has been correctly reassembled.

NOTE 2 The point of separation of the cores of a multicore cord is an example of a place where thermocouples are positioned.

**12.4** *The tool is operated:*

- *for the rated operated time for tools for short-time operation;*
- *on consecutive cycles of operation, until steady conditions are established, for tools for intermittent operation, the "on" and "off" periods being the rated "on" and "off" periods;*
- *until steady conditions are established for tools for continuous operation.*

**12.5** *During the test, protective devices shall not operate. The temperature rises shall not exceed the values shown in Table 1, except as allowed by 12.6.*

*Sealing compound, if any, shall not flow out.*

**Table 1 – Maximum normal temperature rises**

Parts	Temperature rise K
Windings <sup>1)</sup> , if the winding insulation according to IEC 60085 is: <ul style="list-style-type: none"> <li>- class A</li> <li>- class E</li> <li>- class B</li> <li>- class F</li> <li>- class H</li> <li>- class 200</li> <li>- class 220</li> <li>- class 250</li> </ul>	<ul style="list-style-type: none"> <li>75 (65)</li> <li>90 (80)</li> <li>95 (85)</li> <li>115</li> <li>140</li> <li>160</li> <li>180</li> <li>210</li> </ul>
Pins of appliance inlets: <ul style="list-style-type: none"> <li>- for hot conditions</li> <li>- for cold conditions</li> </ul>	<ul style="list-style-type: none"> <li>95</li> <li>40</li> </ul>
Ambient of switches, temperature limiters <sup>2)</sup> : <ul style="list-style-type: none"> <li>- without T-marking</li> <li>- with T-marking</li> </ul>	<ul style="list-style-type: none"> <li>30</li> <li>T-25</li> </ul>
Rubber or polyvinyl chloride insulation of internal and external wiring, including supply cords: <ul style="list-style-type: none"> <li>- without temperature rating <sup>3)</sup></li> <li>- with temperature rating (T)</li> </ul>	<ul style="list-style-type: none"> <li>50</li> <li>T-25</li> </ul>
Cord sheath used as supplementary insulation	35
Rubber, other than synthetic, used for gaskets or other parts, the deterioration of which could affect safety: <ul style="list-style-type: none"> <li>- when used as supplementary insulation or as reinforced insulation</li> <li>- in other cases</li> </ul>	<ul style="list-style-type: none"> <li>40</li> <li>50</li> </ul>
Lampholders E14 and B15: <ul style="list-style-type: none"> <li>- metal or ceramic type</li> <li>- insulated type, other than ceramic</li> <li>- with T-marking</li> </ul>	<ul style="list-style-type: none"> <li>130</li> <li>90</li> <li>T-25</li> </ul>
Material used as insulation other than that specified for wires and windings <sup>4)</sup> <ul style="list-style-type: none"> <li>- impregnated or varnished textile, paper or press board</li> <li>- laminates bonded with:                             <ul style="list-style-type: none"> <li>• melamine-formaldehyde; phenol-formaldehyde or phenol-furfural resins</li> <li>• urea-formaldehyde resin</li> </ul> </li> <li>- Printed circuit boards bonded with epoxy resin</li> <li>- moulding of:                             <ul style="list-style-type: none"> <li>• phenol-formaldehyde with cellulose fillers</li> <li>• phenol-formaldehyde with mineral fillers</li> <li>• melamine-formaldehyde</li> <li>• urea-formaldehyde</li> </ul> </li> <li>- polyester with glass-fibre reinforcement</li> <li>- silicone rubber</li> <li>- polytetrafluoroethylene</li> <li>- pure mica and tightly sintered ceramic material when such materials are used as supplementary insulation or reinforced insulation</li> <li>- thermoplastic material <sup>5)</sup></li> </ul>	<ul style="list-style-type: none"> <li>70</li> <li>85 (175)</li> <li>65 (150)</li> <li>120</li> <li>85 (175)</li> <li>100 (200)</li> <li>75 (175)</li> <li>65 (150)</li> <li>110</li> <li>145</li> <li>265</li> <li>400</li> <li>-</li> </ul>

Table 1 (continued)

Wood, in general <sup>6)</sup>	65
Outer surface of capacitors <sup>7)</sup> :	
– with marking of maximum operating temperature (T)	T-25
– without marking of maximum operating temperature:	
• small ceramic capacitors for radio and television interference suppression	50
• capacitors complying with IEC 60384-14 or 14.2 of IEC 60065	50
• other capacitors <sup>7)</sup>	20
External enclosure of tools without heating elements except handles held in normal use	60
Handles, knobs, grips and the like which, in normal use, are continuously held:	
– of metal	30
– of porcelain or vitreous material	40
– of moulded material, rubber or wood	50
Handles, knobs, grips and the like which, in normal use, are held for short periods only (e.g. switches):	
– of metal	35
– of porcelain or vitreous material	45
– of moulded material, rubber or wood	60
Parts in contact with oil having a flash-point of t °C	t-50
<p><sup>1)</sup> To allow for the fact that the average temperature of windings of universal motors, relays, solenoids, etc., is usually above the temperature at the points on the windings where thermocouples are placed, the figures without parentheses apply when the resistance method is used, and those within parentheses apply when thermocouples are used. For windings of vibrator coils and a.c. motors, the figures without parentheses apply in both cases. For motors constructed so that the circulation of the air between the inside and the outside of the case is prevented, but not necessarily sufficiently enclosed to be called airtight, the temperature rise limits may be increased by 5 K.</p> <p><sup>2)</sup> T signifies the maximum operating temperature.</p> <p>The ambient temperature of switches, thermostats and temperature limiters is the temperature of the air at the hottest point at a distance of 5 mm from the surface of the switch and component concerned.</p> <p>For the purpose of this test, switches and thermostats marked with individual ratings may be considered as having no marking for the maximum operating temperature, if requested by the tool manufacturer.</p> <p><sup>3)</sup> This limit applies to cables, cords and wires complying with the relevant IEC standards; for others, it may be different.</p> <p><sup>4)</sup> The values in parentheses apply, if the material is used for handles, knobs, grips and the like, and is in contact with hot metal.</p> <p><sup>5)</sup> There is no specific limit for thermoplastic material, which has to withstand the tests of 29.1, for which purpose the temperature rise must be determined.</p> <p><sup>6)</sup> The limit specified concerns the deterioration of wood, and it does not take into account deterioration of surface finishes.</p> <p><sup>7)</sup> There is no limit for the temperature rise of capacitors which are short-circuited in 18.10.</p> <p>If these or other materials are used, they shall not be subjected to temperatures in excess of the thermal capabilities as determined by ageing tests made on the materials themselves.</p>	

NOTE 1 The values in the table are based on an ambient temperature not normally exceeding 25 °C, but occasionally reaching 35 °C. However, the temperature rise values specified are based on 25 °C.

NOTE 2 The value of the temperature rise of a winding is calculated from the formula:

$$\Delta t = \frac{R_2 - R_1}{R_1} (k + t_1) - (t_2 - t_1)$$

where

$\Delta t$  is the temperature rise;

$R_1$  is the resistance at the beginning of the test;

$R_2$  is the resistance at the end of the test;

$k$  is equal to 234,5 for copper windings, and 225 for aluminium windings;

$t_1$  is the room temperature at the beginning of the test;

$t_2$  is the room temperature at the end of the test.

At the beginning of the test, the windings are to be at room temperature. It is recommended that the resistance of windings at the end of the test be determined by taking resistance measurements as soon as possible after switching off, and then at short intervals so that a curve of resistance against time can be plotted for ascertaining the resistance at the instant of switching off.

**12.6** *If the windings are classified according to IEC 60085 and the temperature rise does not exceed the value in Table 1, the following test is not necessary.*

*Three additional samples are subjected to the following tests.*

- a) *The temperature rise of the windings is determined by the test of 12.2.*
- b) *The samples are then dismantled as far as is possible without damaging any part. Windings are kept for 10 days (240 h) in a heating cabinet, the temperature of which is  $(80 \pm 1) ^\circ\text{C}$  in excess of the temperature rise determined according to item 1.*
- c) *After this treatment, the samples are reassembled and no interturn short circuit shall occur. Interturn short circuits may be detected by means of a winding tester.*
- d) *Immediately afterwards, the samples shall withstand the tests of clause 13 and 15.*
- e) *The samples are then subjected to a humidity treatment as specified in 14.3.*
- f) *After this treatment, they shall again withstand the tests of clause 13 and 15.*

*Faults which may occur in insulation, which did not show an excessive temperature rise during the test of item 1, are ignored and are repaired, if necessary, in order to complete the tests of this subclause.*

## **13 Leakage current**

**13.1** *The leakage current shall not be excessive.*

*Compliance is checked by the following test at a supply voltage equal to 1,06 times rated voltage.*

*The leakage current test is made with a.c. unless the tool is for d.c. only, in which case the test is not made.*

*Protective impedance is disconnected from live parts before carrying out the tests.*

*It is recommended that the tool be supplied through an isolating transformer; otherwise, it must be insulated from earth.*

**13.2** *The leakage current is measured by means of the circuit described in Annex C between any pole of the supply and:*

- *accessible metal parts and metal foil with an area not exceeding  $20 \text{ cm} \times 10 \text{ cm}$  in contact with accessible surfaces of insulating material, connected together. The metal foil has the largest area possible on the surface under test, without exceeding the dimensions specified. If its area is smaller than the surface under test, it is moved so as to test all parts of the surface. The heat dissipation of the tool must, however, not be affected by the metal foil.*

*Single-phase tools having a rated voltage not exceeding 250 V, and three-phase tools, which are suitable for single-phase supply are tested as single-phase tools with the three sections connected in parallel. The leakage current is measured with the selector switch shown in Figures 3 and 4, in each of the positions 1 and 2.*

*For three-phase tools not suitable for single-phase supply, the leakage current is measured according to Figure 4. For tools intended to be connected in star connection only, the neutral is not connected.*

*The leakage current is measured within 5 s after the application of the test voltage and shall not exceed the following values:*

- *to accessible metal parts and metal foil:*
  - *for class I tools* 0,75 mA;
  - *for class II tools* 0,25 mA;
  - *for class III tools* 0,5 mA.

*If the tool incorporates one or more capacitors, and is provided with a single-pole switch, the measurements are repeated with the switch in the “off” position.*

*For tools with heating elements, the total leakage current may be within the limits specified for heating elements, as specified in clause 16 of IEC 60335-1, or for motor-operated tools, whichever is the greater, but the two limits are not added.*

## **14 Moisture resistance**

**14.1** The enclosure of the tool shall provide the degree of protection against moisture in accordance with the classification of the tool.

*Compliance is checked by the appropriate treatment specified in 14.1.2, with the tool conditions as in 14.1.1.*

**14.1.1** *The tool is not connected to the supply.*

*Tools are turned continuously through the most unfavourable positions during the test.*

*Tools with type X attachment are fitted with the lightest permissible type of flexible cord of the smallest cross-sectional area specified in 25.2; other tools are tested as delivered.*

*Electrical components, covers and other parts which can be removed without the aid of a tool are removed and subjected, if necessary, to the relevant treatment with the main part.*

**14.1.2** *Tools other than IPX0 are subjected to tests of IEC 60529 as follows:*

- *IPX1 tools are subjected to the test described in 14.2.1;*
- *IPX2 tools are subjected to the test described in 14.2.2;*
- *IPX3 tools are subjected to the test described in 14.2.3;*
- *IPX4 tools are subjected to the test described in 14.2.4;*
- *IPX5 tools are subjected to the test described in 14.2.5;*
- *IPX6 tools are subjected to the test described in 14.2.6;*
- *IPX7 tools are subjected to the test described in 14.2.7.*

*For this last test, the tool is immersed in water containing 1 % NaCl.*

*Immediately after the appropriate treatment, the tool shall withstand the electric strength test of clause 15, and inspection shall show that there is no trace of water on insulation which could result in a reduction of creepage distances and clearances below the values specified in 28.1.*

*Tools which are not subject to spillage of liquid in normal use are allowed to stand in normal test-room atmosphere for 24 h before being subjected to the test of 14.3.*

**14.2** Tools subject to spillage of liquid in normal use shall be so constructed that such spillage does not affect their electrical insulation.

*Compliance is checked by the following test.*

*Tools incorporating an appliance inlet are fitted with an appropriate connector and flexible cord; tools with type X attachment are fitted with the lightest permissible type of flexible cord of the smallest cross-sectional area specified in 25.2; other tools are tested as delivered.*

*Electrical components, covers and other parts which can be removed without the aid of a tool are removed, except those fulfilling the test of 21.23.*

*The liquid container of the tool is completely filled with water containing approximately 1 % NaCl, and a further quantity, equal to 15 % of the capacity of the container, or 0,25 l, whichever is the greater, is poured in steadily over a period of 1 min.*

*Immediately after this treatment, the tool shall withstand an electric strength test as specified in clause 15, and inspection shall show that there is no trace of water on insulation which could result in a reduction of creepage distances and clearances below the values specified in 28.1.*

*The tool is allowed to stand in normal test-room atmosphere for 24 h before being subjected to the test of 14.3.*

**14.3** Tools shall be proof against humid conditions which may occur in normal use.

*Compliance is checked by the following humidity test.*

*Cable entries, if any, are left open; if knock-outs are provided, one of them is opened.*

*Electrical components, covers, and other parts which can be removed without the aid of a tool are removed and subjected, if necessary, to the humidity test with the main part.*

*The humidity treatment is carried out in a humidity cabinet containing air with a relative humidity of  $(93 \pm 2)$  %. The temperature of the air, at all places where samples can be located, is maintained within 1 K of any convenient value  $t$  between 20 °C and 30 °C. A relative humidity of  $(93 \pm 2)$  % can be obtained by placing in the humidity cabinet a saturated solution of  $\text{Na}_2\text{SO}_4$  or  $\text{KNO}_3$  in water, having a sufficiently large contact surface with the air. In order to achieve the specified conditions within the cabinet, it is necessary to ensure constant circulation of the air within and, in general, to use a cabinet which is thermally insulated.*

*Before being placed in the humidity cabinet, the sample is brought to a temperature between  $t$  and  $(t + 4)$  °C. In most cases, the tool may be brought to the specified temperature by keeping it at this temperature for at least 4 h before the humidity treatment.*

*The tool is kept in the cabinet for 48 h.*

*Immediately after this test, the tool shall withstand the tests of clause 13 at rated voltage or the mean of the rated voltage range with the tool switch in the “on” position and under the following conditions:*

*For single-phase tools and for three-phase tools to be tested as single-phase tools: S1 of Figure 3 in the “off” position.*

*For three-phase tools not suitable for single-phase supply: a in Figure 4 in the “on” position, b and c in “off” position.*

