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Titre

**CEI 60335-1 Ed 5.0: Appareils
électrodomestiques et analogues –
Sécurité – Partie 1: Exigences générales**

Title

**IEC 60335-1 Ed 5.0: Household and
similar electrical appliances - Safety -
Part 1: General requirements**

<p>ATTENTION VOTE PARALLÈLE CEI – CENELEC</p> <p>L'attention des Comités nationaux de la CEI, membres du CENELEC, est attirée sur le fait que ce projet finale de Norme internationale est soumis au vote parallèle. Les membres du CENELEC sont invités à voter via le système de vote en ligne du CENELEC.</p>	<p>ATTENTION IEC – CENELEC PARALLEL VOTING</p> <p>The attention of IEC National Committees, members of CENELEC, is drawn to the fact that this final draft International Standard (DIS) is submitted for parallel voting. The CENELEC members are invited to vote through the CENELEC online voting system.</p>
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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**HOUSEHOLD AND SIMILAR ELECTRICAL APPLIANCES –
SAFETY –****Part 1: General requirements**

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of 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, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). 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. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 60335-1 has been prepared by IEC technical committee 61: Safety of household and similar electrical appliances.

This fifth edition cancels and replaces the fourth edition published in 2001 including its Amendment 1 (2004) and amendment 2 (2006). It constitutes a technical revision.

The principal changes in this edition as compared with the fourth edition of IEC 60335-1 are as follows (minor changes are not listed):

- updated the text of the standard to align with the most recent editions of the dated normative references;
- modified the functional safety requirements using programmable electronic circuits including software validation requirements;
- updated Clause 29 to cover insulation requirements subjected to high frequency voltages as in switch mode power supply circuits;

- updated Subclause 30.2 to further align the pre-selection option with the end-product test option;
- deleted some notes and converted many other notes to normative text;
- clarified requirements for class III appliances and class III constructions.

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

FDIS	Report on voting
61/XX/FDIS	61/XX/RVD

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

This part is to be used in conjunction with the appropriate part 2 of IEC 60335. The parts 2 contain clauses to supplement or modify the corresponding clauses in this part to provide the relevant requirements for each type of appliance.

NOTE 1 The following annexes contain provisions suitably modified from other IEC standards:

- | | | |
|-----------|-------------------------------|-------------------------------|
| – Annex E | Needle-flame test | IEC 60695-11-5 |
| – Annex F | Capacitors | IEC 60384-14 |
| – Annex G | Safety isolating transformers | IEC 61558-1 and IEC 61558-2-6 |
| – Annex H | Switches | IEC 61058-1 |
| – Annex J | Coated printed circuit boards | IEC 60664-3 |
| – Annex N | Proof tracking test | IEC 60112 |
| – Annex R | Software evaluation | IEC 60730-1 |

NOTE 2 The following print types are used:

- requirements: in roman type;
- *test specifications: in italic type;*
- notes: in small roman type.

Words in **bold** in the text are defined in Clause 3. When a definition concerns an adjective, the adjective and associated noun are also in bold.

A list of all parts of the IEC 60335 series, under the general title: *Household and similar electrical appliances – Safety*, can be found on the IEC website.

The committee has decided that the contents of the base publication and its amendments will remain unchanged until the maintenance result date¹⁾ indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

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

NOTE 3 The attention of National Committees is drawn to the fact that equipment manufacturers and testing organizations may need a transitional period following publication of a new, amended or revised IEC publication in

¹⁾ National committees are requested to note that for this publication the maintenance result date is 2013.

which to make products in accordance with the new requirements and to equip themselves for conducting new or revised tests.

It is the recommendation of the committee that the content of this publication be adopted for implementation nationally not earlier than 12 months or later than 36 months from the date of publication.

The following differences exist in the countries indicated below.

- Introduction: The Part 1 standard (UL60335-1) is only used in combination with a part 2 (UL60335-2-x). National differences are specified in these standards (USA).
- 5.7: The ambient temperature is $25\text{ °C} \pm 10\text{ °C}$ (Japan).
- 5.7: The ambient temperature is $27\text{ °C} \pm 5\text{ °C}$ (India).
- 6.1: Class 0 appliances and class 0I appliances are not allowed (Australia, Austria, Belgium, Czech Republic, Finland, France, Germany, Greece, Hungary, India, Israel, Ireland, Italy, Netherlands, New Zealand, Norway, Poland, Singapore, Slovakia, Sweden, Switzerland, United Kingdom).
- 7.12.2: The requirements for full disconnection do not apply (Japan).
- 13.2: The test circuit and some leakage current limits are different (India).
- 22.2: The second paragraph of this subclause dealing with single-phase class I appliances with heating elements cannot be complied with because of the supply system (France and Norway).
- 22.2: Double-pole switches or protective devices are required (Norway).
- 22.35 Accessible metal parts separated from live parts by earthed metal parts are not regarded as likely to become live in the event of an insulation fault (USA).
- 24.1: IEC component standard requirements are replaced by the relevant requirements of component standards specified in UL60335-1 and parts 2 (UL60335-2-x) (USA).
- 25.3: A set of supply leads is not permitted (Norway, Denmark, Finland, Netherlands).
- 25.8: 0,5 mm² supply cords are not allowed for class I appliances (Australia and New Zealand).
- 26.6: Conductor cross-sectional areas are different (USA).
- 29.1: Different rated impulse voltages are used between 50 V and 150 V (Japan).

INTRODUCTION

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

This standard recognizes the internationally accepted level of protection against hazards such as electrical, mechanical, thermal, fire and radiation of appliances when operated as in normal use taking into account the manufacturer's instructions. It also covers abnormal situations that can be expected in practice and takes into account the way in which electromagnetic phenomena can affect the safe operation of appliances.

This standard takes into account the requirements of IEC 60364 as far as possible so that there is compatibility with the wiring rules when the appliance is connected to the supply mains. However, national wiring rules may differ.

If the functions of an appliance are covered by different parts 2 of IEC 60335, the relevant part 2 is applied to each function separately, as far as is reasonable. If applicable, the influence of one function on the other is taken into account.

NOTE 1 Throughout this publication, when "Part 2" is mentioned, it refers to the relevant part of IEC 60335.

When a part 2 standard does not include additional requirements to cover hazards dealt with in Part 1, Part 1 applies.

NOTE 2 This means that the technical committees responsible for the part 2 standards have determined that it is not necessary to specify particular requirements for the appliance in question over and above the general requirements.

This standard is a product family standard dealing with the safety of appliances and takes precedence over horizontal and generic standards covering the same subject.

NOTE 3 Horizontal and generic standards covering a hazard are not applicable since they have been taken into consideration when developing the general and particular requirements for the IEC 60335 series of standards. For example, in the case of temperature requirements for surfaces on many appliances, generic standards, such as ISO 13732-1 for hot surfaces, are not applicable in addition to Part 1 or part 2 standards.

Individual countries may wish to consider the application of the standard, as far as is reasonable, to appliances not mentioned in a part 2, and to appliances designed on new principles.

An appliance that complies with the text of this standard will not necessarily be considered to comply with the safety principles of the standard if, when examined and tested, it is found to have other features which impair the level of safety covered by these requirements.

An appliance 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 intent of the requirements and, if found to be substantially equivalent, may be considered to comply with the standard.

NOTE 4 Standards dealing with non-safety aspects of household appliances are

- IEC standards published by TC 59 concerning methods of measuring performance;
- CISPR 11, CISPR 14-1, IEC 61000-3-2 and IEC 61000-3-3 concerning electromagnetic emissions;
- CISPR 14-2 concerning electromagnetic immunity;
- IEC standards published by TC 111 concerning environmental matters.

HOUSEHOLD AND SIMILAR ELECTRICAL APPLIANCES – SAFETY –

Part 1: General requirements

1 Scope

This International Standard deals with the safety of electrical appliances for household and similar purposes, their **rated voltage** being not more than 250 V for single-phase appliances and 480 V for other appliances.

NOTE 1 Battery-operated appliances and other d.c. supplied appliances are within the scope of this standard.

Appliances not intended for normal household use but which nevertheless may be a source of danger to the public, such as appliances intended to be used by laymen in shops, in light industry and on farms, are within the scope of this standard.

NOTE 2 Examples of such appliances are catering equipment, cleaning appliances for commercial use, and appliances for hairdressers.

As far as is practicable, this standard deals with the common hazards presented by appliances that are encountered by all persons in and around the home. However, in general, it does not take into account

- persons (including children) whose
 - physical, sensory or mental capabilities; or
 - lack of experience and knowledgeprevents them from using the appliance safely without supervision or instruction;
- children playing with the appliance.

NOTE 3 Attention is drawn to the fact that

- for appliances intended to be used in vehicles or on board ships or aircraft, additional requirements may be necessary;
- 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 and similar authorities.

NOTE 4 This standard does not apply to

- appliances intended exclusively for industrial purposes;
- appliances intended to be used in locations where special conditions prevail, such as the presence of a corrosive or explosive atmosphere (dust, vapour or gas);
- audio, video and similar electronic apparatus (IEC 60065);
- appliances for medical purposes (IEC 60601);
- hand-held motor-operated electric tools (IEC 60745);
- personal computers and similar equipment (IEC 60950-1);
- transportable motor-operated electric tools (IEC 61029).

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60061-1, *Lamp caps and holders together with gauges for the control of interchangeability and safety – Part 1: Lamp caps*

IEC 60065:2001, *Audio, video and similar electronic apparatus – Safety requirements*
Amendment 1 (2005)²⁾

IEC 60068-2-2, *Environmental testing – Part 2-2: Tests – Test B: Dry heat*

IEC 60068-2-31, *Environmental testing – Part 2-31: Tests – Test Ec: Rough handling shocks, primarily for equipment-type specimens*

IEC 60068-2-75, *Environmental testing – Part 2-75: Tests – Test Eh: Hammer tests*

IEC 60068-2-78, *Environmental testing – Part 2-78: Tests – Test Cab: Damp heat, steady state*

IEC/TR 60083, *Plugs and socket-outlets for domestic and similar general use standardized in member countries of IEC*

IEC 60085:2007, *Electrical insulation – Thermal evaluation and designation*

IEC 60112:2003, *Method for the determination of the proof and the comparative tracking indices of solid insulating materials*
Amendment 1 (2009)³⁾

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 60238, *Edison screw lampholders*

IEC 60245 (all parts), *Rubber insulated cables – Rated voltages up to and including 450/750 V*

IEC 60252-1, *AC motor capacitors – Part 1: General – Performance testing and rating – Safety requirements – Guide for installation and operation*

IEC 60309 (all parts), *Plugs, socket-outlets and couplers for industrial purposes*

IEC 60320-1, *Appliance couplers for household and similar general purposes – Part 1: General requirements*

IEC 60320-2-2, *Appliance couplers for household and similar general purposes – Part 2-2: Interconnection couplers for household and similar equipment*

IEC 60320-2-3, *Appliance coupler for household and similar general purposes – Part 2-3: Appliance coupler with a degree of protection higher than IPX0*

IEC 60384-14:2005, *Fixed capacitors for use in electronic equipment – Part 14: Sectional specification: Fixed capacitors for electromagnetic interference suppression and connection to the supply mains*

IEC 60417, *Graphical symbols for use on equipment*

IEC 60529:1989, *Degrees of protection provided by enclosures (IP Code)*
Amendment 1 (1999)⁴⁾

2) There exists a consolidated edition 7.1 (2005) that includes edition 7 and its Amendment 1.

3) There exists a consolidated edition 4.1 (2009) that includes edition 4 and its Amendment 1.

4) There exists a consolidated edition 2.1 (2001) that includes edition 2 and its Amendment 1.