*Then the tool shall withstand the test of clause 15 in the humidity cabinet, or in the room in which the tool was brought to the prescribed temperature after reassembly of those parts which may have been removed.*

*The leakage current limit values specified in the test of clause 13 are doubled if all controls have an off-position in all poles.*

*They are also doubled if:*

- *the tool has no control other than a thermal cut-out; or*
- *all thermostats and energy regulators do not have an off position; or*
- *the tool has radio interference filters. In that case, the leakage current with the filter disconnected shall not exceed the limits specified.*

*However, for class II tools, doubling of the value of 0,25 mA is only allowed if all controls have an “off” position.*

## 15 Electric strength

**15.1** The electric strength shall be adequate.

*Compliance is checked by the tests of 15.2.*

*Protective impedance is disconnected from live parts before carrying out the tests.*

*The tests are made on the tools at room temperature and not connected to the supply.*

**15.2** *The insulation is subjected for 1 min to a voltage of substantially sinusoidal waveform, having a frequency of 50 Hz or 60 Hz. The value of the test voltage and the points of application are shown in Table 2, unless otherwise specified.*

*Accessible parts of insulated material are covered with metal foil.*

**Table 2 – Test voltages**

Points of application	Test voltage V		
	Class III tools and construction	Class II tools and construction	Other tools
1. Between live parts and accessible parts separated from live parts by <ul style="list-style-type: none"> <li>– basic insulation only</li> <li>– reinforced insulation</li> </ul>	500 –	– 3 750	1 250 3 750
2. For parts with double insulation, between metal parts separated from live parts by basic insulation only, and <ul style="list-style-type: none"> <li>– live parts</li> <li>– accessible parts</li> </ul>	– –	1 250 2 500	1 250 2 500
3. Between metal enclosures or covers lined with insulating material and metal foil in contact with the inner surface of the lining, if the distance between live parts and these metal enclosures or covers, measured through the lining, is less than the appropriate clearance as specified in 28.1	–	2 500	1 250

**Table 2 (continued)**

Points of application	Test voltage V		
	Class III tools and construction	Class II tools and construction	Other tools
4. Between metal foil in contact with handles, knobs, grips and the like and their shafts, if these shafts can become live in the event of an insulation fault	–	2 500	2 500
5. Between accessible parts and internal diameter of cord guard wrapped with metal foil	–	2 500	1 250
6. Between the point where a winding and a capacitor are connected together, if a resonance voltage $U$ occurs between this point and any terminal for external conductors, and			
– accessible parts <sup>1)</sup>	–	–	$2 U + 1\,000$
– metal parts separated from live parts by basic insulation only	–	$2 U + 1\,000$	–
<sup>1)</sup> The test between the point where a winding and a capacitor are connected together, and accessible parts or metal parts, is only made where the insulation is subjected to the resonance voltage under normal running conditions. Other parts are disconnected, and the capacitor is short-circuited.			

*Initially, not more than half the prescribed voltage is applied, then it is raised rapidly to the full value.*

*No flashover or breakdown shall occur during the test.*

*The high-voltage transformer used for the test must be so designed that, when the output terminals are short-circuited after the output voltage has been adjusted to the appropriate test voltage, the output current is at least 200 mA.*

*The overcurrent relay must not trip when the output current is less than 100 mA.*

*Care is taken that the r.m.s. value of the test voltage applied is measured within  $\pm 3\%$  and the metal foil is so placed that no flashover occurs at its edges.*

*Care is taken that the metal foil is so placed that no flashover occurs at the edges of the insulation.*

*For class II construction incorporating both reinforced insulation and double insulation, care is taken that the voltage applied to the reinforced insulation does not overstress the basic insulation, or the supplementary insulation.*

*In cases where basic insulation and supplementary insulation cannot be tested separately, the insulation provided is subjected to the test voltages specified for reinforced insulation.*

*When testing insulating coatings, the metal foil may be pressed against the insulation by means of a sandbag of such a size that the pressure is about 5 kPa (0,5 N/cm<sup>2</sup>). The test may be limited to places where the insulation is likely to be weak, for example where there are sharp metal edges under the insulation.*

*If practicable, insulating linings are tested separately.*

*For tools with heating elements incorporated, the test voltages specified in IEC 60335-1 apply to the heating elements only and not to other parts of the tool.*

## 16 Overload protection of transformers and associated circuits

**16.1** Tools incorporating circuits supplied from a transformer shall be so constructed that, in the event of short circuits which are likely to occur in normal use, excessive temperatures do not occur in the transformer, or in the circuits associated to the transformer.

Examples of short-circuits which are likely to occur in normal use are the short-circuiting of bare or inadequately insulated conductors of safety extra-low voltage circuits which are accessible, and the internal short-circuiting of lamp filaments.

A failure of insulation complying with the requirements specified for basic insulation of class I or class II construction is not, for the purpose of this requirement, considered as likely to occur in normal use.

*Compliance is checked by applying the most unfavourable short circuit or overload which is likely to occur in normal use, the tool being operated at a voltage equal to 1,06 times, or 0,94 times, rated voltage, whichever is the more unfavourable.*

*The temperature rise of the insulation of the conductors of safety extra-low voltage circuits is determined, and shall not exceed the relevant value specified in Table 1 by more than 15 K.*

*The winding temperature of transformers shall not exceed the value specified for windings in 18.9, except for transformers which comply with IEC 61558-1.*

## 17 Endurance

**17.1** Tools shall be so constructed that, in extended normal use, there will be no electrical or mechanical failure that might impair compliance with this standard. The insulation shall not be damaged and contacts and connections shall not work loose as a result of heating, vibrations, etc.

Moreover, overload protection devices shall not operate under normal running conditions.

*Compliance is checked by the test of 17.2 and, for tools provided with a centrifugal or other starting switch, also by the test of 17.3.*

*Immediately after these tests, the tool shall withstand an electric strength test as specified in clause 15, the test voltages being, however, reduced to 75 % of the specified values. Connections shall not have worked loose, and there shall be no deterioration impairing safety in normal use.*

**17.2** *The tool is operated intermittently with no load for 24 h of operation at a voltage equal to 1,1 times rated voltage, and then for 24 h at a supply voltage equal to 0,9 times rated voltage.*

*The tool may be switched on and off by means of a switch other than that incorporated in the tool.*

*Each cycle of operation comprises an "on" period of 100 s and an "off" period of 20 s, the "off" periods being included in the specified operating time.*

*The operating period for tools for short-time or intermittent operation is equal to the operating time, if this is limited by the construction of the tool; otherwise, it is in accordance with the prescriptions given in part 2, or with the marking, whichever is the more unfavourable.*

*During the test, the tool is placed in three different positions, the operating time, at each test voltage, being approximately 8 h for each position.*

*During this test, replacement of the carbon brushes is allowed, and the tool is oiled and greased as in normal use.*

*If the temperature rise of any part of the tool exceeds the temperature rise determined during the test of 12.1, forced cooling or rest periods are applied, the rest periods being excluded from the specified operating time.*

*During these tests, overload protection devices shall not operate.*

NOTE The change of position is made to prevent abnormal accumulation of carbon dust in any particular place. The three positions are, in general, horizontal, vertically up and vertically down.

**17.3** *Tools provided with a centrifugal or other automatic starting switch are started 10 000 times under normal load, and at a voltage equal to 0,9 times rated voltage, the operating cycle being that specified in 17.2.*

## **18 Abnormal operation**

**18.1** Tools shall be so designed that the risk of fire, mechanical damage impairing safety, or the protection against electric shock as a result of abnormal operation is obviated as far as is practicable.

Fuses, thermal cut-outs, overcurrent protection devices or the like, incorporated into the tool, may be used to provide the necessary protection.

*Compliance is checked by the following test.*

**18.2** *Tools incorporating heating elements are subjected to the tests of 18.3 and 18.4. Moreover, tools provided with a control limiting the temperature during clause 12 tests unless specifically excluded by part 2, are subjected to the tests of 18.5, and where applicable, to the test of 18.6.*

*Unless otherwise specified, the tests are continued until a non-self-resetting thermal cut-out operates, or until steady conditions are established. If, during the test, a heating element or an intentionally weak part is permanently open-circuited, the relevant test is repeated on a second sample. This second test shall be terminated in the same way, unless the test is otherwise satisfactorily completed.*

*An intentionally weak part is a part intended to fail under conditions of abnormal operation so as to prevent the occurrence of a condition which could impair compliance with this standard. Such a part may be a replaceable component, such as a resistor, a capacitor, or a thermal link, or a part of a component to be replaced, such as an inaccessible and non-resettable thermal cut-out incorporated in a motor.*

*Only one abnormal condition is simulated each time. If more than one of the tests are applicable to the same tool, these tests are made consecutively.*

**18.3** *Tools with heating elements are tested under the conditions specified in clause 12, but with restricted heat dissipation. The supply voltage, determined prior to the test, is that required to provide a power input of 0,85 times the rated power input under normal operation, when steady conditions have been established. This voltage is maintained throughout the test.*

*The tool is allowed to cool down to approximately room temperature before being subjected to the test of 18.4.*

**18.4** The test of 18.3 is repeated, but with a supply voltage, determined prior to the test, equal to that required to provide a power input of 1,24 times rated power input under normal operation, when steady conditions have been established. This voltage is maintained throughout the test.

**18.5** The tool is tested under the conditions specified in clause 12, under normal operation, the supply voltage being such that the power input is 1,15 times rated power input, but with any control which limits the temperature during the test of clause 12 short-circuited.

If the tool is provided with more than one control, these are short-circuited in turn.

**18.6** Unless an all-pole disconnection occurs during the test of 18.5 for class I tools with tubular sheathed and embedded heating elements, but which are not intended to be permanently connected to fixed wiring, the test of 18.5 is repeated, with the controls which limit the temperature during the test of clause 12 not short-circuited, and one end of the element connected to earth. This test is repeated with the polarity of the supply to the tool reversed and with the other end of the element connected to earth.

NOTE Usually, the test is made with the neutral connected to earth.

**18.7** The following test is performed with cutting tools, such as sawblades, grinding wheels, etc., removed.

- Tools incorporating a commutator motor are operated at a voltage equal to 1,3 times rated voltage, or the upper limit of the voltage range, for 1 min at no-load.

After this test, the safety of the tool shall not have been impaired, in particular windings and connections shall not have worked loose. After the test, the tool need not be capable of further use.

**18.8** The following categories of tools incorporating induction motors and:

- a) with a starting torque less than the full-load torque; or
- b) started by hand; or
- c) provided with moving parts which are liable to be jammed, or where the moving parts can be stopped by hand, the motor remaining switched on during this operation; are connected, starting from cold, to their rated voltage or the upper limit of their rated voltage range with the moving parts locked
  - for 30 s for tools that are operated by hand during use;
  - for 5 min for tools that are attended during use.

At the end of the test period specified, or at the instant of operation of fuses, thermal cut-outs, motor protection devices, and the like, the temperature of the windings shall not exceed the values shown in Table 3.

**18.9** Tools incorporating three-phase motors are operated, starting from cold,

- for 30 s, if they are kept switched on by hand or continuously loaded by hand;
- or otherwise, for 5 min,

with one phase disconnected, and under the torque producing normal load.

At the end of the test period specified, or at the instant of operation of fuses, thermal cut-outs, motor protection devices, and the like, the temperature of the windings shall not exceed the values shown in Table 3.

**Table 3 – Maximum winding temperature**

Protection of windings	Limiting temperature °C							
	Class							
	A	E	B	F	H	200	220	250
Protection by inherent impedance	150	165	175	190	210	230	250	280
Protection by protective devices which operate during the test	200	215	225	240	260	280	300	330

**18.10** Tools incorporating electronic devices shall be so designed that, in the event of a failure in the electronic equipment, this shall not result in a hazard.

*Compliance is checked by operating the tool for 1 min, at a voltage equal to the rated voltage or the mean value of the voltage range, at no load with the electronic device short-circuited.*

*The test is then repeated with the electronic device open-circuited.*

*Following these tests, the tool shall show no damage due to fire, mechanical damage impairing safety and protection against electric shock.*

*Where the tool incorporates a device for limiting speed should the electronic device fail to operate, the tool is considered to have withstood the test when the said speed-limiting device operates during the test.*

**18.11** Switches or other devices for motor reversal shall withstand the stresses occurring when the sense of rotation is reversed under running conditions where such a reversal is possible in normal use.

*Compliance is checked by the following test.*

*The tool is operated at a voltage equal to rated voltage, or at the upper limit of the rated voltage range, at no load; the device for reversing the sense of rotation being in such a position that the rotor rotates in one direction at full speed.*

*The direction of the rotation is then reversed, without the device resting in an intermediate "off" position.*

*This operation sequence is performed 25 times.*

*After the test, the switch shall have no electrical or mechanical failure.*

**18.12** A class I tool employing class II construction (see 5.10) or a class II tool shall be able to operate under extreme overload conditions without impairing protection against electric shock.

*Compliance is checked by the following test on a separate sample.*

*The sample is connected to a minimum 12 kVA circuit. The tool is loaded to 160 % of normal load current for either 15 min or until the tool open-circuits or flame appears. If the tool will not operate at 160 %, the tool is stalled for 15 min or until the tool open-circuits or flame appears. If flames appear, extinguish immediately with CO<sub>2</sub> extinguisher. The leakage current between live parts and accessible parts, measured in accordance with clause 13, is monitored throughout the test and after the test until leakage current has stabilized or decreases. Leakage current shall not exceed 2 mA.*

*After the tool is cooled to room temperature, an electric strength test per clause 15 is performed between live parts and accessible parts as follows:*

- *If a tool does not operate after 15 min, apply a 1 500 V electric strength test.*
- *If a tool operates after 15 min, apply a 2 500 V electric strength test.*

## **19 Mechanical hazards**

**19.1** Moving and other dangerous parts shall, as far as is compatible with the use and mode of function of the tool, be so arranged or enclosed that, in normal use, adequate protection against injury is provided.

Protective enclosures, covers, guards and the like shall possess adequate mechanical strength for their intended purpose. They shall not be removable without the aid of a tool.

When used as protection of the working element, the guard shall have an easily accessible means of accurate adjustment with the objective of minimizing access to the dangerous parts.

The use and adjustment of a guard shall not create other dangers, for example by reducing or obstructing the operator's view, by transferring heat, or causing other predictable hazards.

All working elements, including special features or attachments intended as part of the tool, shall be secured so that they cannot create dangers during normal use by moving, or being released, out of the normal working constraints of the tool.

NOTE Such dangers might be caused by vibration, reversal of motion, or electric braking.

*Compliance is checked by inspection, by the tests of clause 20 and by means of a test using the standard test finger shown in Figure 1. It shall not be possible to touch dangerous moving parts with this finger.*

NOTE 1 In some cases, specified in the relevant part 2, a rigid test finger is used.

NOTE 2 The rigid test finger has the same dimensions of the test finger in Figure 1, without any articulation.

**19.2** Accessible parts likely to be touched during normal use shall be free from sharp edges, burrs, flashes and the like.

*Compliance is checked by inspection.*

**19.3** Moving parts shall not be reached with the provisions for dust collection removed, if any.

*Compliance is checked by a test with the rigid finger shown in Figure 1. It shall not be possible to touch dangerous moving parts with the test finger through dust collection openings after the removing of the removable provisions.*

**19.4** Tools shall have adequate grasping surfaces to ensure safe handling during use.

*Compliance is checked by inspection.*

**19.5** Tools shall be designed and constructed to allow, where necessary, a visual check of the contact of the cutting tool with the work piece.

*Compliance is checked by inspection.*

## 20 Mechanical strength

**20.1** Tools shall have adequate mechanical strength, and shall be so constructed that they withstand such rough handling as may be expected in normal use.

*Compliance is checked by the tests specified in 20.2, 20.3 and 20.4.*

*Following the tests, the tool shall withstand an electric strength test as specified in clause 15, and shall show no damage which could impair compliance with this standard; in particular, live parts shall not have become accessible, as specified in clause 9.*

*Damage to the finish, small dents which do not reduce creepage distances or clearances below the values specified in 28.1, or small chips which do not adversely affect protection against shock or moisture are neglected.*

*The function of mechanical safety devices shall not be impaired thereby.*

*Cracks not visible to the naked eye and surface cracks in fibre-reinforced mouldings and the like are ignored.*

*If a decorative cover is backed by an inner cover, a fracture of the decorative cover is neglected when the inner cover withstands the test after removal of the decorative cover.*

**20.2** Blows are applied to the total by means of the spring-operated impact test apparatus according to clause 5 of IEC 60068-2-75.

*The spring is so adjusted that it causes the hammer to strike with an impact energy as shown in Table 4.*

**Table 4 – impact energies**

Parts to be tested	Impact energy Nm
Brush caps	0,5 ± 0,05
Other parts	1,0 ± 0,05

*Three blows are applied to every point of the enclosure which is likely to be weak.*

*Where necessary, blows are also applied to protective devices, handles, levers, knobs and the like.*

**20.3** A hand-held tool shall withstand being dropped three times on a concrete surface from a height of 1 m. The sample shall be positioned to vary the point of impact.

**20.4** Brush holders and their caps shall have adequate mechanical strength.

*Compliance is checked by inspection and, in case of doubt, by removing and replacing the brushes 10 times, the torque applied when tightening the cap being as shown in Table 5.*

**Table 5 – Test torques**

Blade width of test screwdriver mm	Torque Nm
Up to and including 2,8	0,4
Over 2,8 up to and including 3,0	0,5
Over 3,0 up to and including 4,1	0,6
Over 4,1 up to and including 4,7	0,9
Over 4,7 up to and including 5,3	1,0
Over 5,3 up to and including 6,0	1,25

*After this test, the brush holder shall show no damage impairing its further use, the thread, if any, shall not be damaged and the cap shall show no cracks.*

*The blade width of the test screwdriver must be as large as possible, but must not exceed the length of the recess in the cap. If, however, the thread diameter is smaller than the length of the recess, the blade width must not exceed this said diameter. The torque must not be applied in jerks.*

## **21 Construction**

**21.1** Tools which can be adjusted to suit different voltages, or to different speeds, shall be so constructed that accidental changing of the setting is unlikely to occur, if such a change might result in a hazard.

*Compliance is checked by inspection and by manual test.*

**21.2** Tools shall be so constructed that accidental changing of the setting of control devices is unlikely to occur.

*Compliance is checked by manual test.*

**21.3** It shall not be possible to remove parts which ensure the required degree of protection against moisture without the aid of a tool.

*Compliance is checked by manual test.*

**21.4** If handles, knobs and the like are used to indicate the position of switches or similar components, it shall not be possible to fix them in a wrong position if this might result in a hazard.

*Compliance is checked by inspection and by manual test.*

**21.5** Replacement of a flexible cable or cord requiring the moving of a switch which acts also as a terminal for external conductors shall be possible without subjecting internal wiring to undue stress; after repositioning the switch, and before reassembling the tool, it shall be possible to verify whether the internal wiring is correctly positioned.

*Compliance is checked by inspection and by manual test.*

**21.6** Wood, cotton, silk, ordinary paper and similar fibrous or hygroscopic material shall not be used as insulation, unless impregnated.

Insulating material is considered to be impregnated if the interstices between the fibres of the material are substantially filled with a suitable insulant.

*Compliance is checked by inspection.*

**21.7** Asbestos shall not be used in the construction of tools.

*Compliance is checked by inspection.*

**21.8** Driving belts shall not be relied upon to provide the required level of insulation.

This requirement does not apply if the tool incorporates a special design of belt which prevents inappropriate replacement.

*Compliance is checked by inspection.*

**21.9** Insulating barriers of class II tools, and parts of class II tools which serve as supplementary insulation or reinforced insulation, and which might be omitted during reassembly after servicing, shall either:

- *be fixed in such a way that they cannot be removed without being seriously damaged; or*
- *be so designed that they cannot be replaced in an incorrect position, and that, if they are omitted, the tool is rendered inoperable or manifestly incomplete.*

*Compliance is checked by inspection and by manual test.*

*Servicing includes replacement of components such as supply cords and switches.*

*This requirement is met if the barrier is so fixed that it can only be removed by breaking or cutting.*

*Fixing by means of rivets is allowed, provided that these rivets need not be removed when replacing the brushes, capacitors, switches, non-detachable flexible cables and cords and the like.*

*Fixing by means of an adhesive is only allowed if the mechanical strength of the joint is equal to that of the barrier.*

*An adequate internal lining of insulation material, or an adequate internal insulating coating on metal enclosures, is considered to be an insulating barrier provided that the coating cannot easily be removed by scraping.*

*For class II tools, a sleeve on an insulated internal conductor, other than the core of an external flexible cable or cord, is considered to be an adequate insulating barrier, if it can only be removed by breaking or cutting, or if it is clamped at both ends.*

*Ordinary lacquering on the inside of metal enclosures, varnished cambric, flexible resin-bonded paper, or the like are not considered to be insulating barriers.*

**21.10** Inside the tool, the sheath (jacket) of a flexible cable or cord shall only be used as supplementary insulation where it is not subject to undue mechanical or thermal stresses.

**21.11** Any assembly gap with a width greater than 0,3 mm in supplementary insulation shall not be coincidental with any such gap in basic insulation, neither shall any such gap in reinforced insulation give direct access to live parts.

*Compliance is checked by inspection and measurement.*

**21.12** Class I tools shall be so constructed that, should any wire, screw, nut, washer, spring or similar part become loose or fall out of position, it cannot become so disposed that accessible metal is made live.

Class II tools or class II constructions shall be so constructed that, should any such part become loose or fall out of position, it cannot become so disposed that creepage distances or clearances over supplementary insulation or reinforced insulation are reduced to less than 50 % of the values specified in 28.1.

Class II tools or class II constructions, other than those of the all-insulated type, shall be provided with insulating barriers between accessible metal and motor parts and other live parts.

For class I tools, this requirement can be met by the provision of barriers, or by fixing the parts adequately, and by providing sufficiently large creepage distances and clearances.

It is not to be expected that two independent parts will become loose or fall out of position at the same time. For electrical connections, spring washers are not considered to be adequate for preventing the loosening of the parts.

Wires are considered as likely to become free from terminals or soldered connections, unless they are held in place near to the terminal or termination, independent of the terminal connection or solder.

Short rigid wires are not regarded as liable to come away from a terminal, if they remain in position when the terminal screw is loosened.

*Compliance is checked by inspection, by measurement and by manual test.*

**21.13** Supplementary insulation and reinforced insulation shall be so designed or protected that they are not likely to be impaired by deposition of dirt, or by dust resulting from wear of parts within the tool, to such an extent that creepage distances or clearance are reduced below the values specified in 28.1.

Ceramic material not tightly sintered and similar materials, and beads alone, shall not be used as supplementary insulation or reinforced insulation.

Parts of natural or synthetic rubber used as supplementary insulation shall be resistant to ageing, or be so arranged and dimensioned that creepage distances are not reduced below the values specified in 28.1, even if cracks occur.

Insulating material in which heating conductors are embedded serves as basic insulation, and shall not be used as reinforced insulation.

*Compliance is checked by inspection, by measurement and, for rubber, by the following test.*

*Parts of rubber are aged at a temperature of  $(100 \pm 2)$  °C for 70 h. After the test, the samples are examined, and shall show no crack visible to the naked eye.*

NOTE In case of doubt with regard to materials other than rubber, special tests may be made.

**21.14** Tools shall be so constructed that internal wiring, windings, commutators, slip rings and the like, and insulation in general, are not exposed to oil, grease or similar substances.

If the construction necessitates that insulation be exposed to oil or grease or similar substance, as in gears and the like, the oil or grease or substance shall have adequate insulating properties so that compliance with the standard is not impaired, and shall have no effect on insulation.

*Compliance is checked by inspection and by the tests of this standard.*

**21.15** It shall not be possible to gain access to brushes without the aid of a tool.

Screw-type brush-caps shall be so designed that, when tightening, two surfaces are clamped together.

Brush-holders, which retain the brushes in position by means of a locking device, shall be so designed that the locking does not depend upon the brush-spring tension, if the loosening of the locking device might make accessible metal parts live.

Screw-type brush-caps, which are accessible from the outside of the tool, shall be of insulating material, or be covered with insulating material of adequate mechanical and electrical strength; they shall not project beyond the surrounding surface of the tool.

*Compliance is checked by inspection and by manual test, the properties of the insulating material being verified:*

- *by the tests of 20.2 and 20.4 for screw-type brush-caps which are accessible from the outside of the tool;*
- *by the tests specified for supplementary insulation for class I tools and class III tools;*
- *by the tests specified for reinforced insulation for class II tools.*

**21.16** Tools with water supply shall be either of class III, or designed for use in conjunction with an isolating transformer having a rated output voltage not exceeding 115 V.

*Compliance is checked by inspection.*

**21.17** Switches and reset buttons on non-self-resetting controls shall be so located that accidental operation is unlikely to occur.

*Compliance is checked by inspection, and by the following test:*

*The tool is connected to the power supply, placed in any possible position and dragged across a horizontal surface.*

*Inadvertent operation of the switch shall not then occur.*

**21.18** Tools, other than those provided with a flexible shaft, shall be fitted with a mains switch which can be switched off by the user without releasing his grasp on the tool. When a switch has a locking arrangement to lock it in the ON position, the requirement in 21.18 is considered as being met provided the switch unlocks automatically when the trigger or actuating member is actuated.

*Compliance is checked by inspection and by manual test.*

**21.18.1** Where there is a risk associated with continued operation, the switch shall not have any locking device to lock it on the ON position and it shall not remain in the ON position when the trigger is released. This shall be stated in the relevant part 2.

**21.18.2** Where there is a risk associated with inadvertent starting, the switch shall have a locking device to lock it on the OFF position. This shall be stated in the relevant part 2.

**21.19** Tools shall be so designed that the protection against electric shock is not affected when screws intended for replacement from the outside during routine servicing are replaced by screws having a greater length.

*Compliance is checked by inserting longer screws, without appreciable force, after which creepage distances and clearances between live parts and accessible metal parts shall not have been reduced below the values specified in 28.1.*

**21.20** If the tool is marked with the first numeral of the IP system, the relevant requirements of IEC 60529 shall be fulfilled.

*Compliance is checked by making the relevant tests.*

**21.21** Tools shall be so designed that in normal use there is no risk of electric shock from charged capacitors when touching the pins of the plug.

*Compliance is checked by the following test, which is made 10 times.*

*The tool is operated at rated voltage.*

*The tool switch, if any, is then moved to the "off" position and the tool is disconnected from the supply by means of the plug.*

*One second after disconnection, the voltage between the pins of the plug is measured with an instrument which does not appreciably affect the value to be measured.*

*The voltage shall not exceed 34 V.*

*Capacitors, having a rated capacitance less than or equal to 0,1  $\mu$ F, are not considered to entail a risk of electric shock.*

**21.22** Non-detached parts, which provide the necessary degree of protection against electric shock, moisture, or contact with moving parts, shall be fixed in a reliable manner, and shall withstand the mechanical stress occurring in normal use.

Snap-in devices used for fixing such parts shall have an obvious locked position. The fixing properties of snap-in devices used in parts which are likely to be removed during servicing shall not deteriorate.

*Compliance is checked by the following tests.*

*Parts which are likely to be removed during servicing are disassembled and assembled 10 times before the test is carried out.*

*Servicing includes replacement of the supply cord.*

*The tool is at room temperature. However, in cases where compliance may be affected by temperature, the test is also carried out immediately after the tool has been operated under the conditions specified in clause 12.*

The test is applied to all parts which are likely to be detachable, whether or not they are fixed by screws, rivets, or similar parts.

A force is applied without jerks for 10 s in the most unfavourable direction to those areas of the cover or part which are likely to be weak. The force is as follows:

- push force 50 N;
- pull force
  - a) if the shape of the part is such that the fingertips cannot easily slip off 50 N;
  - b) if the projection of the part which is gripped is less than 10 mm in the direction of removal 30 N.

The push force is applied by means of a rigid test finger similar in dimensions to the standard test finger shown in Figure 1.

The pull force is applied by a suitable means such as a suction cup, so that the test results are not affected.

While the pull test of a) or b) is being applied, the test fingernail shown in Figure 7 is inserted in any aperture or joint with a force of 10 N. The fingernail is then slid sideways with a force of 10 N; it is not twisted or used as a lever.

If the shape of the part is such that an axial pull is unlikely, no pull force is applied, but the test fingernail shown in Figure 7 is inserted in any aperture or joint with a force of 10 N, and is then pulled for 10 s by means of the loop with a force of 30 N in the direction of removal.

If the cover or part is likely to be subjected to a twisting force, a torque as detailed below is applied at the same time as the pull or push force:

- for major dimensions up to and including 50 mm 2 Nm;
- for major dimensions over 50 mm 4 Nm.

This torque is also applied when the test fingernail is pulled by means of the loop.

If the projection of the part which is gripped is less than 10 mm, the above torque is reduced to 50 % of the value.

Parts shall not become detached, and they shall remain in the locked position.

**21.23** Handles, knobs, grips, levers and the like shall be fixed in a reliable manner so that they will not work loose in normal use, if loosening might result in a hazard.

Compliance is checked by inspection, by manual test, and by trying to remove the handle, knob, grip or lever applying, for 1 min, a 30 N axial force either pushing or pulling.