IEC 60598-1:2008, *Luminaires – Part 1: General requirements and tests*

IEC 60664-1:2007, *Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests*

IEC 60664-3:2003, *Insulation coordination for equipment within low-voltage systems – Part 3: Use of coating, potting or moulding for protection against pollution*

IEC 60664-4:2005, *Insulation coordination for equipment within low-voltage systems – Part 4: Consideration of high-frequency voltage stress*

IEC 60691, *Thermal-links – Requirements and application guide*

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, *Fire hazard testing – Part 2-12: Glowing/hot wire based test methods – Glow-wire flammability test method for materials*

IEC 60695-2-13, *Fire hazard testing – Part 2-13: Glowing/hot wire based test methods – Glow-wire ignitability test method for materials*

IEC 60695-10-2, *Fire hazard testing – Part 10-2: Abnormal heat – Ball pressure test*

IEC 60695-11-5:2004, *Fire hazard testing – Part 11-5: Test flames – Needle-flame test method – Apparatus, confirmatory test arrangement and guidance*

IEC 60695-11-10, *Fire hazard testing – Part 11-10: Test flames – 50 W horizontal and vertical flame test methods*

IEC 60730-1:1999, *Automatic electrical controls for household and similar use – Part 1: General requirements*
Amendment 1 (2003)
Amendment 2 (2007)⁵⁾

IEC 60730-2-8:2000, *Automatic electrical controls for household and similar use – Part 2-8: Particular requirements for electrically operated water valves, including mechanical requirements*
Amendment 1 (2002)⁶⁾

IEC 60730-2-10, *Automatic electrical controls for household and similar use – Part 2-10: Particular requirements for motor-starting relays*

IEC 60738-1, *Thermistors – Directly heated positive temperature coefficient – Part 1: Generic specification*

IEC 60906-1, *IEC system of plugs and socket-outlets for household and similar purposes – Part 1: Plugs and socket-outlets 16 A 250 V a.c.*

IEC 60990:1999, *Methods of measurement of touch current and protective conductor current*

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 mm² up to 35 mm² (included)*

IEC 61000-4-2, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test*

⁵⁾ There exists a consolidated edition 3.2 (2007) that includes edition 3 and its Amendment 1 and Amendment 2.

⁶⁾ There exists a consolidated edition 2.1 (2003) that includes edition 2 and its Amendment 1.

IEC 61000-4-3, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test*

IEC 61000-4-4, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test*

IEC 61000-4-5, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test*

IEC 61000-4-6, *Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency fields*

IEC 61000-4-11:2004, *Electromagnetic compatibility (EMC) – Part 4-11: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations immunity tests*

IEC 61000-4-13:2002, *Electromagnetic compatibility (EMC) – Part 4-13: Testing and measurement techniques – Harmonics and interharmonics including mains signalling at a.c. power port, low frequency immunity tests*
Amendment 1 (2009)⁷⁾

IEC 61000-4-34:2005, *Electromagnetic compatibility (EMC) - Part 4-34: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations immunity tests for equipment with input current more than 16 A per phase*
Amendment 1 (2009)

IEC 61032:1997, *Protection of persons and equipment by enclosures – Probes for verification*

IEC 61058-1:2000, *Switches for appliances – Part 1: General requirements*
Amendment 1 (2001)
Amendment 2 (2007)⁸⁾

IEC 61180-1, *High-voltage test techniques for low-voltage equipment – Part 1: Definitions, test and procedure requirements*

IEC 61180-2, *High-voltage techniques for low-voltage equipment – Part 2: Test equipment*

IEC 61558-1:2005, *Safety of power transformers, power supply units and similar products – Part 1: General requirements and tests*
Amendment 1(2009)⁹⁾

IEC 61558-2-6:2009, *Safety of transformers, reactors, power supply units and similar products for supply voltages up to 1 100 V – Part 2-6: Particular requirements and tests for safety isolating transformers and power supply units incorporating safety isolating transformers*

IEC 61770, *Electric appliances connected to the water mains – Avoidance of backsiphonage and failure of hose-sets*

IEC 62151, *Safety of equipment electrically connected to a telecommunication network*

ISO 2768-1, *General tolerances – Part 1: Tolerances for linear and angular dimensions without individual tolerance indications*

ISO 7000:2004, *Graphical symbols for use on equipment – Index and synopsis*

ISO 9772:2001, *Cellular plastics – Determination of horizontal burning characteristics of small specimens subjected to a small flame*
Amendment 1 (2003)

⁷⁾ There exists a consolidated edition 1.1 (2009) that includes edition 1 and its Amendment 1.

⁸⁾ There exists a consolidated edition 3.2 (2008) that includes edition 3 and its Amendment 1 and Amendment 2.

⁹⁾ There exists a consolidated edition 2.1 (2009) that includes edition 2 and its Amendment 1.

ISO 9773, *Plastics – Determination of burning behaviour of thin flexible vertical specimens in contact with a small-flame ignition source*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

NOTE 1 An Index of the defined terms is provided at the end of this publication.

NOTE 2 When the terms “voltage” and “current” are used, they are r.m.s. values, unless otherwise specified.

3.1 Definitions relating to physical characteristics

3.1.1

rated voltage

voltage assigned to the appliance by the manufacturer

3.1.2

rated voltage range

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

3.1.3

working voltage

maximum voltage to which the part under consideration is subjected when the appliance is supplied at its **rated voltage** and operating under **normal operation**, with controls and switching devices positioned so as to maximize the value

NOTE 1 **Working voltage** takes into account resonant voltages.

NOTE 2 When deducing the **working voltage**, the effect of transient voltages is ignored.

3.1.4

rated power input

power input assigned to the appliance by the manufacturer

NOTE If no power input is assigned to the appliance, the **rated power input** for **heating appliances** and **combined appliances** is the power input measured when the appliance is supplied at **rated voltage** and operated under **normal operation**.

3.1.5

rated power input range

power input range assigned to the appliance by the manufacturer, expressed by its lower and upper limits

3.1.6

rated current

current assigned to the appliance by the manufacturer

NOTE If no current is assigned to the appliance, the **rated current** is

- for **heating appliances**, the current calculated from the **rated power input** and the **rated voltage**;
- for **motor-operated appliances** and **combined appliances**, the current measured when the appliance is supplied at **rated voltage** and operated under **normal operation**.

3.1.7

rated frequency

frequency assigned to the appliance by the manufacturer

3.1.8

rated frequency range

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

3.1.9

normal operation

conditions under which the appliance is operated in normal use when it is connected to the supply mains

3.1.10

rated impulse voltage

voltage derived from the **rated voltage** and the overvoltage category of the appliance, characterizing the specified withstand capability of its insulation against transient over-voltages

3.1.11

dangerous malfunction

unintended operation of the appliance that may impair safety

3.1.12

remote operation

control of an appliance by a command that can be initiated out of sight of the appliance using means such as telecommunications, sound controls or bus systems

NOTE An infra-red control by itself is not considered one used for **remote operation**. However, it may be incorporated as part of a system such as a telecommunication, sound control or bus system.

3.2 Definitions relating to means of connection

3.2.1

supply leads

set of wires intended for connecting the appliance to fixed wiring and accommodated in a compartment within or attached to the appliance

3.2.2

interconnection cord

external flexible cord provided as part of a complete appliance for purposes other than connection to the supply mains

NOTE A remote hand-held switching device, an external interconnection between two parts of an appliance and a cord connecting an accessory to the appliance or to a separate signalling circuit are examples of **interconnection cords**.

3.2.3

supply cord

flexible cord, for supply purposes, that is fixed to the appliance

3.2.4

type X attachment

method of attachment of the **supply cord** such that it can easily be replaced

NOTE The **supply cord** may be specially prepared and only available from the manufacturer or its service agent. A specially prepared cord may include a part of the appliance.

3.2.5

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

3.2.6

type Z attachment

method of attachment of the **supply cord** such that it cannot be replaced without breaking or destroying the appliance

3.3 Definitions relating to protection against electric shock

3.3.1

basic insulation

insulation applied to **live parts** to provide basic protection against electric shock

3.3.2

supplementary insulation

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

3.3.3

double insulation

insulation system comprising both **basic insulation** and **supplementary insulation**

3.3.4

reinforced insulation

single insulation applied to **live parts**, that provides a degree of protection against electric shock equivalent to **double insulation** under the conditions specified in this standard

NOTE It is not implied that the insulation is one homogeneous piece. The insulation may comprise several layers which cannot be tested singly as **supplementary insulation** or **basic insulation**.

3.3.5

functional insulation

insulation between conductive parts of different potential which is necessary only for the proper functioning of the appliance

3.3.6

protective impedance

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

3.3.7

class 0 appliance

appliance in which protection against electric shock relies upon **basic insulation** only, there being no means for the connection of conductive **accessible parts**, if any, to the protective conductor in the fixed wiring of the installation, reliance in the event of a failure of the **basic insulation** being placed upon the environment

NOTE **Class 0 appliances** have either an enclosure of insulating material which may form a part or the whole of the **basic insulation**, or a metal enclosure which is separated from **live parts** by an appropriate insulation. If an appliance with an enclosure of insulating material has provision for earthing internal parts, it is considered to be a **class I appliance** or **class 0I appliance**.

3.3.8

class 0I appliance

appliance having at least **basic insulation** throughout and incorporating an earthing terminal but having a **supply cord** without earthing conductor and a plug without earthing contact

3.3.9

class I appliance

appliance 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**

NOTE This provision includes a protective earthing conductor in the **supply cord**.

3.3.10

class II appliance

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

NOTE 1 Such an appliance may be of one of the following types:

- an appliance having a durable and substantially continuous enclosure of insulating material which envelops all metal parts, with the exception of parts, such as nameplates, screws and rivets, which are isolated from **live parts** by insulation at least equivalent to **reinforced insulation**; such an appliance is called an insulation-encased **class II appliance**;
- an appliance having a substantially continuous metal enclosure, in which **double insulation** or **reinforced insulation** is used throughout; such an appliance is called a metal-encased **class II appliance**;
- an appliance which is a combination of an insulation-encased **class II appliance** and a metal-encased **class II appliance**.

NOTE 2 The enclosure of an insulation-encased **class II appliance** may form a part or the whole of the **supplementary insulation** or of the **reinforced insulation**.

NOTE 3 If an appliance with **double insulation** or **reinforced insulation** throughout has provision for earthing, it is considered to be a **class I appliance** or a **class 0I appliance**.

3.3.11

class II construction

part of an appliance for which protection against electric shock relies upon **double insulation** or **reinforced insulation**

3.3.12

class III appliance

appliance 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 voltage** are not generated

NOTE **Basic insulation** may be required in addition to supply at **SELV**. Refer to 8.1.4.

3.3.13

class III construction

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

NOTE 1 **Basic insulation** may be required in addition to supply at **SELV**. Refer to 8.1.4.

NOTE 2 If the main part of the appliance operates at **SELV** and is delivered together with a **detachable power supply unit** then this main part of the appliance is considered to be of **class III construction** in a **class I appliance** or **class II appliance** as appropriate.

3.3.14

clearance

shortest distance in air between two conductive parts or between a conductive part and the **accessible surface**

3.3.15

creepage distance

shortest distance along the surface of insulation between two conductive parts or between a conductive part and the **accessible surface**

3.4 Definitions relating to extra-low voltage

3.4.1

extra-low voltage

voltage supplied from a source within the appliance that does not exceed 50 V between conductors and between conductors and earth when the appliance is supplied at **rated voltage**

3.4.2

safety extra-low voltage

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 insulation** or **reinforced insulation** requirements.

NOTE 1 The voltage limits specified are based on the assumption that the **safety isolating transformer** is supplied at its **rated voltage**.

NOTE 2 **Safety extra-low voltage** is also known as **SELV**.

3.4.3

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**, that is intended to supply an appliance or circuit at **safety extra-low voltage**

3.4.4

protective extra-low voltage circuit

earthed circuit operating at **safety extra-low voltage** which is separated from other circuits by **basic insulation** and protective screening, **double insulation** or **reinforced insulation**

NOTE 1 Protective screening is the separation of circuits from **live parts** by means of an earthed screen.

NOTE 2 A **protective extra-low voltage circuit** is also known as a **PELV circuit**.

3.5 Definitions relating to types of appliances

3.5.1

portable appliance

appliance that is intended to be moved while in operation or an appliance, other than a **fixed appliance**, having a mass less than 18 kg

3.5.2

hand-held appliance

portable appliance intended to be held in the hand during normal use

3.5.3

stationary appliance

fixed appliance or an appliance which is not a **portable appliance**

3.5.4

fixed appliance

appliance that is intended to be used while fastened to a support or while secured in a specific location

3.5.5

built-in appliance

fixed appliance intended to be installed in a cabinet, in a prepared recess in a wall or in a similar location

3.5.6

heating appliance

appliance incorporating heating elements but without any motor

3.5.7

motor-operated appliance

appliance incorporating motors but without any heating element

NOTE Magnetically driven appliances are considered to be **motor-operated appliances**.

3.5.8

combined appliance

appliance incorporating heating elements and motors

3.6 Definitions relating to parts of an appliance

3.6.1

non-detachable part

part that can only be removed or opened with the aid of a **tool** or a part that fulfils the test of 22.11

3.6.2

detachable part

part that can be removed or opened without the aid of a **tool**, a part that is removed or opened in accordance with the instructions for use, even if a **tool** is needed for removal, or a part that does not fulfil the test of 22.11

NOTE 1 If for installation purposes a part has to be removed, this part is not considered to be detachable even if the instructions state that it is to be removed.

NOTE 2 Components that can be removed without the aid of a **tool** are considered to be **detachable parts**.

3.6.3

accessible part

part or surface that can be touched by means of test probe B of IEC 61032, and if the part or surface is metal, any conductive part connected to it

NOTE **Accessible non-metallic parts** with conductive coatings are considered to be **accessible metal parts**.

3.6.4

live part

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

NOTE 1 Parts, accessible or not, complying with 8.1.4 are not considered to be **live parts**.

NOTE 2 A PEN conductor is a protective earthed neutral conductor combining the functions of both a protective conductor and a neutral conductor.

3.6.5

tool

screwdriver, coin or any other object that may be used to operate a screw or similar fixing means

3.6.6

small part

part, where each surface lies completely within a circle of 15 mm diameter, or a part where some of the surface lies outside a 15 mm diameter circle but in such a way that it is not possible to fit a circle of 8 mm diameter on any of the surfaces

NOTE A part that is too small to grip and at the same time to be able to apply the glow-wire tip is shown in example A in Figure 5. A part that is large enough to grip but that is too small to be able to apply the glow-wire tip is shown in example B in Figure 5. A part that is not a **small part** is shown in example C in Figure 5.

3.7 Definitions relating to safety components

3.7.1

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

3.7.2

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

NOTE A **temperature limiter** does not make the reverse operation during the normal duty cycle of the appliance. It may or may not require manual resetting.

3.7.3

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 is constructed so that its setting cannot be altered by the user

3.7.4

self-resetting thermal cut-out

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

3.7.5

non-self-resetting thermal cut-out

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

NOTE Manual operation includes disconnection of the appliance from the supply mains.

3.7.6

protective device

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

3.7.7

thermal link

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

3.7.8

intentionally weak part

part intended to rupture under conditions of abnormal operation to prevent the occurrence of a condition which could impair compliance with this standard

NOTE Such a part may be a replaceable component, such as a resistor or a capacitor, or a part of a component to be replaced, such as an **inaccessible thermal link** incorporated in a motor.

3.8 Definitions relating to miscellaneous matters

3.8.1

all-pole disconnection

disconnection of both supply conductors by a single initiating action or, for multi-phase appliances, disconnection of all supply conductors by a single initiating action

NOTE For multi-phase appliances, the neutral conductor is not considered to be a supply conductor.

3.8.2

off position

stable position of a switching device in which the circuit controlled by the switch is disconnected from its supply or, for electronic disconnection, the circuit is de-energized

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

3.8.3

visibly glowing heating element

heating element that is partly or completely visible from the outside of the appliance and has a temperature of at least 650 °C when the appliance has been operated under **normal operation** at **rated power input** until steady conditions have been established

3.8.4

PTC heating element

element intended for heating consisting mainly of positive temperature coefficient resistors that are thermally sensitive and have a rapid non-linear increase in resistance when the temperature is raised through a particular range

3.8.5

user maintenance

any maintenance operation stated in the instructions for use, or marked on the appliance, that the user is intended to perform

3.9 Definitions relating to electronic circuits

3.9.1

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**.

3.9.2

electronic circuit

circuit incorporating at least one **electronic component**

3.9.3

protective electronic circuit

electronic circuit that prevents a hazardous situation under abnormal operating conditions

NOTE Parts of the circuit may also be used for functional purposes.

4 General requirement

Appliances shall be constructed so 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

Unless otherwise specified, the tests are carried out in accordance with this clause.

5.1 Tests according to this standard are type tests.

NOTE Routine tests are described in Annex A.

5.2 *The tests are carried out on a single appliance that shall withstand all the relevant tests. However, the tests of Clauses 20, 22 (except 22.10, 22.11 and 22.18) to 26, 28, 30 and 31 may be carried out on separate appliances. The test of 22.3 is carried out on a new appliance.*

NOTE 1 Additional samples may be required if the appliance has to be tested under different conditions, for example if it can be supplied with different voltages.

If an **intentionally weak part** becomes open circuit during the tests of Clause 19, an additional appliance may be needed.

The testing of components may require the submission of additional samples of these components.

If the test of Annex C has to be carried out, six samples of the motor are needed.

If the test of Annex D has to be carried out, an additional appliance may be used.

If the tests of Annex G are carried out, four additional transformers are needed.

If the tests of Annex H are carried out, three switches or three additional appliances are needed.

NOTE 2 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**.

NOTE 3 If an appliance has to be dismantled in order to carry out a test, care is to be taken to ensure that it is reassembled as originally supplied. In case of doubt, subsequent tests may be carried out on a separate sample.

5.3 *The tests are carried out in the order of the clauses. However, the test of 22.11 on the appliance at room temperature is carried out before the tests of Clause 8. The tests of Clause 14 and 21.2 and 22.24 are carried out after the tests of Clause 29. The test of 19.14 is carried out before the tests of 19.11.*

If it is evident from the construction of the appliance that a particular test is not applicable, the test is not carried out.

5.4 *When testing appliances that are also supplied by other energies such as gas, the influence of their consumption has to be taken into account.*

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

5.6 *Appliances 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.*

NOTE 1 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.

NOTE 2 Adequate sealing is regarded as preventing alteration of the setting by the user.

*For appliances fitted with a voltage selector switch, unless otherwise specified, the tests are carried out with the switch in the position corresponding to the **rated voltage** value used for the tests.*

5.7 *The tests are carried out in a draught-free location at an ambient temperature of $20\text{ °C} \pm 5\text{ °C}$.*

If the temperature attained by any part is limited by a temperature sensitive device or is influenced by the temperature at which a change of state occurs, for example when water boils, the ambient temperature is maintained at $23\text{ °C} \pm 2\text{ °C}$ in case of doubt.

5.8 Test conditions relating to frequency and voltage

5.8.1 *Appliances for a.c. only are tested with a.c. at **rated frequency**, and those for a.c. and d.c. are tested at the more unfavourable supply.*

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

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

*For **motor-operated appliances**, and **combined appliances**, marked with a **rated voltage range**, when it is specified that the supply voltage is equal to the **rated voltage** multiplied by a factor, the appliance is supplied at*

- *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**.*

NOTE 1 If a **heating appliance** has a **rated voltage range**, the upper limit of the voltage range will usually be the most unfavourable voltage within the range.

NOTE 2 For **motor-operated appliances**, **combined appliances** and appliances 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.

5.8.3 *For **heating appliances**, and **combined appliances**, marked with a **rated power input range**, when it is specified that the power input is equal to the **rated power input** multiplied by a factor, the appliance is operated at*

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

*When a factor is not specified, the power input is the most unfavourable within the **rated power input range**.*

5.8.4 *For appliances marked with a **rated voltage range** and **rated power input** corresponding to the mean of the **rated voltage range**, when it is specified that the power input is equal to **rated power input** multiplied by a factor, the appliance is operated at*

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

- the calculated power 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 power input corresponds to the power input at the most unfavourable voltage within the **rated voltage range**.

5.9 When alternative heating elements or accessories are made available by the appliance manufacturer, the appliance is tested with those elements or accessories which give the most unfavourable results.

5.10 The tests are carried out on the appliance as supplied. However, an appliance constructed as a single appliance but supplied in a number of units is tested after assembly in accordance with the instructions provided with the appliance.

Built-in appliances and fixed appliances are installed in accordance with the instructions provided with the appliance before testing.

5.11 Appliances intended to be connected to fixed wiring by means of a flexible cord are tested with the appropriate flexible cord connected to the appliance.

5.12 For **heating appliances** and **combined appliances**, when it is specified that the appliance has to operate at a power input multiplied by a factor, this applies only to heating elements without appreciable positive temperature coefficient of resistance.

For heating elements with appreciable positive temperature coefficient of resistance, other than **PTC heating elements**, the supply voltage is determined by supplying the appliance at **rated voltage** until the heating element reaches its operating temperature. The supply voltage is then rapidly increased to the value necessary to give the power input required for the relevant test, this value of the supply voltage being maintained throughout the test.

NOTE In general, the temperature coefficient is considered to be appreciable if, at **rated voltage**, the power input of the appliance in cold condition differs by more than 25 % from the power input at operating temperature.

5.13 The tests for appliances with **PTC heating elements** and for **heating appliances** and **combined appliances** where the heating elements are supplied via a switch mode power supply are carried out at a voltage corresponding to the specified power input.

When a power input greater than the **rated power input** is specified, the factor for multiplying the voltage is equal to the square root of the factor for multiplying the power input.

5.14 If **class 0I appliances** or **class I appliances** have **accessible metal parts** that are not earthed and are not separated from **live parts** by an intermediate metal part that is earthed, such parts are checked for compliance with the appropriate requirements specified for **class II construction**.

If **class 0I appliances** or **class I appliances** 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 that is earthed.

NOTE Guidance is given in Annex P for enhanced requirements that may be used to ensure an acceptable level of protection against electrical and thermal hazards for particular types of appliances used in an installation without a protective earthing conductor in countries that have warm damp equable climates.

5.15 If appliances have parts operating at **safety extra-low voltage**, such parts are checked for compliance with the appropriate requirements specified for **class III construction**.

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

5.17 Appliances powered by rechargeable batteries are tested in accordance with Annex B.

5.18 If linear and angular dimensions are specified without a tolerance, ISO 2768-1 is applicable.

5.19 If a component or part of the appliance has both a **self resetting feature** and a **non-self-resetting feature** and if the **non-self-resetting feature** is not required in order to comply with the standard, then appliances incorporating such a component or part shall be tested with the **non-self-resetting feature** rendered inoperative.

6 Classification

6.1 Appliances shall be of one of the following classes with respect to protection against electric shock:

class 0, class 0I, class I, class II, class III.

Compliance is checked by inspection and by the relevant tests.

6.2 Appliances shall have the appropriate degree of protection against harmful ingress of water.

Compliance is checked by inspection and by the relevant tests.

NOTE The degrees of protection against harmful ingress of water are given in IEC 60529.

7 Marking and instructions

7.1 Appliances shall be marked with the

- **rated voltage** or **rated voltage range** in volts;
- symbol for nature of supply, unless the **rated frequency** is marked;
- **rated power input** in watts or **rated current** in amperes;
- name, trade mark or identification mark of the manufacturer or responsible vendor;
- model or type reference;
- symbol IEC 60417-5172 (2003-02) for **class II appliances** only;
- IP number according to degree of protection against ingress of water, other than IPX0;
- symbol IEC 60417-5180 (2003-02), for **class III appliances**. This marking is not necessary for appliances that are operated only by batteries (primary batteries or secondary batteries that are recharged outside of the appliance).

NOTE 1 The first numeral of the IP number need not be marked on the appliance.

NOTE 2 Additional markings are allowed provided they do not give rise to misunderstanding.