**21.24** Storage hooks and similar devices for flexible cords shall be smooth and well rounded.

Compliance is checked by inspection.

**21.25** Current-carrying parts and other parts, the corrosion of which might result in a hazard, shall be resistant to corrosion under normal conditions of use.

Compliance is checked by verifying that after the tests of clause 18, the relevant parts show no sign of corrosion. Stainless steel and similar corrosion-resistant alloys and plated steel are considered to be satisfactory for the purpose of this requirement.

NOTE Attention is to be paid to the compatibility of the materials of terminals and to the effect of heating.

**21.26** Direct contact between live parts and thermal insulation shall be effectively prevented, unless such material is non-corrosive, non-hygroscopic, and non-combustible.

*Compliance is checked by inspection, by the tests of clauses 16 and 17 and, if necessary, by chemical tests or flammability tests.*

*Glass-wool is an example of thermal insulation which is satisfactory for the purpose of this requirement. Non-impregnated slag-wool is an example of corrosive thermal insulation.*

**21.27** Tools other than class II, having parts where reliance is placed upon safety extra-low voltage to provide the necessary degree of protection against electric shock, shall be so designed that the insulation between parts operating at safety extra-low voltage and other live parts complies with the requirements for double insulation or reinforced insulation.

*Compliance is checked by the tests specified for double insulation or reinforced insulation.*

**21.28** Parts separated by protection impedance shall comply with the requirements for double insulation or reinforced insulation.

*Compliance is checked by the tests specified for double insulation or reinforced insulation.*

**21.29** Void

**21.30** Shafts of operating knobs, handles, levers and the like shall not be live unless the shaft is not accessible when the knob, handle, lever and the like is removed.

*Compliance is checked by inspection and by applying the test finger as specified in 9.2 after removal of the knob, handle, lever, or the like, even with the aid of a tool.*

**21.31** For constructions other than those of class III, handles, levers and knobs which are held or actuated in normal use shall not become live in the event of an insulation fault. If these handles, levers or knobs are of metal, and if their shafts or fixings are likely to become live in the event of a basic insulation fault, they shall either be adequately covered by insulating material, or their accessible parts shall be separated from their shafts or fixings by insulation.

The covering or insulating material shall comply with the electric strength test in clause 15, Table 2 item 4, but need not be insulation.

*Compliance is checked by inspection, and if necessary, by the tests specified for insulation.*

**21.32** For tools other than those of class III, handles which, in normal use, are continuously held in the hand shall be so constructed that when gripped as in normal use, the operator's hand is not likely to touch metal parts unless they are separated from live parts by double insulation or reinforced insulation.

*Compliance is checked by inspection.*

**21.33** For class II tools, capacitors shall not be connected to accessible metal parts, and their casings, if of metal, shall be separated from accessible metal parts by supplementary insulation.

This requirement does not apply to capacitors complying with the requirements for protective impedance specified in 9.1 and 21.36.

*Compliance is checked by inspection and by the tests specified for supplementary insulation.*

**21.34** Capacitors shall not be connected between the contacts of a thermal cut-out.

*Compliance is checked by inspection.*

**21.35** Lampholders shall be used only for the connection of lamps.

*Compliance is checked by inspection.*

**21.36** Protective impedance shall consist of at least two separate components, the impedance of which is unlikely to change significantly during the lifetime of the tool. If any one of the components is short-circuited or open-circuited, the values specified in 9.1 shall not be exceeded.

Resistors complying with 14.1 of IEC 60065 and capacitors complying with 14.2 of IEC 60065 are considered to comply with this requirement.

*Compliance is checked by inspection and by measurement.*

**21.37** Air-intake ventilation openings shall not be excessively large.

*Compliance is checked by inspection, and by trying to insert a steel ball, 6 mm in diameter, through the air-intake openings other than those adjacent the fan.*

*The ball shall not enter.*

*This requirement does not imply that live parts must not be visible through ventilation openings.*

## **22 Internal wiring**

**22.1** Wireways shall be smooth and free from sharp edges.

Wires shall be protected so that they do not come into contact with burrs, cooling fins, etc., which may cause damage to the insulation of conductors.

Holes in metal through which insulated wires pass shall be provided with bushings or, unless required otherwise in part 2, shall have smooth, well-rounded edges. A radius of 1,5 mm is considered to be well rounded.

Wiring shall be effectively prevented from coming into contact with moving parts.

*Compliance is checked by inspection.*

**22.2** Internal wiring and electrical connections between different parts of the tool shall be adequately protected or enclosed.

*Compliance is checked by inspection.*

**22.3** Bare internal wiring shall be so rigid and so fixed that, in normal use, creepage distances and clearances cannot be reduced below the values specified in 28.1.

Insulated internal wiring shall have an adequate insulation so that it cannot be damaged in normal use.

*Compliance is checked by inspection, by measurement, and by manual test.*

*For bare internal wiring, it is checked that either their insulation is electrically equivalent to the insulation of the cords complying with IEC 60227 or IEC 60245, or it complies with the following electric strength test.*

*A voltage of 2 000 V is applied for 15 min between the conductor and metal foil wrapped around the insulation. There shall be no breakdown.*

*If the insulation of the conductor does not fulfil one of the above conditions, the conductor is considered to be bare.*

When sleeving is used as supplementary insulation on internal wiring, it shall be retained in position by positive means.

*Compliance is checked by inspection and by manual test. A sleeve is considered to be fixed by positive means if it can only be removed by breaking or cutting, or if it is clamped at both ends.*

**22.4** Conductors identified by the colour combination green/yellow shall not be connected to terminals other than earthing terminals.

*Compliance is checked by inspection.*

**22.5** Aluminium wires shall not be used for internal wiring.

*Compliance is checked by inspection.*

NOTE Windings of a motor are not considered as internal wiring.

**22.6** Stranded conductors shall not be consolidated by lead-tin soldering where they are subjected to contact pressure, unless the clamping means is so designed that there is no risk of bad contact due to cold flow of the solder.

Consolidation of a stranded conductor by lead-tin soldering is allowed if spring terminals are used; securing the clamping screws alone is not considered adequate.

Soldering of the tip of a stranded conductor is allowed.

*Compliance is checked by inspection.*

## **23 Components**

**23.1** Components shall comply with the safety requirements specified in the relevant IEC standards, as far as they reasonably apply.

If components are marked with their operating characteristics, the conditions under which they are used in the tool shall be in accordance with these markings, unless a specific exception is made.

**23.1.1** *Capacitors in auxiliary windings of motors shall be marked with their rated voltage and their rated capacitance.*

**23.1.2** *Fixed capacitors for radio interference suppression shall comply with IEC 60384-14.*

**23.1.3** *Small lampholders similar to E10 lampholders shall comply with the requirements for E10 lampholders; they need not accept a lamp with E10 cap complying with the current edition of Standard Sheet 7004-22 of IEC 60061-1.*

**23.1.4** *Isolating transformers and safety isolating transformers shall comply with IEC 61558-1.*

**23.1.5** *Appliance couplers other than those used for IPX0 tools shall comply with IEC 60309. Those used for IPX0 shall comply with IEC 60320.*

*Where appliance couplers not standardized by IEC are used, the manufacturer shall inform the user in the instructions for use to connect the tool only by means of the appropriate connector specified by the manufacturer.*

**23.1.6** *Automatic controls not complying with IEC 60730-1 shall be tested according to this standard, and additionally, according to 11.3.5 to 11.3.8 and clause 17 of IEC 60730-1. Controls may be tested separately from the tool.*

*The tests according to IEC 60730-1 are carried out under the conditions occurring in the tool.*

*For the tests of clause 17 of IEC 60730-1, the number of cycles to be used are:*

- for thermostats, 10 000 cycles of operation;*
- for temperature limiters, 1 000 cycles of operation;*
- for self-resetting thermal cut-out, 300 cycles of operation;*
- for non-self-resetting thermal cut-out which is manually reset, 10 cycles of operation.*

*Automatic controls which comply with the requirements of IEC 60730-1, and which are used in accordance with their marking, are considered to meet the requirements of this standard (the term "marking" includes documentation and declaration as specified in clause 7 of IEC 60730-1).*

*The tests of clause 17 of IEC 60730-1 are not carried out on automatic controls which operate during clause 12, if the tool meets the requirements of this standard when they are short-circuited.*

*A specific exception with regard to the testing of thermostats and temperature limiters is made in note 2) of Table 1 of Clause 12.*

**23.1.7** *The testing of components which have to comply with other standards is, in general, carried out separately, according to the relevant standard as follows.*

*If the component is marked and used in accordance with its marking, it is tested in accordance with its marking, the number of samples being that required by the relevant standard.*

*In particular, components not mentioned in Table 1 of clause 12 are tested as a part of that tool.*

**23.1.8** *Where no IEC standard exists for the relevant component, or where the component is not marked, or is not used in accordance with its marking, the component is tested under the conditions occurring in the tool, the number of samples being, in general, that required by a similar specification.*

**23.1.9** *For capacitors connected in series with a motor winding, it is verified that, when the tool is operated at a voltage equal to 1,1 times rated voltage and under minimum load, the voltage across the capacitor does not exceed 1,1 times the rated voltage of the capacitor.*

**23.1.10** *Mains switches shall have adequate breaking capacity, and shall be switches for 50 000 cycles of operation.*

*Compliance is checked by inspection and by the following test.*

*Mains switches are tested together with the tool at rated voltage or at the upper limit of the rated voltage range of the tool.*

*The motor is then stalled, and the switch is operated 50 times, each "on" period being not more than 0,5 s, and each "off" period being not less than 10 s.*

*If, in normal use, an electronic control device switches off the current before opening the main contacts, the number of operations is reduced to five, with the electronic control device short-circuited.*

*After the test, the switch shall have no electrical or mechanical failure.*

*Mains switches marked with individual ratings are also tested in accordance with IEC 61058-1.*

**23.1.11** *Switches, which have not been separately tested and found to comply with IEC 61058-1 under the conditions occurring in the tool, shall comply with Annex I.*

*The test of 17.2.4.4 of IEC 61058-1 is carried out for 50 000 cycles of operation.*

Switches intended for operation under no load, and which can be operated only with the aid of a tool, are subjected to the tests of clause 17 of IEC 61058-1. This applies also to such switches operated by hand which are interlocked so that they cannot be operated under load, but switches without that interlock are subjected to the test of 17.2.7 for 100 cycles of operation.

*The tests of 17.2.4.4 of IEC 61058-1 are not carried out on a switch if the appliance meets the requirements of this standard when the switch is short-circuited.*

**23.2** Tools shall not be fitted with

- switches or automatic controls in flexible cords;
- devices which cause the protection device in the fixed wiring to operate in the event of a fault in the tool;
- thermal cut-outs which can be reset by a soldering operation.

*Compliance is checked by inspection.*

**23.3** Overload protection devices shall be of the non-self-resetting type.

*Compliance is checked by inspection.*

**23.4** Plugs and socket-outlets used as terminal devices for heating elements, and plugs and socket-outlets for extra-low voltage circuits, shall not be interchangeable with plugs and socket-outlets listed in IEC 60083, and with connectors and tool inlets complying with the standard sheets of IEC 60320.

*Compliance is checked by inspection.*

**23.5** Motors connected to the supply mains, and having basic insulation which is inadequate for the rated voltage of the tool, shall comply with the requirements of Annex B.

*Compliance is checked by the tests of Annex B.*

## 24 Supply connection and external flexible cords

**24.1** Tools shall be provided with one of the following means of connection to the supply:

- a supply cord fitted with a plug;
- an appliance inlet having at least the same degree of protection against moisture as required for the tool, and having a locking device preventing inadvertent disconnection;
- a supply cord not exceeding 0,5 m and fixed with an in-line connector (cable coupler) and its mating counterpart. The in-line connector shall have at least the same degree of protection against moisture as required for the tool.

*Compliance is checked by inspection and for locking devices with the pull test of 24.14.*

**24.2** Supply cords shall be assembled to the tool by one of the following methods:

- type X attachment;
- type Y attachment;
- type Z attachment, only for exchange-type tools, as allowed in part 2.

*Compliance is checked by inspection and, if necessary, by manual test.*

**24.3** Plugs shall not be fitted with more than one flexible cord.

*Compliance is checked by inspection.*

**24.4** Supply cords shall be not lighter than:

- ordinary tough rubber sheathed flexible cord (code designation 60245 IEC 53);
- ordinary polyvinyl chloride sheathed flexible cord (code designation 60227 IEC 53).

Polyvinyl chloride insulated flexible cords shall not be used for tools having external metal parts, the temperature rise of which exceeds 75 K during the test of clause 12.

*Compliance is checked by inspection and measurement.*

If provided with a plug, power supply cords of single-phase tools having a rated current not exceeding 16 A shall be provided with a plug complying with IEC 60083 or IEC 60309.

If plugs complying with IEC 60309 are fitted, the standard sheets to be applied are as follows:

- class I tools      Sheet 2 – I
- class II tools      Sheet 2
- class III tools      Sheet 2 – I

The body of the plug shall be of, or covered with, rubber, polyvinyl chloride or material, having no less mechanical strength.

Power supply cores of single-phase tools, having a rated current exceeding 16 A but not exceeding 63 A, and of multi-phase tools having a rated current not exceeding 63 A, shall be provided with a plug complying with IEC 60309, the standard sheets to be applied being as follows:

- class I tools      Sheet 2 – III according to current
- class II tools      Sheet 2\* (see note)
- class III tools      Sheet 2 – III

NOTE Pending the introduction in IEC 60309 of two-pole plugs, appliance inlets and connectors for cable couplers, plugs to standard sheet 2 are allowed in class II tools, but extension leads supplied for use with such tools must have three cores in case these leads are used for class I tools.

**24.5** Supply cords shall have a nominal cross-sectional area not less than those shown in Table 6.

**Table 6 – Minimum cross-sectional area of supply cord**

Rated current of the tool A	Nominal cross-sectional area mm <sup>2</sup>
Up to and including 6	0,75
Over 6 up to and including 10	1
Over 10 up to and including 16	1,5
Over 16 up to and including 25	2,5
Over 25 up to and including 32	4
Over 32 up to and including 40	6
Over 40 up to and including 63	10

*Compliance is checked by measurement.*

**24.6** For class I tools, the supply cord shall be provided with a green/yellow core; it shall be connected to the internal earthing terminal of the tool, and to the earthing contact of the plug.

*Compliance is checked by inspection.*

**24.7** Conductors of supply cords shall not be consolidated by lead-tin soldering where they are subject to contact pressure, unless the clamping means is so designed that there is no risk of a bad contact due to cold flow of the solder.

*Compliance is checked by inspection.*

*The requirement may be met by using spring terminals. Securing the clamping screws alone is not considered adequate.*

**24.8** For all types of attachment, moulding together the supply cord to the enclosure or part of it shall not affect the insulation of the cord.

*Compliance is checked by inspection.*

**24.9** Inlet openings shall be provided with a bushing, or shall be so constructed that the protective covering of the supply cord can be introduced without risk of damage.

*Compliance is checked by inspection and by manual test.*

**24.10** Inlet bushings shall:

- be so shaped as to prevent damage to the supply cord;
- be reliably fixed;
- not be removable without the aid of a tool.

*Compliance is checked by inspection and by manual test.*

**24.11** At inlet openings, the insulation between the conductor of a supply cord and the enclosure of the tool, if of metal, shall consist of the insulation of the conductor and, in addition, of at least two separate insulations.

A separate insulation shall consist of:

- the sheath of a supply cord at least equivalent to that of a cord complying with IEC 60227 or IEC 60245; or
- a lining or bushing of insulating material complying with the requirements for supplementary insulation.

*Compliance is checked by inspection.*

**24.12** Cord guards shall have adequate mechanical strength and shall retain these properties throughout extended normal use.

*Compliance is checked by the following test.*

*The part of the tool comprising the cable entry, fitted with the cord guard and the flexible cable or cord for which the tool is designed, is fixed in the oscillating member of an apparatus similar to that shown in Figure 9. The sample is so mounted that the axis of oscillation is tangential to the outer surface of the part in which the cord guard is secured, and, when the oscillating member is at the middle of its travel, the axis of the cable or cord where it leaves the cord guard is vertical.*

*A weight, having a mass equal to that of the tool, but not less than 2 kg or more than 6 kg, is attached to the cable or cord.*

*The oscillating member is moved backwards and forwards through an angle of 90° (45° on either side of the vertical), the number of flexings being 20 000 and the rate of flexing 60 per min. After 10 000 flexings, the sample is turned through 90° about the centre line of the cord guard.*

NOTE A flexing is one movement, either backwards or forwards.

*After the test, the cord guard shall not have worked loose, and neither the cord guard nor the flexible cable or cord shall show any damage which could impair compliance with this standard, except that not more than 10 % of the number of strands of each conductor may have been broken.*

*Immediately after this test, the cord anchorage and the terminal screws are loosened, without removing the conductors of the flexible cable or cord. However, if the cord guard is clamped under the cord anchorage, the cord anchorage is not loosened.*

*The tool is then lifted by the cord guard, without jerks, over a distance of approximately 500 mm in approximately 1 s, and replaced on a support.*

*The operation is made 10 times.*

*During this test, the cord guard shall not slip out of its location.*

**24.13** Flexible cables or cords of tools shall be protected against excessive bending at the inlet opening of the tool by means of a cord guard of insulating material. Such guards shall not be integral with a power supply cable or cord for type X attachment.

The guards shall be fixed in a reliable manner, and shall be of such a design that they project outside the tool for a distance beyond the inlet opening of at least five times the overall diameter of the cable or cord delivered with the tool.

*Compliance is checked by inspection, by measurement and by the following test.*

*A tool designed for a power supply cord is fitted with a cord guard, the flexible cable or cord being approximately 100 mm longer than the guard.*

*The tool is so held that the axis of the cord guard, where the cable or cord leaves it, projects upwards at an angle 45° to the horizontal when the cable or cord is free from stress.*

*A mass equal to 10 D<sup>2</sup> grams is then attached to the free end of the cable or cord delivered with the tool. D is the external diameter of the flexible cable supplied with the tool in mm.*

*If the cord guard is temperature sensitive, the test is made at a temperature of (23 ± 2) °C.*

*Immediately after the mass has been attached, the curvature of the cable or cord shall nowhere be less than 1,5 D.*

**24.14** Tools provided with a supply cord shall have cord anchorages so that the conductors are relieved from strain, including twisting, where they are connected within the tool, and that the insulation of the conductors is protected from abrasion.

It shall not be possible to push the cord into the tool to such an extent that the cord, or internal parts of the tool, could be damaged.

*Compliance is checked by inspection, by manual test, and by the following test.*

*The cord is subjected 25 times to a pull of the value shown in Table 7. The pulls are applied without jerks in the most unfavourable direction each time for 1 s.*

*Immediately afterwards, the cord, other than that of an automatic cord reel, is subjected for 1 min to a torque of the value shown in Table 7.*

**Table 7 – Pull and torque value**

Mass of tool kg	Pull N	Torque Nm
Up to and including 1	30	0,1
Over 1 up to and including 4	60	0,25
Over 4	100	0,35

*During the tests, the cord shall not be damaged.*

*After the tests, the cord shall not have been longitudinally displaced by more than 2 mm, and the conductors shall not have moved over a distance of more than 1 mm in the terminals, nor shall there be appreciable strain at the connection.*

*Creepage distances and clearances shall not be reduced below the value specified in 28.1.*

*For the measurement of the longitudinal displacement, a mark is made on the cord while it is subjected to the pull, at a distance of approximately 2 cm from the cord anchorage or other suitable point, before starting the tests.*

*After the tests, the displacement of the mark on the cord in relation to the cord anchorage or other point is measured while the cord is subjected to the pull.*

**24.15** Cord anchorages shall either be so arranged that they are only accessible with the aid of a tool, or be so designed that the cord can only be fitted with the aid of a tool.

*Compliance is checked by inspection.*

**24.16** For type X attachments, cord anchorages shall be so designed or located that:

- replacement of the cord is easily possible;
- it is clear how the relief from strain and the prevention of twisting are to be obtained;
- they are suitable for the different types of cord which may be connected, unless the tool is so designed that only one type of cord can be fitted;
- the cord cannot touch the clamping screws of the cord anchorage, if these screws are accessible, or at least not separate from accessible metal parts by supplementary insulation;
- the cord is not clamped by a metal screw which bears directly on the cord;
- at least one part of the cord anchorage is securely fixed to the tool, unless it is part of the specially prepared cord;
- screws, if any, which have to be operated when replacing the cord, do not serve to fix any other component, unless, when omitted or incorrectly mounted, they render the tool inoperative or clearly incomplete, or unless the parts intended to be fastened by them cannot be removed without the aid of a tool during the replacement of the cord;
- in the case of labyrinths, these labyrinths cannot be bypassed in such a way that the test of 24.14 is not withstood;
- glands shall not be used as cord anchorages for power supply cords;
- for class I tools, they are of insulating material or are provided with an insulating lining, if otherwise an insulation fault on the cord could make accessible metal parts live;
- for class II tools, they are of insulating material, or, if of metal, are insulated from accessible metal parts by insulation complying with the requirements for supplementary insulation.

If, for type X attachment, the cord anchorage comprises one or more clamping member(s) to which pressure is applied by means of one or more nuts engaging with studs, which are securely attached to the tool, the cord anchorage is considered to have one part securely fixed to the tool, even if the clamping member(s) can be removed from the studs.

If, however, the pressure on the clamping member(s) is applied by means of one or more screws engaging either with separate nuts, or with a thread in a part which is integral with the tool, the cord anchorage is not considered to have one part securely fixed to the tool, unless one of the clamping members itself is fixed to the tool, or the surface of the tool is of insulating material and so shaped that it is obvious that surface is one of the clamping member(s) (see Figure 6).

*Compliance is checked by inspection, and by the test of 24.14 under the following conditions.*

*The tests are first made with the lightest permissible type of cord of the smallest cross-sectional area specified in 25.2, and then with the next heavier type of cord of the largest cross-sectional area specified, unless the tool is so designed that only one type of cord can be fitted.*

*Tools, for which a specially prepared cord is used, are tested with the cord as delivered.*

*The conductors are introduced into the terminals, the terminal screws, if any, being tightened just sufficiently to prevent the conductors from easily changing their position. The cord anchorage is used in the normal way, the clamping screws, if any, being tightened with a torque equal to two-thirds of that specified in 27.1.*

*Screws of insulating material bearing directly on the cord are fastened with two-thirds of the torque specified in column I of Table 9; the length of the slot in the screw head being taken as the nominal diameter of the screw.*

**24.17** For type Y and Z attachments, cord anchorage shall be adequate.

*Compliance is checked by the test of 24.14, which is made with the cord as delivered.*

**24.18** For type X attachment, production methods such as tying the cord into a knot, or tying the ends with string, are not allowed.

*Compliance is checked by inspection.*

**24.19** For type Y and type Z attachments, the insulated conductors of the supply cord shall be insulated from accessible metal parts by insulation complying with the requirements for basic insulation for class I tools, and complying with the requirements for supplementary insulation for class II tools. This insulation shall consist of:

- a separate insulating lining fixed to the cord anchorage;
- a sleeve or grommet fixed to the cord; or
- for class I tools, the sheath of the sheathed cord.

*Compliance is checked by inspection.*

**24.20** The space for the supply cables or the supply cord provided inside, or as a part of the tool for type X attachment:

- shall be so designed as to permit checking, before fitting the cover, if any, that the conductors are correctly connected and positioned;
- shall be so designed that covers, if any, can be fitted without risk of damage to the supply conductors or their insulation;
- tools shall be so designed that the uninsulated end of the conductor, should it become free from a terminal, cannot come into contact with accessible metal parts, unless the cord is provided with terminations that are unlikely to slip free of the conductor.

*Compliance is checked by inspection and, for type X attachment, by an installation test with cables or flexible cords of the largest cross-sectional area specified in 25.2, except that portable tools with type X attachment are subjected to the following additional test.*

*For pillar terminals where the conductors are not separately clamped at a distance of 30 mm or less from the terminal, and for other terminals with screw clamping, the clamping screws or nuts are loosened in turn. Without removing the conductor from the conductor space, a force of 2 N is applied to the wire in any direction and adjacent to the terminal, screw or stud. The uninsulated end of the conductor shall not then come into contact with accessible metal parts or any other metal part connected thereto.*

*For pillar terminals, where the conductors are separately clamped at a distance of 30 mm or less from the terminal, the tool is considered to meet the requirement that the uninsulated end of the conductor must not come into contact with accessible metal parts.*

*The conductors may be separately clamped, for example by a cord anchorage.*

**24.21** Appliance inlets shall:

- be so located or enclosed that live parts are not accessible during insertion or removal of the connector;
- be so placed that the connector can be inserted without difficulty;

- be so placed that, after insertion of the connector, the tool is not supported by the connector when in any position of normal use on a flat surface.

*Compliance is checked by inspection and, with regard to the first requirement, by means of the standard test finger shown in Figure 1, for tool inlets other than those standardized in IEC 60320.*

*Tools provided with appliance inlets complying with IEC 60320 are considered to comply with the first requirement.*

## **25 Terminals for external conductors**

**25.1** Tools with type X attachments, except those with specially prepared cord, shall be provided with terminals in which connection is made by means of screws, nuts, or equally effective devices. Screwless-type clamping units according to 3.10 of IEC 60999-1 provided with an actuating element are regarded as equally effective devices.

Screws and nuts shall not serve to fix any other component, except that they may also clamp internal conductors, if these are so arranged that they are unlikely to be displaced when fitting the supply conductors.

*Compliance is checked by inspection.*

NOTE Requirements for screwless terminals are given in IEC 60998-2-2.

For tools with type X attachments, soldered connections may be used for the connection of external conductors, provided that the conductor is so positioned or fixed that reliance is not placed upon the soldering alone to maintain the conductor in position, unless barriers are provided so that creepage distances and clearances between live parts and other metal parts cannot be reduced to less than 50 % of the values specified in 28.1, should the conductor become free at the soldered joint.

For type Y and type Z attachments, soldered, welded, crimped and similar connections may be used for the connection of external conductors; moreover, for class II tools, the conductor shall be so positioned or fixed that reliance is not placed upon the soldering, crimping, or welding alone to maintain the conductor in position, unless barriers are provided so that creepage distances and clearances between live parts and other metal parts cannot be reduced to less than 50 % of the values specified in 28.1, should the conductor become free at the soldered or welded joint, or slip out of the crimped connection.

It is not to be expected that two independent fixings will become loose at the same time.

Conductors connected by soldering are not considered to be adequately fixed, unless they are held in place near to the termination, independently of the solder; but "hooking in" before soldering is, in general, considered to be a suitable means for maintaining the conductors of a power supply cord other than a tinsel cord in position, provided the hole through which the conductor is passed is not unduly large.

The terminals of a component (such as a switch) built into the tool – on the assumption that they comply with the requirements of this clause – may be used as terminals intended for external conductors.

Conductors connected to terminals or terminations by other means are not considered to be adequately fixed, unless an additional fixing is provided near the terminal or termination; this additional fixing, in the case of stranded conductors, clamps both the insulation and the conductor.

*Compliance is checked by inspection and by measurement.*

**25.2** Terminals for type X attachment, except those with specially prepared cords, shall allow the connection of conductors having nominal cross-sectional areas as shown in Table 8, unless the tool is so designed that only one type of cord can be fitted, in which case the terminals shall be suitable for the connection of that cord.

**Table 8 – Nominal cross-sectional area of conductors**

Rated current of tool A	Nominal cross-sectional area of flexible cables and cords mm <sup>2</sup>
Up to and including 6	0,75 and 1
Over 6 up to and including 10	1 and 1,5
Over 10 up to and including 16	1,5 and 2,5
Over 16 up to and including 25	2,5 and 4
Over 25 up to and including 32	4 and 6
Over 32 up to and including 40	6 and 10
Over 40 up to and including 63	10 and 16

*Compliance is checked by inspection, by measurement and by fitting cables or cords of the smallest and largest cross-sectional areas specified.*

Terminals for supply cord shall be suitable for their purpose.

*Compliance is checked by inspection and by applying a pull of 5 N to the connection.*

*After the test, the connections shall show no damage which could impair compliance with this standard.*

**25.3** For tools with type X attachments, terminals shall be so fixed that, when the clamping means is tightened or loosened, the terminal does not work loose, internal wiring is not subjected to stress, and creepage distances and clearances are not reduced below the values specified in 28.1.

*Compliance is checked by inspection, and by the test of 9.6 of IEC 60999-1, the torque applied being, however, equal to two-thirds of the torque specified in Table IV of that standard.*

*Terminals may be prevented from working loose by fixing with two screws, by fixing with one screw in a recess, so that there is no appreciable play, or by other suitable means.*

*The requirement for fixation of terminals does not preclude the provision of supply terminals on switches, or similar device in a recess if, after connection of the supply cable, and after re-positioning of the switch or similar device in its recess, it can be verified by inspection that these components and the supply cable are, after re-assembly of the tool, in the correct position.*

*Covering with sealing compound without other means of locking is not considered to be sufficient. Self-hardening resins may, however, be used to lock terminals which are not subject to torsion in normal use.*

**25.4** For tools with type X attachments, terminals shall be so designed that they clamp the conductor between metal surfaces with sufficient contact pressure, and without damage to the conductor.