NOTE 3 If components are marked separately, the marking of the appliance and that of the components is to be such that there can be no doubt with regard to the marking of the appliance itself.

NOTE 4 If the appliance is marked with rated pressure, the units used may be bars but only together with pascals and placed in brackets.

The enclosure of electrically-operated water valves incorporated in external hose-sets for connection of an appliance to the water mains shall be marked with symbol IEC 60417-5036 (2002-10) if their **working voltage** exceeds **extra-low voltage**.

Compliance is checked by inspection.

7.2 Stationary appliances for multiple supply shall be marked with the substance of the following:

Warning: Before obtaining access to terminals, all supply circuits must be disconnected.

This warning shall be placed in the vicinity of the terminal cover.

Compliance is checked by inspection.

7.3 Appliances having a range of rated values and which can be operated without adjustment throughout the range shall be marked with the lower and upper limits of the range separated by a hyphen.

NOTE 1 Example: 115-230 V: The appliance is suitable for any value within the marked range (a curling iron with a **PTC heating element** or an appliance incorporating an input switch mode power supply).

Appliances having different rated values and which have to be adjusted for use at a particular value by the user or installer shall be marked with the different values separated by an oblique stroke.

NOTE 2 Example: 115/230 V: The appliance is only suitable for the marked values (a shaver with a selector switch).

NOTE 3 This requirement is also applicable to appliances with provision for connection to both single-phase and multi-phase supplies.

Example: 230 V/400 V: The appliance is only suitable for the voltage values indicated, 230 V being for single-phase operation and 400 V for three-phase operation (a dishwasher with terminals for both supplies).

Compliance is checked by inspection.

7.4 If the appliance can be adjusted for different **rated voltages**, the voltage to which the appliance is adjusted shall be clearly discernible. If frequent changes in voltage setting are not required, this requirement is considered to be met if the **rated voltage** to which the appliance is to be adjusted can be determined from a wiring diagram fixed to the appliance.

NOTE The wiring diagram may be on the inside of a cover that has to be removed to connect the supply conductors. It is not to be on a label loosely attached to the appliance.





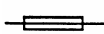
Compliance is checked by inspection.

7.5 For appliances marked with more than one **rated voltage** or with one or more **rated voltage ranges**, the **rated power input** or **rated current** for each of these voltages or ranges shall be marked. However, if the difference between the limits of a **rated voltage range** does not exceed 10 % of the arithmetic mean value of the range, the marking for **rated power input** or **rated current** may be related to the arithmetic mean value of the range.

The upper and lower limits of the **rated power input** or **rated current** shall be marked on the appliance so that the relation between input and voltage is clear.

Compliance is checked by inspection.

7.6 When symbols are used, they shall be as follows

	[symbol IEC 60417- 5031 (2002-10)]	direct current
	[symbol IEC 60417- 5032 (2002-10)]	alternating current
3 	[symbol IEC 60417- 5032-1 (2002-10)]	three-phase alternating current
3N 	[symbol IEC 60417- 5032-2 (2002-10)]	three-phase alternating current with neutral
	[symbol IEC 60417- 5016 (2002-10)]	fuse-link

NOTE 1 The **rated current** of the fuse link may be indicated in association with this symbol.



time-lag miniature fuse-link where X is the symbol for the time/current characteristic as given in IEC 60127



[symbol IEC 60417- 5019 (2006-08)]

protective earth



[symbol IEC 60417- 5018 (2006-10)]

functional earthing



[symbol IEC 60417- 5172 (2003-02)]

class II equipment



[symbol IEC 60417- 5012 (2002-10)]

lamp

NOTE 2 The rated wattage of the lamp may be indicated in association with this symbol.



[symbol ISO 7000-0434 (2004-01)]

caution



[symbol ISO 7000-0790 (2004-01)]

read operator's manual



[symbol IEC 60417- 5021 (2002-10)]

equipotentiality



[symbol IEC 60417-5036 (2002-10)]

dangerous voltage



[symbol IEC 60417-5180 (2003-02)]

Class III appliance

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

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

Units of physical quantities and their symbols shall be those of the international standardized system.

NOTE 3 Additional symbols are allowed provided that they do not give rise to misunderstanding.

NOTE 4 Symbols specified in IEC 60417 and ISO 7000 may be used.

Compliance is checked by inspection.

7.7 Appliances to be connected to more than two supply conductors and appliances for multiple supply shall have a connection diagram fixed to them, unless the correct mode of connection is obvious.

Compliance is checked by inspection.

NOTE 1 The correct mode of connection for multi-phase appliances is considered to be obvious if the terminals for the supply conductors are indicated by arrows pointing towards the terminals.

NOTE 2 Marking in words is an acceptable means of indicating the correct mode of connection.

NOTE 3 The connection diagram may be the wiring diagram referred to in 7.4.

7.8 Except for **type Z attachment**, terminals used for connection to the supply mains shall be indicated as follows:

- terminals intended exclusively for the neutral conductor shall be indicated by the letter N;
- protective earthing terminals shall be indicated by symbol IEC 60417- 5019 (2006-08).

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

Compliance is checked by inspection.

7.9 Unless it is obviously unnecessary, switches which may give rise to a hazard when operated shall be marked or placed so as to indicate clearly which part of the appliance they control. Indications used for this purpose shall, wherever practicable, be comprehensible without a knowledge of languages or national standards.

Compliance is checked by inspection.

7.10 The different positions of switches on **stationary appliances** and the different positions of controls on all appliances shall be indicated by figures, letters or other visual means. This requirement also applies to switches which are part of a control.

If figures are used for indicating the different positions, the **off position** shall be indicated by the figure 0 and the position for a higher value, such as output, input, speed or cooling effect, shall be indicated by a higher figure.

The figure 0 shall not be used for any other indication unless it is positioned and associated with other numbers so that it does not give rise to confusion with the indication of the **off position**.

NOTE For example, figure 0 may be used on a digital programming keyboard.

Compliance is checked by inspection.

7.11 Controls intended to be adjusted during installation or in normal use shall be provided with an indication for the direction of adjustment.

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

Compliance is checked by inspection.

7.12 Instructions for use shall be provided with the appliance so that the appliance can be used safely.

NOTE Instructions for use may be marked on the appliance as long as they are visible in normal use.

If it is necessary to take precautions during **user maintenance**, appropriate details shall be given.

The instructions shall state the substance of the following:

This appliance is not intended for use by persons (including children) with reduced physical, sensory or mental capabilities, or lack of experience and knowledge, unless they have been given supervision or instruction concerning use of the appliance by a person responsible for their safety.

Children should be supervised to ensure that they do not play with the appliance.

The instructions for appliances having a part of **class III construction** supplied from a **detachable power supply unit** shall state that the appliance is only to be used with the power supply unit provided with the appliance.

The instructions for **class III appliances** shall state that it must only be supplied at safety extra low voltage corresponding to the marking on the appliance. This instruction is not necessary for battery-operated appliances if the battery is a primary battery or secondary battery charged outside of the appliance.

Compliance is checked by inspection.

7.12.1 If it is necessary to take precautions during installation of the appliance, appropriate details shall be given.

If an appliance is intended to be permanently connected to the water mains and not connected by a hose-set, this shall be stated.

Compliance is checked by inspection.

7.12.2 If a **stationary appliance** is not fitted with a **supply cord** and a plug, or with other means for disconnection from the supply mains having a contact separation in all poles that provide full disconnection under overvoltage category III conditions, the instructions shall state that means for disconnection must be incorporated in the fixed wiring in accordance with the wiring rules.

Compliance is checked by inspection.

7.12.3 If the insulation of the fixed wiring supplying an appliance for permanent connection to the supply mains can come into contact with parts having temperature rise exceeding 50 K

during the test of Clause 11, the instructions shall state that the fixed wiring insulation must be protected, for example, by insulating sleeving having an appropriate temperature rating.

Compliance is checked by inspection and during the test of Clause 11.

7.12.4 The instructions for **built-in appliances** shall include information with regard to the following:

- dimensions of the space to be provided for the appliance;
- dimensions and position of the means for supporting and fixing the appliance within this space;
- minimum distances between the various parts of the appliance and the surrounding structure;
- minimum dimensions of ventilating openings and their correct arrangement;
- connection of the appliance to the supply mains and the interconnection of any separate components;
- necessity to allow disconnection of the appliance from the supply after installation, unless the appliance incorporates a switch complying with 24.3. The disconnection may be achieved by having the plug accessible or by incorporating a switch in the fixed wiring in accordance with the wiring rules.

Compliance is checked by inspection.

7.12.5 For appliances with **type X attachment** having a specially prepared cord, the instructions shall contain the substance of the following:

If the supply cord is damaged, it must be replaced by a special cord or assembly available from the manufacturer or its service agent.

For appliances with **type Y attachment**, the instructions shall contain the substance of the following.

If the supply cord is damaged, it must be replaced by the manufacturer, its service agent or similarly qualified persons in order to avoid a hazard.

For appliances with **type Z attachment**, the instructions shall contain the substance of the following.

The supply cord cannot be replaced. If the cord is damaged the appliance should be scrapped.

Compliance is checked by inspection.

7.12.6 If a **non-self-resetting thermal cut-out** is required in order to comply with the standard then the instructions for appliances incorporating a **non-self-resetting thermal cut-out** that is reset by disconnection of the supply mains shall contain the substance of the following:

CAUTION: In order to avoid a hazard due to inadvertent resetting of the thermal cut-out, this appliance must not be supplied through an external switching device, such as a timer, or connected to a circuit that is regularly switched on and off by the utility.

Compliance is checked by inspection.

7.12.7 The instructions for **fixed appliances** shall state how the appliance is to be fixed to its support. The method of fixing stated is not to depend on the use of adhesives since they are not considered to be a reliable fixing means.

Compliance is checked by inspection.

7.12.8 The instructions for appliances connected to the water mains shall state

- the maximum inlet water pressure, in pascals;
- the minimum inlet water pressure, in pascals, if this is necessary for the correct operation of the appliance.

The instructions for appliances connected to the water mains by **detachable hose-sets** shall state that the new hose-sets supplied with the appliance are to be used and that old hose-sets should not be reused.

Compliance is checked by inspection.

7.13 Instructions and other text required by this standard shall be written in an official language of the country in which the appliance is to be sold.

Compliance is checked by inspection.

7.14 The markings required by the standard shall be clearly 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. The petroleum spirit to be used for the test is aliphatic solvent hexane.

After all the tests of this standard, the marking shall be clearly legible. It shall not be easily possible to remove marking plates nor shall they show curling.

NOTE In considering the durability of the marking, the effect of normal use is taken into account. 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.

7.15 The markings specified in 7.1 to 7.5 shall be on a main part of the appliance.

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

For **stationary appliances**, at least the name or trademark or identification mark of the manufacturer or responsible vendor and the model or type reference shall be visible when the appliance is installed as in normal use. These markings may be beneath a **detachable cover**. Other markings may be beneath a cover only if they are near to the terminals. For **fixed appliances**, this requirement applies after the appliance has been installed according to the instructions provided with the appliance.

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

Compliance is checked by inspection.

7.16 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 at such a place that it is clearly visible when the appliance has been dismantled to the extent necessary for replacing the link.

NOTE Marking on the link is allowed as long as the marking is legible after the link has functioned.

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

Compliance is checked by inspection.

8 Protection against access to live parts

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

Compliance is checked by inspection and by the tests of 8.1.1 to 8.1.3, as applicable, taking into account 8.1.4 and 8.1.5.

8.1.1 *The requirement of 8.1 applies for all positions of the appliance when it is operated as in normal use, and after the removal of **detachable parts**.*

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

*Lamps located behind a **detachable cover** are not removed, provided that the appliance can be isolated from the supply mains 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.*

Test probe B of IEC 61032 is applied with a force not exceeding 1 N, the appliance being in every possible position except that appliances normally used on the floor and having a mass exceeding 40 kg are not tilted. Through openings, the test probe is applied to any depth that the probe will permit and is rotated or angled before, during and after insertion to any position. If the opening does not allow the entry of the probe, the force on the probe in the straight position is increased to 20 N. If the probe then enters the opening, the test is repeated with the probe in the angled position.