*Compliance is checked by inspection of the terminals and of the conductors after the test of 25.3.*

**25.5** For tools with type X attachments, except those with specially prepared cords, terminals shall not require special preparation of the conductor in order to effect correct connection, and they shall be so designed or placed that the conductor cannot slip out when clamping screws or nuts are tightened.

*Compliance is checked by inspection of the terminals and of the conductors after the test of 25.3.*

*The term "special preparation of the conductor" covers soldering of the strands, use of cable lugs, formation of eyelets, etc.; but not the reshaping of the conductor before its introduction into the terminal, or the twisting of a stranded conductor to consolidate the end.*

*Conductors are considered to be damaged if they show deep or sharp indentations.*

**25.6** Terminals of the pillar type shall be so located that the end of a conductor introduced into the hole is visible, or can pass beyond the threaded hole for a distance at least equal to half the nominal diameter of the screw, or 2,5 mm, whichever is the greater.

*Compliance is checked by inspection and by measurement.*

**25.7** For type X attachments, the terminals shall be clearly recognizable and accessible after opening the tool. All terminals shall be located behind one cover, or one part of the enclosure.

*Compliance is checked by inspection.*

**25.8** Terminal devices shall not be accessible without the aid of a tool, even if their live parts are not accessible.

*Compliance is checked by inspection and by manual test.*

**25.9** Terminal devices of tools with type X attachment shall be so located or shielded that should a wire of a stranded conductor escape when the conductors are fitted, there is no risk of accidental connection between live parts and accessible metal parts and, in the case of class II tools, between live parts and metal parts separated from accessible metal parts by supplementary insulation only.

*Compliance is checked by the following test.*

*An 8 mm length of insulation is removed from the end of a flexible conductor having a nominal cross-sectional area as specified in 24.5.*

*One wire of the stranded conductor is left free, and the other wires are fully inserted into and clamped in the terminal.*

*The free wire is bent, without tearing the insulation back, in every possible direction, but without making sharp bends around barriers.*

*The free wire of a conductor connected to a live terminal shall not touch any metal part which is accessible, or is connected to an accessible metal part or, for class II tools, any metal part which is separated from accessible metal parts by supplementary insulation only. The free wire of a conductor connected to an earthing terminal shall not touch any live part.*

## 26 Provision for earthing

**26.1** Accessible metal parts of class I tools, which may become live in the event of an insulation fault, shall be permanently and reliably connected to an earthing terminal or termination within the tool, or to the earthing contact of the tool inlet.

The printed conductors of printed circuit boards shall not be used to provide continuity of the protective earthing circuit.

Earthing terminals and earthing contacts shall not be electrically connected to the neutral terminal.

Class II and class III tools shall have no provision for earthing.

If accessible metal parts are screened from live parts by metal parts which are connected to the earthing terminal or termination, or to the earthing contact, they are not, for the purpose of this requirement, regarded as likely to become live in the event of an insulation fault.

Accessible metal parts, which are separated from live parts by double insulation or by reinforced insulation, are not considered likely to become live in the event of an insulation fault.

Metal parts behind a decorative cover which does not withstand the test of clause 20 are considered to be accessible metal parts.

*Compliance is checked by inspection.*

**26.2** Terminals with screw clamping shall comply with the relevant requirements of clause 25. Screwless terminals shall comply with IEC 60998-2-2.

The clamping means of earthing terminals shall be adequately locked against accidental loosening, and it shall not be possible to loosen them without the aid of a tool.

In general, the designs commonly used for current-carrying terminals, other than some terminals of the pillar type, provide sufficient resiliency to comply with the latter requirement; for other designs, special provisions, such as the use of an adequately resilient part which is not likely to be removed inadvertently, may be necessary.

*Compliance is checked by inspection, by manual test and, for screwless terminals, by the tests specified in IEC 60998-2-2.*

**26.3** If detachable parts have an earth connection, this connection shall be made before the current-carrying connections are established when placing the part in position, and the current-carrying connections shall be separated before the earth connection is broken when removing the part.

For tools with supply cords, the arrangement of the terminals, or the length of the conductors between the cord anchorage and the terminals, shall be such that the current-carrying conductors become taut before the earthing conductor, if the cord slips out of the cord anchorage.

*Compliance is checked by inspection and by manual test.*

**26.4** All parts of the earthing terminal intended for the connection of external conductors shall be such that there is no risk of corrosion resulting from contact between these parts and the copper of the earthing conductor, or any other metal in contact with these parts.

Parts which may transmit current in the event of an insulation fault, other than parts of a metal frame or enclosure, shall be of coated or uncoated metal having adequate resistance to corrosion. If such parts are of steel, they shall be provided at the essential areas with an electroplated coating having a thickness of at least 5  $\mu\text{m}$ .

Parts of coated or uncoated metal, which are only intended to provide or to transmit contact pressure, shall be adequately protected against rusting.

Examples of parts which may transmit current in the event of an insulation fault, and parts which are only intended to provide or to transmit contact pressure are shown in Figure 8.

If the body of the earthing terminal is a part of a frame or enclosure of aluminium or aluminium alloy, precautions shall be taken to avoid the risk of corrosion resulting from contact between copper and aluminium or its alloys.

Parts of copper alloys containing at least 58 % copper for parts that are worked cold, and at least 50 % copper for other parts, and parts of stainless steel containing at least 13 % chrome, are considered to be sufficiently resistant to corrosion. Parts subjected to a treatment such as chromate conversion coating are in general not considered to be adequately protected against corrosion, but they may be used to provide or to transmit contact pressure.

The essential areas of steel parts are, in particular, those transmitting current. In evaluating such areas, the thickness of the coating in relation to the shape of the part has to be taken into account. In case of doubt, the thickness of the coating is measured as described in ISO 2178 or in ISO 1463.

*Compliance is checked by inspection, by measurement, by manual test, and by the test of 30.1.*

**26.5** The connection between the earthing terminal or earthing contact, and parts required to be connected thereto, shall be of low resistance.

*Compliance is checked by the following test.*

*A current derived from a source having a no-load voltage not exceeding 12 V (a.c. or d.c.) and equal to 1,5 times rated current of the tool, or 25 A, whichever is the greater, is passed between the earthing terminal or earthing contact, and each of the accessible metal parts in turn.*

*The voltage drop between the earthing terminal of the tool or the earthing contact of the tool inlet, and the accessible metal part is measured, and the resistance calculated from the current and this voltage drop.*

*In no case shall the resistance exceed 0,1  $\Omega$ .*

*In case of doubt, the test is carried out until steady conditions have been established.*

*The resistance of the flexible cord is not included in the resistance measurement.*

*Care is taken that the contact resistance between the tip of the measuring probe and the metal part under test does not influence the test results.*

## 27 Screws and connections

**27.1** Fixings, and electrical connections, the failure of which may impair compliance with this standard, shall withstand the mechanical stresses occurring in normal use.

Screws used for this purpose shall not be of metal which is soft or liable to creep, such as zinc or aluminium.

Such screws, when of insulating material, shall have a nominal diameter of at least 3 mm; they shall not be used for any electrical connection.

Screws transmitting electrical contact pressure shall screw into metal.

Screws shall not be of insulating material if their replacement by a metal screw could impair supplementary insulation or reinforced insulation.

Screws which may be removed when replacing a supply cord having a type X attachment, or when undertaking user maintenance, shall not be of insulating material if their replacement by a metal screw could impair basic insulation.

NOTE Electrical connections include earthing connections.

*Compliance is checked by inspection and by the following test.*

*The screws or nuts are tightened and loosened:*

- 10 times for screws in engagement with a thread of insulating material;
- five times for nuts and other screws.

*Screws in engagement with a thread of insulating material are completely removed and reinserted each time.*

*When testing terminal screws and nuts, a flexible conductor of the largest cross-sectional area specified in 25.2 is placed in the terminal.*

*The test is made by means of a suitable test screwdriver, spanner, or key applying a torque as shown in Table 9, the appropriate column being:*

- for metal screws without heads, if the screw when tightened does not protrude from the hole ..... I
- for other metal screws and for nuts..... II
- for screws of insulating material:
  - having a hexagonal head with the dimension across flats exceeding the overall thread diameter; or
  - with a cylindrical head and a socket for a key, the socket having a cross-corner dimension exceeding the overall thread diameter; or
  - with a head having a slot or cross slots, the length of which exceeds 1,5 times the overall thread diameter..... II
- for other screws of insulating material ..... III

**Table 9 – Torque for testing screws and nuts**

Nominal diameter of screw mm	Torque Nm		
	I	II	III
Up to and including 2,8	0,2	0,4	0,4
Over 2,8 up to and including 3,0	0,25	0,5	0,5
Over 3,0 up to and including 3,2	0,3	0,6	0,5
Over 3,2 up to and including 3,6	0,4	0,8	0,6
Over 3,6 up to and including 4,1	0,7	1,2	0,6
Over 4,1 up to and including 4,7	0,8	1,8	0,9
Over 4,7 up to and including 5,3	0,8	2,0	1,0
Over 5,3	–	2,5	1,25

*The conductor is moved each time the screw or nut is loosened.*

*During the test, no damage impairing the further use of the fixing or electrical connections shall occur.*

*The shape of the blade of the test screwdriver is to fit the head of the screw to be tested. The screws and nuts are not to be tightened in jerks.*

**27.2** Electrical connections shall be so designed that contact pressure is not transmitted through insulating material which is liable to shrink or to distort, unless there is sufficient resiliency in the metallic parts to compensate for any possible shrinkage or distortion of the insulating material. Ceramic material is not liable to shrink or to distort.

*Compliance is checked by inspection.*

**27.3** Space-threaded (sheet metal) screws shall not be used for the connection of current-carrying parts, unless they clamp these parts directly in contact with each other, and are provided with a suitable means of locking.

Thread-cutting (self-tapping) screws shall not be used for the electrical connection of current-carrying parts, unless they generate a full-form standard machine screw thread. Such screws shall not, however, be used if they are likely to be operated by the user or installer, unless the thread is formed by a swageing action.

Thread-cutting and space-threaded screws may be used to provide earthing continuity, provided that it is not necessary to disturb the connection in normal use, and that at least two screws are used for each connection.

*Compliance is checked by inspection.*

**27.4** Screws, which make a mechanical connection between different parts of the tool, shall be secured against loosening, if they also make electrical connections.

This requirement does not apply to screws in the earthing circuit if at least two screws are used for the connection, or if an alternative earthing circuit is provided.

Rivets used for electrical connections shall be secured against loosening if these connections are subject to torsion in normal use.

This requirement does not imply that more than one rivet is necessary for providing earthing continuity.

*Compliance is checked by inspection and by manual test.*

*Spring washers and the like may provide satisfactory security.*

*For rivets, a non-circular shank or an appropriate notch may be sufficient.*

*Sealing compound which softens on heating provides satisfactory security only for screw connections not subject to torsion in normal use.*

## **28 Creepage distances, clearances and distances through insulation**

**28.1** Creepage distances and clearances shall not be less than the values in millimetres shown in Table 10.

If a resonance voltage occurs between the point where a winding and a capacitor are connected together, and metal parts are separated from live parts by basic insulation only, the creepage distance and clearance shall not be less than the values specified for the value of the voltage imposed by the resonance, these values being increased by 4 mm in the case of reinforced insulation.

*Compliance is checked by measurement.*

*For tools provided with an appliance inlet, the measurements are made with an appropriate connector inserted; for tools with type X attachment, they are made with supply conductors of the largest cross-sectional area specified in 25.2, and also without conductors; for other tools, they are made on the tool as delivered.*

*For tools provided with belts, the measurements are made with the belts in place, and the devices intended for varying the belt tension adjusted to the most unfavourable position within their range of adjustment, and also with the belts removed.*

*Movable parts are placed in the most unfavourable position; nuts and screws with non-circular heads are assumed to be tightened in the most unfavourable position.*

*The clearances between terminals and accessible metal parts are also measured with the screws or nuts unscrewed as far as possible, but the clearances shall then be not less than 50 % of the value shown in Table 10.*

*Distances through slots or openings in external parts of insulating material are measured to metal foil in contact with the accessible surface; the foil is pushed into corners and the like by means of the standard test finger of Figure 1, but it is not pressed into openings.*

*If necessary, a force is applied to any point on bare conductors, other than those of heating elements, to any point on uninsulated metal capillary tubes of thermostats and similar devices, and to the outside of metal enclosures, in an endeavour to reduce the creepage distances and clearances while taking the measurements.*

**Table 10 – Minimum creepage distances and clearances (in millimetres)**

Distances  mm	Class III tools		Other tools					
			Working voltage ≤130 V		Working voltage >130 V and ≤250 V		Working voltage >250 V and ≤440 V	
	Creepage distance	Clear- ance	Creepage distance	Clear- ance	Creepage distance	Clear- ance	Creepage distance	Clear- ance
Between live parts of different polarity <sup>1)</sup> : – if protected against deposition of dirt <sup>2)</sup> – if not protected against deposition of dirt – if lacquered or enamelled windings – for positive temperature coefficient (PTC) resistors including their connecting wires, if protected against deposition of moisture or dirt <sup>2)</sup>	1,0	1,0	1,0	1,0	2,0	2,0	2,0	2,0
	2,0	1,5	2,0	1,5	3,0	2,5	4,0	3,0
	1,0	1,0	1,5	1,5	2,0	2,0	3,0	3,0
	–	–	1,0	1,0	1,0	1,0	–	–
Between live parts and other metal parts over basic insulation: – if protected against deposition of dirt <sup>2)</sup> • if of ceramic material, pure mica and the like • if of other material – if not protected against deposition of dirt – if the live parts are lacquered or enamelled windings – at the end of tubular sheathed-type heating elements	1,0	1,0	1,0	1,0	2,5 <sup>3)</sup>	2,5 <sup>3)</sup>	–	–
	1,5	1,0	1,5	1,0	3,0	2,5 <sup>3)</sup>	–	–
	2,0	1,5	2,0	1,5	4,0	3,0	–	–
	1,0	1,0	1,5	1,5	2,0	2,0	–	–
	–	–	1,0	1,0	1,0 <sup>5)</sup>	1,0 <sup>4)</sup>	–	–
Between live parts and other metal parts over reinforced insulation: – if the live parts are lacquered or enamelled windings – for other live parts	–	–	6,0	6,0	6,0	6,0	–	–
	–	–	8,0	8,0	8,0	8,0	–	–
Between metal parts separated by supplementary insulation	–	–	4,0	4,0	4,0	4,0	–	–

For the notes, see the end of table

**Table 10** (continued)

<p>1) The clearances specified do not apply to the air gap between the contacts of thermal controls, overload protection devices, switches of micro-gap construction, and the like, or to the air gap between the current-carrying members of such devices where the clearance varies with the movement of the contacts.</p> <p>2) In general, the interior of a tool having a reasonably dust-proof enclosure is considered to be protected against deposition of dirt; provided the tool does not generate dust within itself, hermetic sealing is not required.</p> <p>3) If the parts are rigid and located by mouldings, or if the design is such that there is no likelihood of a distance being reduced by distortion or movement of the parts, this value may be reduced to 2,0 mm.</p> <p>4) If protected against deposition of dirt.</p> <p>5) If over ceramic, pure mica and the like, protected against deposition of dirt.</p>
NOTE The values specified in the table do not apply to cross-over points of motor windings.