*It shall not be possible to touch **live parts** or **live parts** protected only by lacquer, enamel, ordinary paper, cotton, oxide film, beads, or sealing compound except self-hardening resins, with the probe.*

8.1.2 *Test probe 13 of IEC 61032 is applied with a force not exceeding 1 N through openings in **class 0 appliances**, **class II appliances** and **class II constructions**, except for those giving access to lamp caps and **live parts** in socket-outlets.*

NOTE Appliance outlets are not considered to be socket-outlets.

The test probe is also applied through openings in earthed metal enclosures having a non-conductive coating such as enamel or lacquer.

*It shall not be possible to touch **live parts** with the test probe.*

8.1.3 *Instead of test probe B and test probe 13, for appliances other than those of **class II**, test probe 41 of IEC 61032 is applied with a force not exceeding 1 N to **live parts** of **visibly glowing heating elements**, all poles of which can be disconnected by a single switching action. It is also applied to parts supporting such elements, provided that it is obvious from the outside of the appliance, without removing covers and similar parts, that these supporting parts are in contact with the element.*

*It shall not be possible to touch these **live parts**.*

NOTE For appliances provided with a **supply cord** and without a switching device in their supply circuit, the withdrawal of the plug from a socket-outlet is considered to be a single switching action.

8.1.4 An **accessible part** is not considered to be live if

- the part is supplied at **safety extra-low voltage**, provided that
 - for a.c., the peak value of the voltage does not exceed 42,4 V;
 - for d.c., the voltage does not exceed 42,4 V;

or

- the part is separated from **live parts** by **protective impedance**.

If **protective impedance** is used, the current between the part and the supply source shall not exceed 2 mA for d.c., its peak value shall not exceed 0,7 mA for a.c. and

- for voltages having a peak value over 42,4 V up to and including 450 V, the capacitance shall not exceed 0,1 μF ;
- for voltages having a peak value over 450 V up to and including 15 kV, the discharge shall not exceed 45 μC ;
- for voltages having a peak value over 15 kV, the energy in the discharge shall not exceed 350 mJ.

*Compliance is checked by measurement, the appliance being supplied at **rated voltage**.*

Voltages and currents are measured between the relevant parts and each pole of the supply source. Discharges are measured immediately after the interruption of the supply. The quantity of electricity and energy in the discharge is measured using a resistor having a nominal non-inductive resistance of 2 000 Ω .

NOTE 1 Details of a suitable circuit for measuring the current are given in Figure 4 of IEC 60990.

NOTE 2 The quantity of electricity is calculated from the sum of all areas recorded on the voltage/time graph without taking voltage polarity into account.

8.1.5 **Live parts** of **built-in appliances**, **fixed appliances** and appliances delivered in separate units, shall be protected at least by **basic insulation** before installation or assembly.

Compliance is checked by inspection and by the test of 8.1.1.

8.2 **Class II appliances** and **class II constructions** shall be constructed and enclosed so that there is adequate protection against accidental contact with **basic insulation** and metal parts separated from **live parts** by **basic insulation** only.

It shall only be possible to touch parts which are separated from **live parts** by **double insulation** or **reinforced insulation**.

Compliance is checked by inspection and by applying test probe B of IEC 61032 in accordance with the conditions specified in 8.1.1.

*Test probe B of IEC 61032 is applied to **built-in appliances** and **fixed appliances** only after installation.*

9 Starting of motor-operated appliances

NOTE Requirements and tests are specified in part 2 when necessary.

10 Power input and current

10.1 If an appliance is marked with **rated power input**, the power input at normal operating temperature shall not deviate from the **rated power input** by more than the deviation shown in Table 1.

Table 1 – Power input deviation

Type of appliance	Rated power input W	Deviation
All appliances	≤25	+20 %
Heating appliances and combined appliances	>25 and ≤200	±10 %
	>200	+5 % or 20 W (whichever is the greater) –10 %
Motor-operated appliances	>25 and ≤300	+20 %
	>300	+15 % or 60 W (whichever is the greater)

The deviation for **motor-operated appliances** applies for **combined appliances** if the power input of the motors is more than 50 % of the **rated power input**. The permissible deviations apply for both limits of the range for appliances marked with a **rated voltage range** having limits differing by more than 10 % of the arithmetic mean value of the range.

NOTE In case of doubt, the power input of motors may be measured separately.

Compliance is checked by measurement when the power input has stabilized with

- *all circuits which can operate simultaneously being in operation;*
- *the appliance being supplied at **rated voltage**;*
- *the appliance being operated under **normal operation**.*

If the power input varies throughout the operating cycle, the power input is determined as the arithmetic mean value of the power input occurring during a representative period.

*The test is carried out at both the upper and lower limits of the ranges for appliances marked with one or more **rated voltage ranges**, unless the marking of the **rated power input** is related to the arithmetic mean value of the relevant voltage range, in which case the test is carried out at a voltage equal to the arithmetic mean value of that range.*

10.2 If an appliance is marked with **rated current**, the current at normal operating temperature shall not deviate from the **rated current** by more than the deviation shown in Table 2.

Table 2 – Current deviation

Type of appliance	Rated current A	Deviation
All appliances	$\leq 0,2$	+20 %
Heating appliances and combined appliances	$>0,2$ and $\leq 1,0$	± 10 %
	$>1,0$	+5 % or 0,10 A (whichever is the greater) –10 %
Motor-operated appliances	$>0,2$ and $\leq 1,5$	+20 %
	$>1,5$	+15 % or 0,30 A (whichever is the greater)

The deviation for **motor-operated appliances** applies for **combined appliances** if the current of the motors is more than 50 % of the **rated current**. The permissible deviations apply for both limits of the range for appliances marked with a **rated voltage range** having limits differing by more than 10 % of the arithmetic mean value of the range.

NOTE In case of doubt, the current of the motors may be measured separately.

Compliance is checked by measurement when the current has stabilized with

- *all circuits which can operate simultaneously being in operation;*
- *the appliance being supplied at **rated voltage**;*
- *the appliance being operated under **normal operation**.*

If the current varies throughout the operating cycle, the current is determined as the arithmetic mean value of the current occurring during a representative period.

*The test is carried out at both the upper and lower limits of the ranges for appliances marked with one or more **rated voltage ranges**, unless the marking of the **rated current** is related to the arithmetic mean value of the relevant voltage range, in which case the test is carried out at a voltage equal to the arithmetic mean value of that range.*

11 Heating

11.1 Appliances and their surroundings shall not attain excessive temperatures in normal use.

Compliance is checked by determining the temperature rise of the various parts under the conditions specified in 11.2 to 11.7.

11.2 **Hand-held appliances** are held in their normal position of use.

Appliances with pins for insertion into socket-outlets are plugged into an appropriate wall-mounted socket-outlet.

Built-in appliances are installed in accordance with the instructions.

*Other **heating appliances** and other **combined appliances** are placed in a test corner as follows:*

- *appliances normally placed on a floor or table in use, are placed on the floor as near to the walls as possible;*

- *appliances normally fixed to a wall are fixed to one of the walls, as near to the other wall and floor or ceiling as is likely to occur, taking into account the instructions;*
- *appliances normally fixed to a ceiling are fixed to the ceiling as near to the walls as is likely to occur, taking into account in the instructions.*

*Other **motor-operated appliances** are positioned as follows:*

- *appliances normally placed on a floor or table in use are placed on a horizontal support;*
- *appliances normally fixed to a wall are fixed to a vertical support;*
- *appliances normally fixed to a ceiling are fixed underneath a horizontal support.*

*Dull black-painted plywood approximately 20 mm thick is used for the test corner, the supports and for the installation of **built-in appliances**.*

For appliances provided with an automatic cord reel, one-third of the total length of the cord is unreeled. The temperature rise of the cord sheath is determined as near as possible to the hub of the reel and also between the two outermost layers of the cord on the reel.

*For cord storage devices, other than automatic cord reels, which are intended to accommodate the **supply cord** partially while the appliance is in operation, 50 cm of the cord is unwound. The temperature rise of the stored part of the cord is determined at the most unfavourable place.*

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

NOTE 1 Thermocouples having wires with a diameter not exceeding 0,3 mm are considered to be fine-wire thermocouples.

Thermocouples used for determining the temperature rise of the surface of walls, ceiling and floor of the test corner are attached to the back of small blackened disks of copper or brass, 15 mm in diameter and 1 mm thick. The front of the disk is flush with the surface of the board.

As far as is possible, the appliance is positioned so that the thermocouples detect the highest temperatures.

The temperature rise of electrical insulation, other than that of windings, is determined on the surface of the insulation at places where failure could cause

- *a short circuit;*
- *contact between **live parts** and **accessible metal parts**;*
- *bridging of insulation;*
- *a reduction of **clearances** or **creepage distances** below the values specified in Clause 29.*

NOTE 2 If it is necessary to dismantle the appliance to position thermocouples, care has to be taken to ensure that the appliance has been correctly reassembled. In case of doubt, the power input is remeasured.

NOTE 3 The point of separation of the cores of a multicore cord and the point where insulated wires enter lampholders are examples of places where thermocouples are positioned.

Temperature rises of windings are determined by the resistance method unless the windings are non-uniform or if it is difficult to make the necessary connections, in which case the temperature rise is determined by means of thermocouples. At the beginning of the test, the windings are to be at room temperature.

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

Δt *is the temperature rise of the winding;*

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*

- 225 for aluminium windings and copper/aluminium windings with an aluminium content ≥ 85 %,
- 229,75 for copper/aluminium windings with an copper content > 15 % to < 85 %,
- 234,5 for copper windings and copper/aluminium windings with an copper content ≥ 85 %;

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

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

NOTE 4 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.

11.4 Heating appliances are operated under **normal operation** and at 1,15 times **rated power input**.

11.5 Motor-operated appliances are operated under **normal operation** and supplied with the most unfavourable voltage between 0,94 times and 1,06 times the **rated voltage**.

11.6 Combined appliances are operated under **normal operation** and supplied with the most unfavourable voltage between 0,94 times and 1,06 times the **rated voltage**.

11.7 The appliance is operated for a duration corresponding to the most unfavourable conditions of normal use.

NOTE The duration of the test may consist of more than one cycle of operation.

11.8 During the test, the temperature rises are monitored continuously and shall not exceed the values shown in Table 3. The temperature rise limit for metal applies to parts having a metal coating at least 0,1 mm thick and to metal parts having a plastic coating less than 0,3 mm thick.

If the temperature rise of the motor winding exceeds the value specified in Table 3 or if there is doubt with regard to the temperature classification of the insulation of the motor, the tests of Annex C are carried out.

Protective devices shall not operate and sealing compound shall not flow out. However, components in **protective electronic circuits** are allowed to operate provided they are tested for the number of cycles of operation specified in 24.1.4.

Table 3 – Maximum normal temperature rises

Part	Temperature rise K
<i>Windings^a, if the winding insulation according to IEC 60085 is:</i> <ul style="list-style-type: none"> – class 105 (A) – class 120 (E) – class 130 (B) – class 155 (F) – class 180 (H) – class 200 (N) – class 220 (R) – class 250 	75 (65) 90 (80) 95 (85) 115 140 160 180 210
<i>Pins of appliance inlets:</i> <ul style="list-style-type: none"> – for very hot conditions – for hot conditions – for cold conditions 	130 95 45
<i>Terminals, including earthing terminals, for external conductors of stationary appliances, unless they are provided with a supply cord</i>	60
<i>Ambient of switches, thermostats and temperature limiters^b:</i> <ul style="list-style-type: none"> – without T-marking – with T-marking 	30 T-25
<i>Rubber, polychloroprene or polyvinyl chloride insulation of internal and external wiring, including supply cords:</i> <ul style="list-style-type: none"> – without temperature rating or with a temperature rating not exceeding 75 °C – with temperature rating (T) [†] where T exceeds 75 °C 	50 T-25
<i>Cord sheaths used as supplementary insulation</i>	35
<i>Sliding contacts of cord reels</i>	65
<i>Points where the insulation of wires can come into contact with parts of a terminal block or compartment for fixed wiring, for a stationary appliance not provided with a supply cord.</i>	50 ^c
<i>Rubber, other than synthetic, used for gaskets or other parts, the deterioration of which could affect safety:</i> <ul style="list-style-type: none"> – when used as supplementary insulation or as reinforced insulation – in other cases 	40 50
<i>Lampholders with T-marking^d</i> <ul style="list-style-type: none"> – B15 and B22 marked T1 – B15 and B22 marked T2 – other lampholders <i>Lampholders without T-marking^d</i> <ul style="list-style-type: none"> – E14 and B15 – B22, E26 and E27 – other lampholders and starter holders for fluorescent lamps 	140 185 T-25 110 140 55

Table 3 (continued)

Part	Temperature rise K
<p><i>Material used as insulation, other than that specified for wires and windings^e:</i></p> <ul style="list-style-type: none"> – <i>impregnated or varnished textile, paper or press-board</i> – <i>laminates bonded with:</i> <ul style="list-style-type: none"> • <i>melamine-formaldehyde, phenol-formaldehyde or phenol-furfural resins</i> • <i>urea-formaldehyde resin</i> – <i>printed circuit boards bonded with epoxy resin</i> – <i>moulding of:</i> <ul style="list-style-type: none"> • <i>phenol-formaldehyde with cellulose fillers</i> • <i>phenol-formaldehyde with mineral fillers</i> • <i>melamine-formaldehyde</i> • <i>urea-formaldehyde</i> – <i>polyester with glass reinforcement</i> – <i>silicone rubber</i> – <i>polytetrafluoroethylene</i> – <i>pure mica and tightly sintered ceramic material when such materials are used as supplementary insulation or reinforced insulation</i> – <i>thermoplastic material^f</i> 	<p>70</p> <p>85 (175) 65 (150)</p> <p>120</p> <p>85 (175) 100 (200) 75 (150) 65 (150)</p> <p>110</p> <p>145</p> <p>265</p> <p>400</p> <p>–</p>
<p><i>Wood, in general^g</i></p> <ul style="list-style-type: none"> – <i>Wooden supports, walls, ceiling and floor of the test corner and wooden cabinet:</i> <ul style="list-style-type: none"> • <i>stationary appliances liable to be operated continuously for long periods</i> • <i>other appliances</i> 	<p>65</p> <p>60 65</p>
<p><i>Outer surface of capacitors^h:</i></p> <ul style="list-style-type: none"> – <i>with marking of maximum operating temperature (T)ⁱ:</i> – <i>without marking of maximum operating temperature:</i> <ul style="list-style-type: none"> • <i>small ceramic capacitors for radio and television interference suppression</i> • <i>capacitors complying with IEC 60384-14</i> • <i>other capacitors</i> 	<p>T-25</p> <p>50 50 20</p>
<p><i>External enclosure of motor-operated appliances except handles held in normal use:</i></p> <ul style="list-style-type: none"> – <i>of bare metal</i> – <i>of coated metal</i> – <i>of glass and ceramic</i> – <i>of plastic having a thickness exceeding 0,3 mm</i> 	<p>50 60 65 75</p>
<p><i>Surfaces of handles, knobs, grips and similar parts which are continuously held in normal use (e.g. soldering irons):</i></p> <ul style="list-style-type: none"> – <i>of metal</i> – <i>of porcelain or vitreous material</i> – <i>of moulded material, rubber or wood</i> 	<p>30 40 50</p>
<p><i>Surfaces of handles, knobs, grips and similar parts which are held for short periods only in normal use (e.g. switches):</i></p> <ul style="list-style-type: none"> – <i>of metal</i> – <i>of porcelain or vitreous material</i> – <i>of moulded material, rubber or wood</i> 	<p>35 45 60</p>
<p><i>Parts in contact with oil having a flash-point of t °C</i></p>	<p>t-50</p>

Table 3 (continued)

NOTE 1 If other materials than those mentioned in the table are used, they are not to be subjected to temperatures in excess of their thermal capabilities as determined by ageing tests.

NOTE 2 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 3 The temperature of the terminals of switches is measured if the switch is tested in accordance with Annex H.

^a *To allow for the fact that the average temperature of windings of universal motors, relays, solenoids and similar components 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.*

The temperature rise limit of windings in transformers and inductors mounted on printed circuit boards is equal to the thermal class of the winding insulation reduced by 25 K provided the largest dimension of the winding does not exceed 5 mm in cross section or length.

For motors constructed so that the circulation of air between the inside and the outside of the case is prevented but which are not necessarily sufficiently enclosed to be considered airtight, the temperature rise limits may be increased by 5 K.

^b *T means the maximum ambient temperature in which the component or its switch head can operate.*

*The ambient is the temperature of the air at the hottest point at a distance of 5 mm from the surface of the component concerned. However, if a **thermostat** or a **temperature limiter** is mounted on a heat-conducting part, the declared temperature limit of the mounting surface (Ts) is also applicable. Therefore, the temperature rise of the mounting surface has to be measured.*

The temperature rise limit does not apply to switches or controls tested in accordance with the conditions occurring in the appliance.

^c *This limit may be exceeded if the instruction specified in 7.12.3 is supplied.*

^d *Locations for measuring the temperature rises are specified in Table 12.1 of IEC 60598-1.*

^e *The values in parentheses apply to locations where the part is fixed to a hot surface.*

^f *There is no specific limit for thermoplastic material. However, the temperature rise has to be determined in order that the tests of 30.1 can be carried out.*

^g *The limit specified concerns the deterioration of wood and it does not take into account deterioration of surface finishes.*

^h *There is no limit for the temperature rise of capacitors that are short-circuited in 19.11.*

ⁱ *Temperature marking for capacitors mounted on printed circuit boards may be given in the technical sheet.*

^j *IEC 60245 Types 53 and 57 **supply cords** have a T rating of 60 °C;*

*IEC 60245 Type 88 **supply cords** have a T rating of 70 °C;*

*IEC 60227 Types 52 and 53 **supply cords** have a T rating of 70 °C;*

*IEC 60227 Types 56 and 57 **supply cords** have a T rating of 90 °C.*

12 Void

13 Leakage current and electric strength at operating temperature

13.1 At operating temperature, the leakage current of the appliance shall not be excessive and its electric strength shall be adequate.

Compliance is checked by the tests of 13.2 and 13.3.

*The appliance is operated under **normal operation** for the duration specified in 11.7.*

***Heating appliances** are operated at 1,15 times the **rated power input**.*

Motor-operated appliances and combined appliances are supplied at 1,06 times **rated voltage**.

Three-phase appliances, which according to the instructions for installation are also suitable for single-phase supply, are tested as single-phase appliances with the three circuits connected in parallel.

Protective impedance and radio interference filters are disconnected before carrying out the tests.

13.2 For **class 0 appliances**, **class II appliances** and **class III appliances**, the leakage current is measured by means of the circuit described in Figure 4 of IEC 60990. For other appliances, a low impedance ammeter capable of measuring the true r.m.s. value of the leakage current may be used.

The leakage current is measured between any pole of the supply and **accessible metal parts** connected to metal foil having an area not exceeding 20 cm × 10 cm which is in contact with **accessible surfaces** of insulating materials.

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 to test all parts of the surface. The heat dissipation of the appliance is not to be affected by the metal foil.

For single-phase appliances, the measuring circuit is shown in the following figures:

- if of **class II**, Figure 1;
- if other than **class II**, Figure 2.

The leakage current is measured with the selector switch in each of the positions a and b.

For three-phase appliances, the measuring circuit is shown in the following figures:

- if of **class II**, Figure 3;
- if other than **class II**, Figure 4.

For three-phase appliances, the leakage current is measured with the switches a, b and c in the closed position. The measurements are then repeated with each of the switches a, b and c open in turn, the other two switches remaining closed. For appliances intended to be connected in star connection only, the neutral is not connected.

After the appliance has been operated for a duration as specified in 11.7, the leakage current shall not exceed the following values:

- | | |
|---|---|
| – for class II appliances | 0,35 mA peak |
| – for class 0 and class III appliances | 0,7 mA peak |
| – for class 0I appliances | 0,5 mA |
| – for portable class I appliances | 0,75 mA |
| – for stationary class I motor-operated appliances | 3,5 mA |
| – for stationary class I heating appliances | 0,75 mA or 0,75 mA per kW rated power input of the appliance with a maximum of 5 mA, whichever is higher |

For **combined appliances**, the total leakage current may be within the limits specified for **heating appliances** or **motor-operated appliances**, whichever is the greater, but the two limits are not added.

If the appliance incorporates capacitors and is provided with a single-pole switch, the measurements are repeated with the switch in the **off position**.

If the appliance incorporates a thermal control which operates during the test of Clause 11, the leakage current is measured immediately before the control opens the circuit.

NOTE 1 The test with the switch in the **off position** is carried out to verify that capacitors connected behind a single-pole switch do not cause an excessive leakage current.

NOTE 2 It is recommended that the appliance is supplied through an isolating transformer; otherwise it is to be insulated from earth.

13.3 The appliance is disconnected from the supply and the insulation is immediately subjected to a voltage having a frequency of 50 Hz or 60 Hz for 1 min, in accordance with IEC 61180-1.

The high-voltage source used for the test is to be capable of supplying a short circuit current I_s between the output terminals after the output voltage has been adjusted to the appropriate test voltage. The overload release of the circuit is not to be operated by any current below the tripping current I_r . The values of I_s and I_r are given in Table 5 for various high-voltage sources.

The test voltage is applied between **live parts** and **accessible parts**, non-metallic parts being covered with metal foil. For **class II constructions** having intermediate metal between **live parts** and **accessible parts**, the voltage is applied across the **basic insulation** and the **supplementary insulation**.

NOTE 1 Care should be taken to avoid overstressing the components of **electronic circuits**.

The values of the test voltages are specified in Table 4.

Table 4 – Voltage for electric strength test

Insulation	Test voltage V			
	Rated voltage ^a			Working voltage (U)
	SELV	≤150 V	>150 V and ≤250 V ^b	>250 V
Basic insulation	500	1 000	1 000	1,2 U + 700
Supplementary insulation		1 250	1 750	1,2 U + 1 450
Reinforced insulation		2 500	3 000	2,4 U + 2 400
^a For multi-phase appliances, the line to neutral or line to earth voltage is used for rated voltage . The test voltage for 480 V multi-phase appliances is that specified for a rated voltage in the range > 150 V and ≤ 250 V.				
^b For appliances having a rated voltage ≤ 150 V, these test voltages apply to parts having a working voltage > 150 V ≤ 250 V.				

No breakdown shall occur during the test.

NOTE 2 Glow discharges without drop in voltage are neglected.

Table 5 – Characteristics of high-voltage sources

Test voltage V	Minimum current mA	
	I_s	I_r
$\leq 4\,000$	200	100
$> 4\,000$ and $\leq 10\,000$	80	40
$> 10\,000$ and $\leq 20\,000$	40	20
NOTE The currents are calculated on the basis of the short circuit and release energies of 800 VA and 400 VA respectively at the upper end of the voltage ranges.		

14 Transient overvoltages

Appliances shall withstand the transient over-voltages to which they may be subjected.

*Compliance is checked by subjecting each **clearance** having a value less than those specified in Table 16 to an impulse voltage test.*

The impulse test voltage has a no-load wave shape corresponding to the 1,2/50 μ s standard impulse specified in IEC 61180-1. It is supplied from a generator having a conventional output impedance not exceeding 42 Ω . The impulse test voltage is applied three times for each polarity with intervals of at least 1 s.

NOTE 1 The generator is specified in IEC 61180-2.