*The force is applied by means of the test finger of Figure 1, and has a value of:*

- 2 N for bare conductors and for uninsulated capillary tubes of thermostats and similar devices;
- 30 N for enclosures.

*The way in which creepage distances and clearances are measured is indicated in Annex A.*

*If a barrier is interposed, and if it is in two parts which are not cemented together, the creepage distance is also measured through the joint.*

*If a barrier is interposed, clearances are measured over the barrier or, if the barrier is in two parts with mating surfaces which are not cemented together, through the joint.*

*For tools having parts with double insulation where there is no metal between basic insulation and supplementary insulation, the measurements are made as though a metal foil were present between the two insulations.*

*When assessing creepage distances and clearances, the effect of insulating lining of metal enclosures or covers is taken into consideration.*

*Means provided for fixing the tool to a support are considered to be accessible.*

*For conductive patterns on printed circuit boards, except at their edges, the values in the table between parts of different potential may be reduced, as long as the peak value of the voltage stress does not exceed:*

- 150 V per mm with a minimum distance of 0,2 mm, if protected against the deposition of dirt;
- 100 V per mm with a minimum distance of 0,5 mm, if not protected against the deposition of dirt.

*For peak voltages exceeding 50 V, the reduced creepage distances only apply if the Proof Tracking Index (PTI) of the printed circuit board, measured as in Annex G, is greater than 175.*

*These distances may be reduced further, provided that the tool complies with the requirements of clause 18 when the distances are short-circuited in turn.*

NOTE When the limits mentioned above lead to higher values than those of the table, the values of the table apply.

*Creepage distances and clearances within optocouplers are not measured if the individual insulations are adequately sealed, and if air is excluded between individual layers of the material.*

*For live parts of different polarity separated by basic insulation only, creepage distances and clearances smaller than those specified in the table are allowed, provided the requirements of clause 18 are met if these creepage distances and clearances are short-circuited in turn.*

**28.2** The distance through insulation, for working voltages up to and including 250 V, between metal parts shall not be less than 1,0 mm if they are separated by supplementary insulation, and not be less than 2,0 mm if they are separated by reinforced insulation.

This requirement does not apply if the insulation is applied in thin sheet form, other than mica or similar scaly material, and consists:

- for supplementary insulation, of at least two layers, provided that any one of the layers withstands the electric strength test prescribed for supplementary insulation;
- for reinforced insulation, of at least three layers, provided that, when any two of the layers are placed in contact, they withstand the electric strength test prescribed for reinforced insulation.

The test voltage is applied between the outer surfaces of the layer, or of the two layers, as applicable.

Moreover, this requirement does not apply if the supplementary insulation or the reinforced insulation is inaccessible, and meets one of the following conditions:

- the maximum temperature rise determined during the tests of clause 12 does not exceed the permissible value specified in 12.5;
- the insulation, after having been conditioned for seven days (168 h) in a oven maintained at a temperature equal to 50 K greater than the maximum temperature rise determined during the tests of clause 12, withstands an electric strength test as specified in clause 15, this test being made on the insulation both at the temperature occurring in the oven, and at approximately room temperature.

This requirement does not imply that the prescribed distance must be through solid insulation only; it may consist of thickness of solid insulation plus one or more air layers.

For tools having parts with double insulation, where there is no metal between basic insulation and supplementary insulation, the measurements are made as though a metal foil were present between the two insulations.

*Compliance is checked by inspection and by measurement.*

*For optocouplers, the conditioning procedure is carried out at a temperature of 50 K in excess of the maximum temperature rise measured on the optocoupler during the tests of clause 12 and 18, the optocoupler being operated under the most onerous conditions which occur during these tests.*

## 29 Resistance to heat, fire and tracking

NOTE Annex J shows the selection and sequence of the tests of this clause.

**29.1** External parts of non-metallic material, parts of insulating material supporting live parts, including connections and parts of thermoplastic material providing supplementary insulation or reinforced insulation, the deterioration of which might cause the tool to fail to comply with this standard, shall be sufficiently resistant to heat.

*Compliance is checked by subjecting of the relevant parts to a ball-pressure test, which is made by means of the apparatus shown in Figure 8.*

*Before starting the test, the part is maintained for 24 h in an atmosphere having a temperature between 15 °C and 35 °C, and a relative humidity between 45 % and 75 %.*

*The part is supported so that its upper surface is horizontal and the spherical part of the apparatus is pressed against this surface with a force of 20 N. The thickness of the part under test shall be at least 2,5 mm.*

The required thickness may be obtained by using two or more sections of the part.

*The test is made in a heating cabinet at a temperature of  $(40 \pm 2)$  °C plus the maximum temperature rise determined during the test of clause 12, but it shall be at least:*

- for external parts  $(75 \pm 2)$  °C;*
- for parts retaining live parts in position  $(125 \pm 2)$  °C.*

*However, for parts of thermoplastic material providing supplementary insulation or reinforced insulation, the test is made at a temperature of  $(25 \pm 2)$  °C plus the maximum temperature rise determined during the tests of clause 12, if this is higher.*

*Before the test is started, the test apparatus is brought to the temperature determined above.*

*After 1 h, the apparatus is removed and the part is immediately immersed in cold water so that it is cooled to room temperature within 10 s. The diameter of the impression shall not exceed 2 mm.*

*For coil formers, only those parts which support or retain in position terminals or terminations are subjected to the test.*

*Unless otherwise specified, parts operating at safety extra-low voltage not exceeding 24 V are not considered to be live parts.*

The test is not made on parts of ceramic material.

**29.2** Parts of non-metallic material shall be adequately resistant to ignition and to spread of fire.

This requirement does not apply to decorative trims, knobs, and other parts not likely to be ignited or to propagate flames originating from inside the tool.

*Compliance is checked by the following test.*

*Separately moulded specimens of the relevant parts are subjected to the burning test referred to in Annex D.*

However, instead of the burning test, the glow-wire test of Annex E is made at a temperature of 550 °C on corresponding parts of the appliance if

- separately moulded samples are not available;
- there is no evidence that the material withstands the burning test;
- the separately moulded samples do not withstand the burning test.

**29.3** Insulating material, across which a tracking path may occur, shall have adequate resistance to tracking, taking into account the severity of its duty conditions.

*A tracking current may occur*

- between live parts of different polarity;
- between live parts and earthed metal parts;
- across insulating material of commutators and brush-caps.

*For parts of insulating material used under severe or extra-severe duty conditions, compliance is checked by the proof tracking test referred to in Annex G.*

*For parts of insulating material used under normal duty conditions, and parts of ceramic material, no tracking test is made.*

*For parts of insulating material used under severe duty conditions, the test voltage is 175 V. If the specimens do not withstand this test and there is no hazard other than fire, surrounding parts are subjected to the needle-flame test referred to in Annex F.*

*For parts of insulating material used under extra-severe duty conditions, the test voltage is 250 V. If the specimens do not withstand this test, but withstand the test made with a test voltage of 175 V, and there is no hazard other than fire, surrounding parts are subjected to the needle-flame test referred to in Annex F.*

*The needle-flame test is made on all parts of non-metallic material positioned within a distance of 50 mm from any place where a tracking path may occur, unless these parts are shielded by a separate barrier or enclosure from that tracking path, in which case the barrier or enclosure is subjected to the needle-flame test.*

## **30 Resistance to rusting**

**30.1** Ferrous parts, the rusting of which might cause the tool to fail to comply with this standard, shall be adequately protected against rusting.

*Compliance is checked by the following test.*

*All grease is removed from the parts to be tested by immersing them in a suitable degreasing agent for 10 min.*

*The parts are then immersed for 10 min in a 10 % solution of ammonium chloride in water at a temperature of  $(20 \pm 5)$  °C.*

*Without drying, but after shaking off any drops, the parts are placed for 10 min in a box containing air saturated with moisture at a temperature of  $(20 \pm 5)$  °C.*

*After the parts have been dried for 10 min in a heating cabinet at a temperature of  $(100 \pm 5)$  °C, their surfaces shall show no signs of rust.*

*When using the liquids specified for the test, adequate precautions must be taken to prevent the inhalation of their vapours.*

*Traces of rust on sharp edges and any yellowish film removable by rubbing are ignored.*

*For small helical springs and the like, and for parts exposed to abrasion, a layer of grease may provide sufficient protection against rusting. Such parts are only subjected to the test if there is doubt about the effectiveness of the grease film, and the test is then made without previous removal of the grease.*

### **31 Radiation, toxicity and similar hazards**

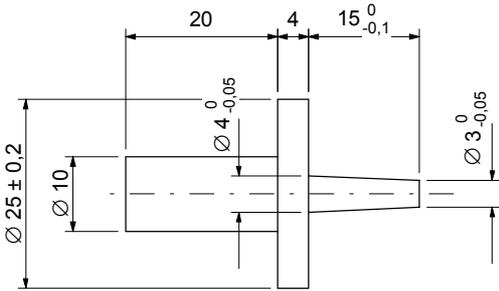
**31.1** Tools shall not emit harmful radiation, or present a toxic or similar hazard.

*Compliance is checked by test.*

NOTE Test specifications are given in part 2, where necessary.

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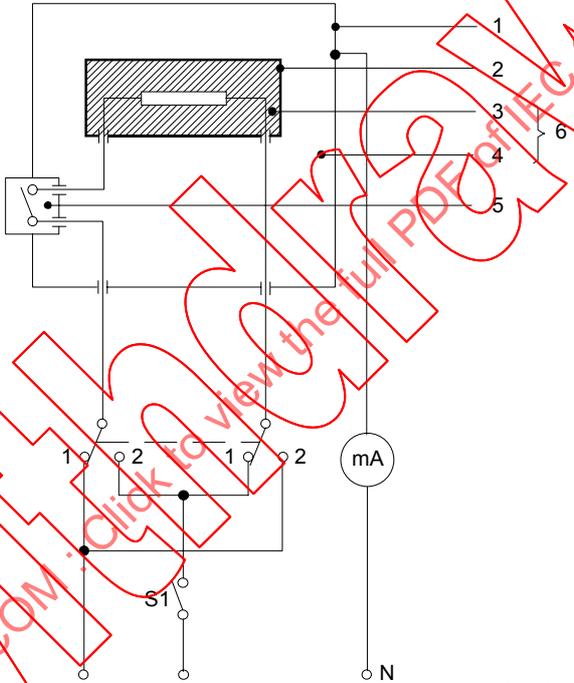




IEC 2337/01

Dimensions in millimetres

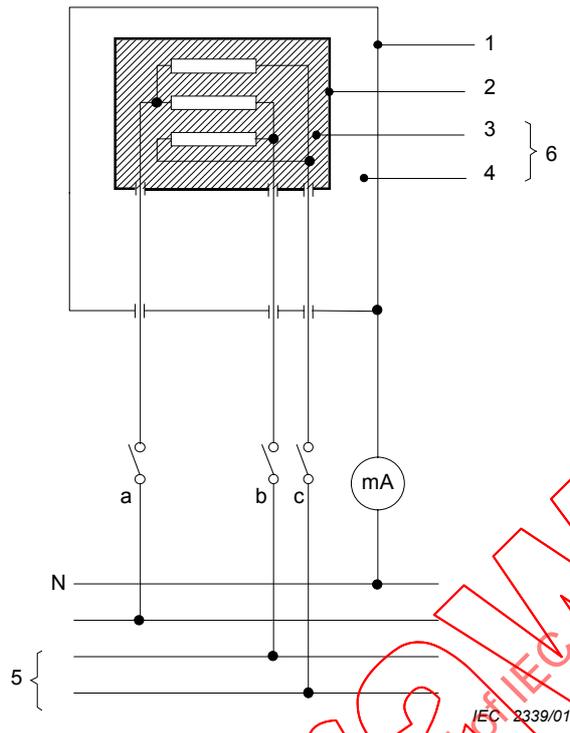
Figure 2 – Test pin



IEC 2338/01

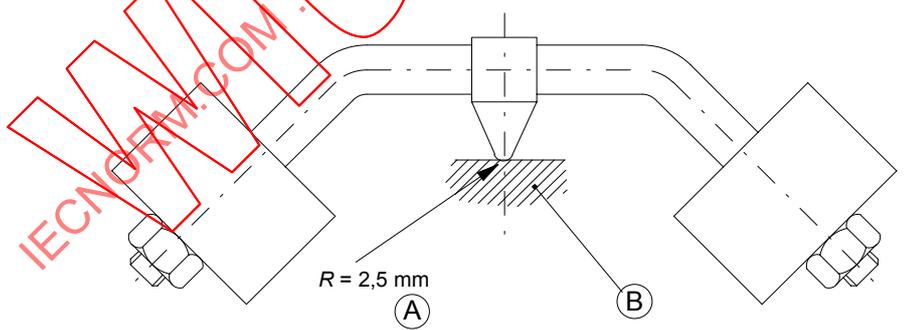
- 1 Accessible part
- 2 Inaccessible metal part
- 3 Basic insulation
- 4 Supplementary insulation
- 5 Reinforced insulation
- 6 Double insulation

Figure 3 – Diagram for leakage current measurement at operating temperature for single-phase connection and three-phase tools suitable for single-phase supply of class II tools



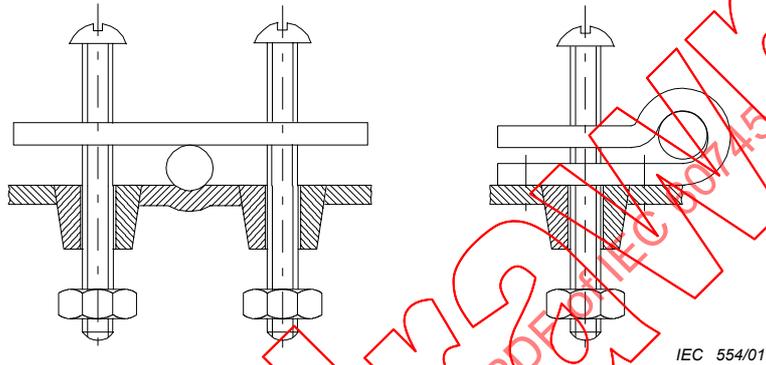
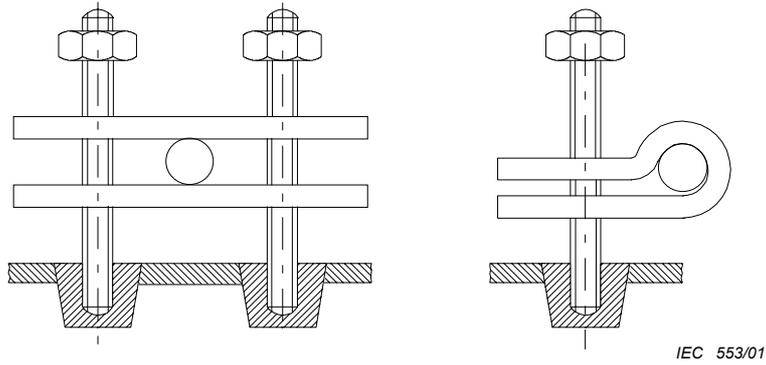
- 1 Accessible part
- 2 Inaccessible metal part
- 3 Basic insulation
- 4 Supplementary insulation
- 5 Three-phase supply
- 6 Double insulation

**Figure 4 – Diagram for leakage current measurement at operating temperature for three-phase connection**



- A = Spherical
- B = Sample

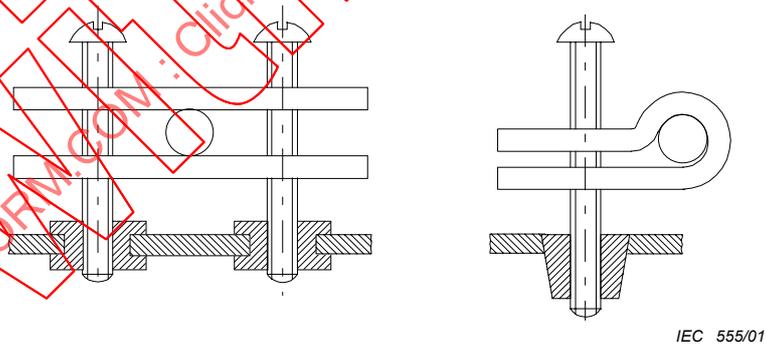
**Figure 5 – Ball-pressure test apparatus**



Part of appliance of insulating material and so-shaped that it obviously forms part of a cord clamp.

One of the clamping measures is fixed to the appliance

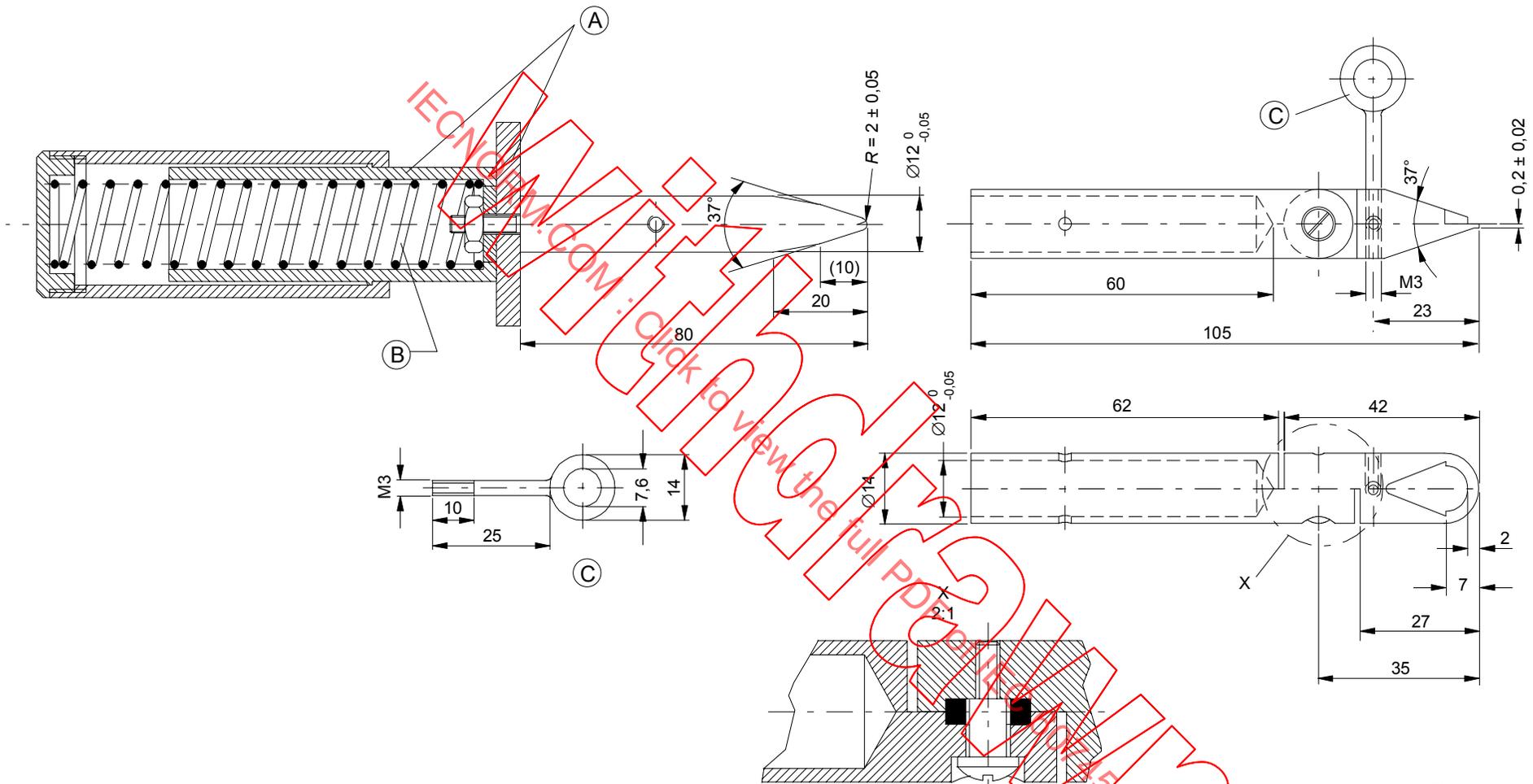
**Acceptable constructions**



Screws passing through threaded holes in the appliance (or screws passing through clearance holes in the appliance and secured by nuts) are equally unacceptable

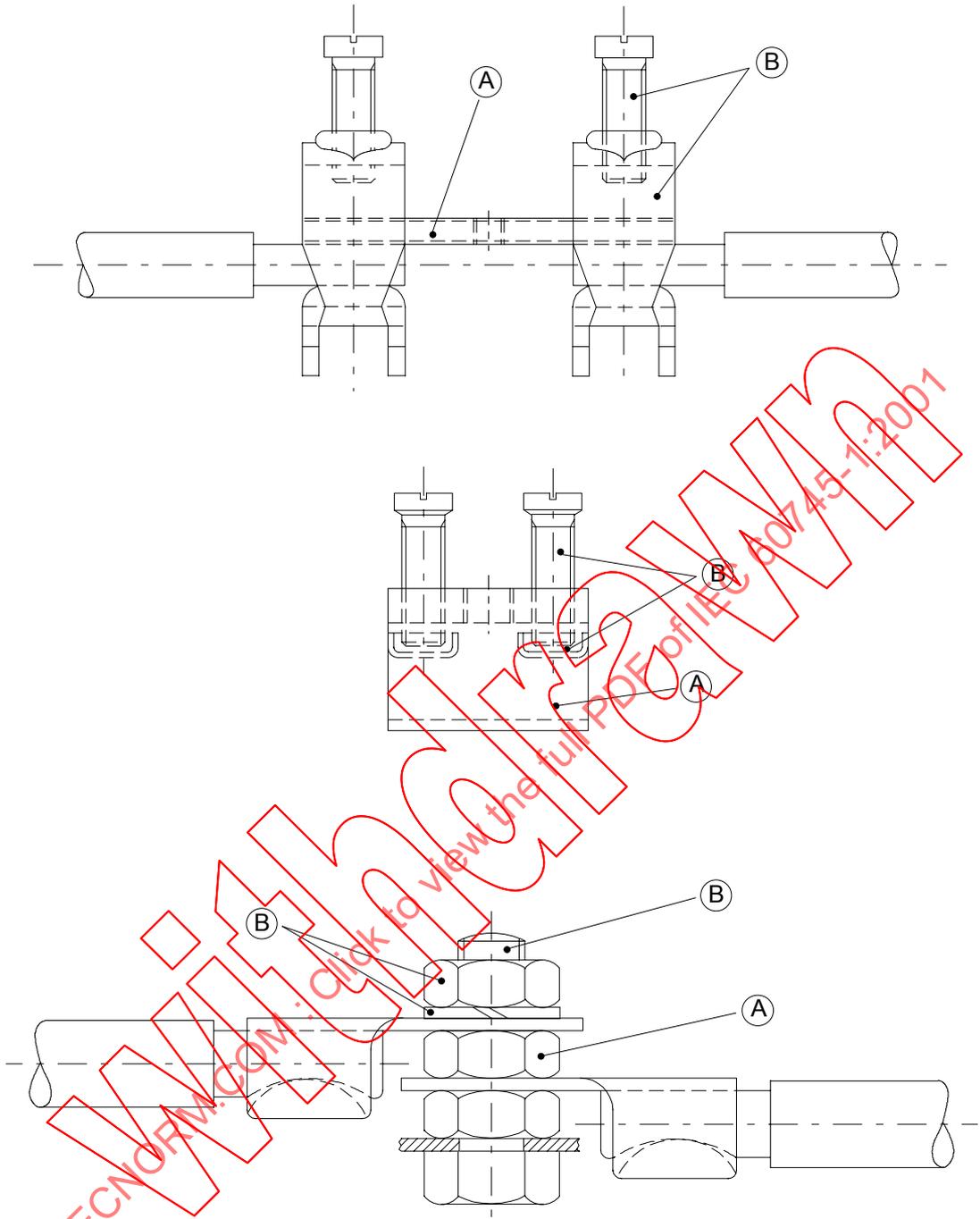
**Unacceptable constructions**

**Figure 6 – Schematic representation of cord anchorages**



- A = Insulating material
- B = Spring diameter
- C = Loop

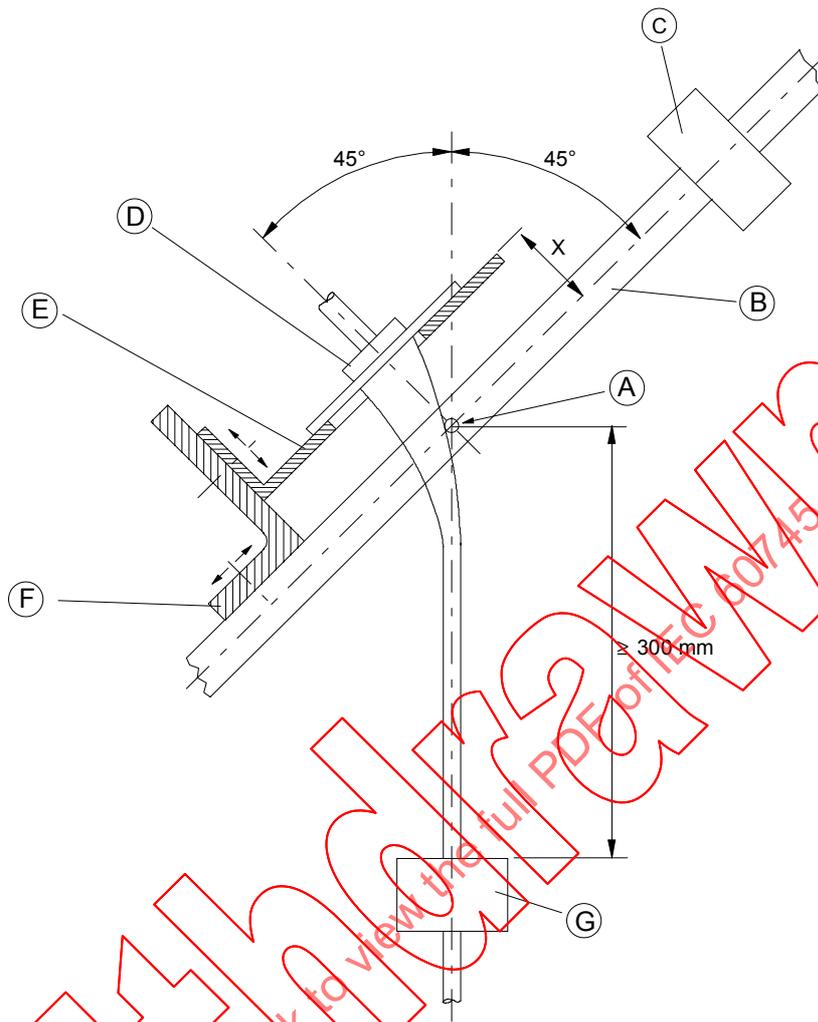
Figure 7 – Test fingernail



IEC 2341/01

- A = Part providing earthing continuity
- B = Part providing or transmitting contact pressure

Figure 8 – Examples of parts of earthing terminals



- A = Axis of oscillation
- B = Oscillating frame
- C = Counterweight
- D = Sample
- E = Adjustable carrier plate
- F = Adjustable bracket
- G = Load

IEC 552/01

Figure 9 – Flexing test apparatus

## Annex A (normative)

### Measurement of creepage distances and clearances

#### A.1 Measurement of creepage distances and clearances

The methods of measuring creepage distances and clearances, which are specified in 28.1, are indicated in cases 1 to 10 (see Figure A.1).

These cases do not differentiate between gaps and grooves, or between types of insulation.

*The following assumptions are made:*

- *a groove may have parallel, converging, or diverging sides;*
- *any groove having diverging sides, a minimum width exceeding 0,25 mm, a depth exceeding 1,5 mm, and a width at the bottom equal to or greater than 1 mm, is regarded as an air gap across which no creepage path exists (case 8);*
- *any corner including an angle less than 80° is assumed to be bridged with an insulating link of 1 mm width (0,25 mm for dirt-free situations), moved into the most unfavourable position (case 3);*
- *where the distance over the top of a groove is 1 mm (0,25 mm for dirt-free situations) or more, no creepage distance exists across the air gap (case 2);*
- *creepage distances and clearances measured between parts moving relative to each other are measured when these parts are placed in their most unfavourable stationary positions;*
- *any air gap less than 1 mm wide (0,25 mm for dirt-free situations) is ignored in computing the total clearance.*