*The impulse test voltage is specified in Table 6 for **rated impulse voltages** given in Table 15.*

Table 6 – Impulse test voltage

Rated impulse voltage V	Impulse test voltage V
330	357
500	540
800	930
1 500	1 750
2 500	2 920
4 000	4 920
6 000	7 380
8 000	9 840
10 000	12 300

*There shall be no flashover. However, flashover of **functional insulation** is allowed if the appliance complies with Clause 19 when the **clearance** is short-circuited.*

NOTE 2 The impulse test voltages have been calculated using correction factors for testing at locations situated at sea level. It is considered that they are appropriate for any location between sea level and 500 m. If tests are carried out at other locations, other correction factors should be used as noted in Subclause 6.1.2.2.1.3 of IEC 60664-1.

15 Moisture resistance

15.1 The enclosure of the appliance shall provide the degree of protection against moisture in accordance with the classification of the appliance.

Compliance is checked as specified in 15.1.1 taking into account 15.1.2, the appliance not being connected to the supply mains.

*The appliance shall then withstand the electric strength test of 16.3 and, after carefully wiping the external enclosure to remove any surplus water, an inspection shall show that there is no trace of water on insulation which could result in a reduction of **clearances** or **creepage distances** below the values specified in Clause 29.*

NOTE Care has to be taken when dismantling to avoid displacing any water within the appliance.

15.1.1 Appliances other than those classified IPX0 are subjected to the tests of IEC 60529 as follows:

- IPX1 appliances as described in Subclause 14.2.1;
- IPX2 appliances as described in Subclause 14.2.2;
- IPX3 appliances as described in Subclause 14.2.3a;
- IPX4 appliances as described in Subclause 14.2.4a;
- IPX5 appliances as described in Subclause 14.2.5;
- IPX6 appliances as described in Subclause 14.2.6;
- IPX7 appliances as described in Subclause 14.2.7. For this test the appliance is immersed in water containing approximately 1 % NaCl.

NOTE The hand-held spray nozzle may be used for testing appliances that cannot be placed under the oscillating tube specified in IEC 60529.

*Water valves containing **live parts** and that are incorporated in external hoses for connection of an appliance to the water mains are subjected to the test specified for IPX7 appliances.*

15.1.2 Hand-held appliances are turned continuously through the most unfavourable positions during the test.

Built-in appliances are installed in accordance with the instructions.

Appliances normally used on the floor or table are placed on a horizontal unperforated support having a diameter of twice the oscillating tube radius minus 15 cm.

Appliances normally fixed to a wall and appliances with pins for insertion into socket-outlets are mounted as in normal use in the centre of a wooden board having dimensions which are 15 cm \pm 5 cm in excess of those of the orthogonal projection of the appliance on the board. The wooden board is placed at the centre of the oscillating tube.

For IPX3 appliances, the base of wall-mounted appliances is placed at the same level as the pivot axis of the oscillating tube.

For IPX4 appliances, the horizontal centre line of the appliance is aligned with the pivot axis of the oscillating tube. However, for appliances normally used on the floor or table, the movement is limited to two times 90° from the vertical for a period of 5 min, the support being placed at the level of the pivot axis of the oscillating tube.

If the instructions for wall-mounted appliances state that the appliance is to be placed close to the floor level and specifies a distance, a board is placed under the appliance at that distance. The dimensions of the board are 15 cm more than the horizontal projection of the appliance.

Appliances normally fixed to a ceiling are mounted underneath a horizontal unperforated support that is constructed to prevent water spraying onto its top surface. The pivot axis of the oscillating tube is located at the same level as the underside of the support and aligned centrally with the appliance. The spray is directed upwards. For IPX4 appliances, the movement of the tube is limited to two times 90° from the vertical for a period of 5 min.

*Appliances with **type X attachment**, except those having a specially prepared cord, are fitted with the lightest permissible type of flexible cord of the smallest cross-sectional area specified in Table 13.*

***Detachable parts** are removed and subjected, if necessary, to the relevant treatment with the main part. However, if the instructions state that a part has to be removed for **user maintenance** and a **tool** is needed, this part is not removed.*

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

Compliance is checked by the following test.

*Appliances with **type X attachment**, except those having a specially prepared cord, are fitted with the lightest permissible type of flexible cord of the smallest cross-sectional area specified in Table 13.*

Appliances incorporating an appliance inlet are tested with or without an appropriate connector in position, whichever is most unfavourable.

***Detachable parts** are removed.*

The liquid container of the appliance 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.

*The appliance shall then withstand the electric strength test of 16.3 and inspection shall show that there is no trace of water on insulation that could result in a reduction of **clearances** or **creepage distances** below the values specified in Clause 29.*

15.3 Appliances shall be proof against humid conditions that may occur in normal use.

Compliance is checked by test Cab: Damp heat steady state in IEC 60068-2-78 under the following conditions.

Appliances that were subjected to the tests of 15.1 or 15.2 are placed in normal ambient conditions for 24 h.

*Cable entries, if any, are left open. If knock-outs are provided, one of them is opened. **Detachable parts** are removed and subjected, if necessary, to the humidity test with the main part.*

The humidity test is carried out for 48 h in a humidity cabinet containing air with a relative humidity of $(93 \pm 3) \%$. The temperature of the air is maintained within 2 K of any convenient

value t between 20 °C and 30 °C. Before being placed in the humidity cabinet, the appliance is brought to a temperature of t_0^{+4} °C.

NOTE If it is not possible to place the whole appliance in the humidity cabinet, parts containing electrical insulation may be tested separately, taking into account the conditions that the electrical insulation is subjected to within the appliance.

The appliance shall then withstand the tests of Clause 16 in the humidity cabinet or in the room in which the appliance was brought to the prescribed temperature after reassembly of those parts that may have been removed.

16 Leakage current and electric strength

16.1 The leakage current of the appliance shall not be excessive and its electric strength shall be adequate.

Compliance is checked by the tests of 16.2 and 16.3.

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

The tests are carried out on the appliance at room temperature and not connected to the supply mains.

16.2 An a.c. test voltage is applied between **live parts** and **accessible metal parts** that are connected to metal foil having an area not exceeding 20 cm × 10 cm in contact with **accessible surfaces** of insulating materials.

The test voltage is

- 1,06 times **rated voltage**, for single-phase appliances;
- 1,06 times **rated voltage**, divided by $\sqrt{3}$, for three-phase appliances.

The leakage current is measured within 5 s after the application of the test voltage.

The leakage current shall not exceed the following values:

- | | |
|---|---|
| – for class II appliances | 0,25 mA |
| – for class 0, class 0I and class III appliances | 0,5 mA |
| – for portable class I appliances | 0,75 mA |
| – for stationary class I motor-operated appliances | 3,5 mA |
| – for stationary class I heating appliances | 0,75 mA or 0,75 mA per kW rated power input of the appliance with a maximum of 5 mA, whichever is higher |

*The values specified above are doubled if all controls have an **off position** in all poles. They are also doubled if*

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

For **combined appliances**, the total leakage current may be within the limits specified for **heating appliances** or **motor-operated appliances**, whichever is the greater, but the two limits are not added.

For measuring the leakage current, a low impedance ammeter capable of measuring the true r.m.s. value of current may be used.

16.3 Immediately after the test of 16.2, the insulation is subjected to a voltage having a frequency of 50 Hz or 60 Hz for 1 min in accordance with IEC 61180-1. The values of the test voltage for different types of insulation are given in Table 7.

Accessible parts of insulating material are covered with metal foil.

NOTE 1 Care is to be taken that the metal foil is placed so that no flashover occurs at the edges of the insulation.

Table 7 – Test voltages

Insulation	Test voltage V			
	Rated voltage ^a			Working voltage (U)
	SELV	≤150 V	>150 V and ≤250 V ^b	>250 V
Basic insulation ^c	500	1 250	1 250	1,2 U + 950
Supplementary insulation ^c	–	1 250	1 750	1,2 U + 1 450
Reinforced insulation	–	2 500	3 000	2,4 U + 2 400

^a For multi-phase appliances, the line to neutral or line to earth voltage is used for **rated voltage**. The test voltage for 480 V multi-phase appliances is that specified for a **rated voltage** in the range > 150 V and ≤ 250 V.

^b For appliances having a **rated voltage** ≤150 V, these test voltages apply to parts having a **working voltage** > 150 V and ≤ 250 V.

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

A test voltage is applied between **accessible metal parts** and the **supply cord** which is wrapped with metal foil at the point where the **supply cord** is located in an inlet bushing and where, for appliances having a **type X attachment**, the **supply cord** is located in a cord guard or a cord anchorage with their clamping screws, if any, being tightened to two-thirds of the torque specified in Table 14. The test voltage is 1 250 V for **class 0 appliances** and **class I appliances** and 1 750 V for **class II appliances**.

NOTE 2 The characteristics of the high-voltage source used for the test are described in Table 5.

NOTE 3 For **class II constructions** incorporating both **reinforced insulation** and **double insulation**, care is to be taken that the voltage applied to the **reinforced insulation** does not overstress the **basic insulation** or the **supplementary insulation**.

NOTE 4 When testing insulating coatings, the metal foil may be pressed against the insulation by means of a sandbag so that the pressure is approximately 5 kPa. 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.

NOTE 5 If practicable, insulating linings should be tested separately.

NOTE 6 Care is to be taken to avoid overstressing the components of **electronic circuits**.

No breakdown shall occur during the test.

17 Overload protection of transformers and associated circuits

Appliances incorporating circuits supplied from a transformer shall be constructed so 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 with the transformer.

NOTE Examples are the short-circuiting of bare or inadequately insulated conductors of **accessible circuits** operating at **safety extra-low voltage**.

*Compliance is checked by applying the most unfavourable short circuit or overload which is likely to occur in normal use, the appliance being supplied with 1,06 times or 0,94 times **rated voltage**, whichever is the more unfavourable. **Basic insulation** is not short circuited.*

*The temperature rise of the insulation of the conductors of **safety extra-low voltage** circuits shall not exceed the relevant value specified in Table 3 by more than 15 K.*

The temperature of windings shall not exceed the values specified in Table 8. However, these limits do not apply to fail-safe transformers complying with Subclause 15.5 of IEC 61558-1.

18 Endurance

NOTE Requirements and tests are specified in part 2 when necessary.

19 Abnormal operation

19.1 Appliances shall be constructed so that as a result of abnormal or careless operation, the risk of fire, mechanical damage impairing safety or protection against electric shock is obviated as far as is practicable.

Electronic circuits shall be designed and applied so that a fault condition will not render the appliance unsafe with regard to electric shock, fire hazard, mechanical hazard or **dangerous malfunction**.

*Appliances incorporating heating elements are subjected to the tests of 19.2 and 19.3. In addition, such appliances having a control that limits the temperature during the test of Clause 11 are subjected to the tests of 19.4 and, when applicable, to the test of 19.5. Appliances incorporating **PTC heating elements** are also subjected to the test of 19.6.*

Appliances incorporating motors are subjected to the tests of 19.7 to 19.10, as applicable.

*Appliances incorporating **electronic circuits** are also subjected to the tests of 19.11 and 19.12, as applicable.*

Appliances incorporating contactors or relays are subjected to the test of 19.14.

Appliances incorporating voltage selector switches are subjected to the test of 19.15.

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

NOTE Fuses, **thermal cut-outs**, overcurrent protection devices, or similar devices incorporated in the appliance, may be used to provide the necessary protection. The **protective device** in the fixed wiring does not provide the necessary protection.

Unless otherwise specified, only one abnormal condition is simulated at any one time.

If more than one of the tests are applicable to the same appliance, these tests are carried out consecutively after the appliance has cooled down to room temperature.

*For **combined appliances**, the tests are carried out with motors and heating elements operating simultaneously under **normal operation**, the appropriate tests being applied one at a time to each motor and heating element.*

When it is stated that a control is short-circuited, it may be rendered inoperative instead.

Unless otherwise specified, compliance with the tests of this clause is checked as described in 19.13.

19.2 *Appliances with heating elements are tested under the conditions specified in Clause 11 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 **rated power input** under **normal operation** when the power input has stabilized. This voltage is maintained throughout the test.*

NOTE Controls that operate during the test of Clause 11 are allowed to operate.

19.3 *The test of 19.2 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 the power input has stabilized. This voltage is maintained throughout the test.*

NOTE Controls that operate during the test of Clause 11 are allowed to operate.

19.4 *The appliance is tested under the conditions specified in Clause 11. Any control that limits the temperature during the test of Clause 11 is short-circuited.*

If the appliance incorporates more than one control, they are short-circuited in turn.

19.5 *The test of 19.4 is repeated on **class 0I appliances** and **class I appliances** incorporating tubular sheathed or embedded heating elements. However, controls are not short-circuited but one end of the element is connected to the sheath of the heating element.*

This test is repeated with the polarity of the supply to the appliance reversed and with the other end of the element connected to the sheath.

*The test is not carried out on appliances intended to be permanently connected to fixed wiring and on appliances where an **all-pole disconnection** occurs during the test of 19.4.*

Appliances with a neutral are tested with the neutral connected to the sheath.

NOTE For embedded heating elements, the metal enclosure is considered to be the sheath.

19.6 *Appliances with **PTC heating elements** are supplied at **rated voltage** until steady conditions with regard to power input and temperature are established.*

*The **working voltage** of the **PTC heating element** is increased by 5 % and the appliance is operated until steady conditions are re-established. The voltage is then increased in similar steps until 1,5 times **working voltage** is reached, or until the **PTC heating element** ruptures, whichever occurs first.*

19.7 *The appliance is operated under stalled conditions by*

- *locking the rotor of appliances for which the locked rotor torque is smaller than the full load torque;*
- *locking moving parts of other appliances.*

If an appliance has more than one motor, the test is carried out for each motor separately.

Appliances incorporating motors and having capacitors in the circuit of an auxiliary winding, are operated with the rotor locked, the capacitors being open-circuited one at a time. The test is repeated with the capacitors short-circuited one at a time, unless they are of class P2 of IEC 60252-1.

NOTE 1 This test is carried out with the rotor locked since some motors may start thus giving rise to inconsistent results.

*For each of the tests, appliances provided with a timer or programmer are supplied at **rated voltage** for a period equal to the maximum period allowed by the timer or programmer.*

*Other appliances are supplied at **rated voltage** for a period*

- *of 30 s for*
 - ***hand-held appliances,***
 - *appliances that have to be kept switched on by hand or foot, and*
 - *appliances that are continuously loaded by hand;*
- *of 5 min for other appliances that are operated while attended;*
- *until steady conditions are established, for other appliances.*

NOTE 2 Appliances that are tested for 5 min are indicated in the relevant part 2.

During the test, the temperature of the windings shall not exceed the relevant value specified in Table 8.

Table 8 – Maximum winding temperature

Type of appliance	Temperature °C							
	<i>Class 105 (A)</i>	<i>Class 120 (E)</i>	<i>Class 130 (B)</i>	<i>Class 155 (F)</i>	<i>Class 180 (H)</i>	<i>Class 200 (N)</i>	<i>Class 220 (R)</i>	<i>Class 250</i>
<i>Appliances other than those operated until steady conditions are established</i>	200	215	225	240	260	280	300	330
<i>Appliances operated until steady conditions are established</i>								
– <i>if impedance protected</i>	150	165	175	190	210	230	250	280
– <i>if protected by a protective device</i>								
• <i>during the first hour, maximum value</i>	200	215	225	240	260	280	300	330
• <i>after the first hour, maximum value</i>	175	190	200	215	235	255	275	305
• <i>after the first hour, arithmetic average</i>	150	165	175	190	210	230	250	280

19.8 *One phase of appliances incorporating multi-phase motors is disconnected. The appliance is then operated under **normal operation** and supplied at **rated voltage** for the period specified in 19.7.*

19.9 A running overload test is carried out on appliances incorporating motors that are intended to be remotely or automatically controlled or liable to be operated continuously.

Motor-operated appliances and combined appliances for which Subclause 30.2.3 is applicable and that use overload **protective devices** relying on **electronic circuits** to protect the motor windings, other than those that sense winding temperatures directly, are also subjected to the running overload test.

The appliance is operated under **normal operation** and supplied at **rated voltage** until steady conditions are established. The load is then increased so that the current through the motor windings is raised by 10 % and the appliance is operated again until steady conditions are established, the supply voltage being maintained at its original value. The load is again increased and the test is repeated until the **protective device** operates or the motor stalls.

During the test, the winding temperature shall not exceed

- 140 °C, for class 105 (A) winding insulation;
- 155 °C, for class 120 (E) winding insulation;
- 165 °C, for class 130 (B) winding insulation;
- 180 °C, for class 155 (F) winding insulation;
- 200 °C, for class 180 (H) winding insulation;
- 220 °C, for class 200 (N) winding insulation;
- 240 °C, for class 220 (R) winding insulation;
- 270 °C, for class 250 winding insulation.

NOTE If the load cannot be increased in appropriate steps, the motor may be removed from the appliance and tested separately.

19.10 Appliances incorporating series motors are operated with the lowest possible load and supplied at 1,3 times **rated voltage** for 1 min.

During the test, parts shall not be ejected from the appliance.

19.11 Electronic circuits are checked by evaluation of the fault conditions specified in 19.11.2 for all circuits or parts of circuits, unless they comply with the conditions specified in 19.11.1.

NOTE 1 In general, examination of the appliance and its circuit diagram will reveal the fault conditions which have to be simulated, so that testing can be limited to those cases that may be expected to give the most unfavourable results.

Appliances incorporating an **electronic circuit** that relies upon a programmable component to function correctly are subjected to the test of 19.11.4.8, unless restarting at any point in the operating cycle after interruption of operation due to a supply voltage dip will not result in a hazard. The test is carried out after removal of all batteries and other components intended to maintain the programmable component supply voltage during mains supply voltage dips, interruptions and variations.

Appliances having a device with an **off position** obtained by electronic disconnection, or a device that can place the appliance in a stand-by mode, are subjected to the tests of 19.11.4.

NOTE 2 For information on general guidance relating to the sequence of tests for the evaluation of **electronic circuits**, reference should be made to Annex Q. It should be realized that in the Parts 2 there may be additional or alternative abnormal operation tests specified; these are not shown in the flow chart. For correct application of the standard, the normative text takes precedence over the guidance given in Annex Q.

If the safety of the appliance under any of the fault conditions depends on the operation of a miniature fuse-link complying with IEC 60127, the test of 19.12 is carried out.

*During and after each test, the temperature of windings shall not exceed the values specified in Table 8. However, these limits do not apply to fail-safe transformers complying with Subclause 15.5 of IEC 61558-1. The appliance shall comply with the conditions specified in 19.13. Any current flowing through **protective impedance** shall not exceed the limits specified in 8.1.4.*

NOTE 3 Unless it is necessary to replace components after any of the tests, the electric strength test required by 19.13 need only be carried out after the final test on the **electronic circuit**.

If a conductor of a printed circuit board becomes open-circuited, the appliance is considered to have withstood the particular test, provided both of the following conditions are met:

- *the base material of the printed circuit board withstands the test of Annex E;*
- *any loosened conductor does not reduce **clearances** or **creepage distances** between **live parts** and **accessible metal parts** below the values specified in Clause 29.*

19.11.1 *Fault conditions a) to g) specified in 19.11.2 are not applied to circuits or parts of circuits when both of the following conditions are met:*

- *the **electronic circuit** is a low-power circuit as described below;*
- *protection against electric shock, fire hazard, mechanical hazard or **dangerous malfunction** of other parts of the appliance does not rely on the correct functioning of the **electronic circuit**.*

An example of a low-power circuit is shown in Figure 6 and is determined as follows.

*The appliance is supplied at **rated voltage** and a variable resistor, adjusted to its maximum resistance, is connected between the point to be investigated and the opposite pole of the supply source. The resistance is then decreased until the power consumed by the resistor reaches a maximum. Points closest to the supply source at which the maximum power delivered to this resistor does not exceed 15 W at the end of 5 s are called low-power points. The part of the circuit farther from the supply source than a low-power point is considered to be a low-power circuit.*

NOTE 1 The measurements should be made from only one pole of the supply source, preferably the one that gives the fewest low-power points.

NOTE 2 When determining the low-power points, it is recommended to start with points close to the supply source.

NOTE 3 The power consumed by the variable resistor should be measured by a wattmeter.

19.11.2 *The following fault conditions are considered and, if necessary, applied one at a time, consequential faults being taken into consideration:*

- a) *short circuit of **functional insulation** if **clearances** or **creepage distances** are less than the values specified in Clause 29;*
- b) *open circuit at the terminals of any component;*
- c) *short circuit of capacitors, unless they comply with IEC 60384-14;*
- d) *short circuit of any two terminals of an **electronic component**, other than an integrated circuit. This fault condition is not applied between the two circuits of an optocoupler;*
- e) *failure of triacs in the diode mode;*
- f) *failure of microprocessors and integrated circuits except components such as thyristors and triacs. All possible output signals are considered for faults occurring within the component. If it can be shown that a particular output signal is unlikely to occur, then the relevant fault is not considered.*
- g) *failure of an electronic power switching device in a partial turn-on mode with loss of gate (base) control.*

NOTE 1 This mode may be simulated by disconnecting the electronic power switching device gate (base) terminal and connecting an external adjustable power supply between the gate (base) terminal and the source (emitter) terminal of the electronic power switching device. The power supply is then varied so as to achieve a current that will not damage the electronic power switching device but will give the most onerous conditions of test.

NOTE 2 Examples of electronic power switching devices are field effect transistors (FET's and MOSFET's) and bipolar transistors (including IGBT's).

Fault condition f) is applied to encapsulated and similar components if the circuit cannot be assessed by other methods.

Positive temperature coefficient resistors are not short-circuited if they are used within the manufacturer's specification. However, PTC-S thermistors are short-circuited unless they comply with IEC 60738-1.

In addition, each low-power circuit is short-circuited by connecting the low-power point to the pole of the supply source from which the measurements were made.

*For simulation of the fault conditions, the appliance is operated under the conditions specified in Clause 11 but supplied at **rated voltage**.*

When any of the fault conditions are simulated, the duration of the test is

- as specified in 11.7 but only for one operating cycle and only if the fault cannot be recognized by the user, for example, a change in temperature;*
- as specified in 19.7, if the fault can be recognized by the user, for example, when the motor of a kitchen machine stops;*
- until steady conditions are established, for circuits continuously connected to the supply mains, for example, stand-by circuits.*

In each case, the test is ended if a non-self-resetting interruption of the supply occurs within the appliance.

19.11.3 *If the appliance incorporates a **protective electronic circuit** which operates to ensure compliance with Clause 19, the relevant test is repeated with a single fault simulated, as indicated in a) to g) of 19.11.2.*

NOTE The compliance criteria applied for these tests are those detailed in 19.13.

19.11.4 *Appliances having a device with an **off position** obtained by electronic disconnection, or a device that can be placed in the stand-by mode, are subjected to the tests of 19.11.4.1 to 19.11.4.7. The tests are carried out with the appliance supplied at **rated voltage**, the device being set in the **off position** or in the stand-by mode.*

*Appliances incorporating a **protective electronic circuit** are subjected to the tests of 19.11.4.1 to 19.11.4.7. The tests are carried out after the **protective electronic circuit** has operated during the relevant tests of Clause 19 except 19.2, 19.6 and 19.11.3. However, appliances that are operated for 30 s or 5 min during the test of 19.7 are not subjected to the tests for electromagnetic phenomena.*

*The tests are carried out with surge **protective devices** disconnected, unless they incorporate spark gaps.*

NOTE 1 If the appliance has several modes of operation, the tests are carried out with the appliance operating in each mode, if necessary.

NOTE 2 Appliances incorporating electronic controls complying with the IEC 60730 series of standards are not exempt from the tests.

19.11.4.1 *The appliance is subjected to electrostatic discharges in accordance with IEC 61000-4-2, test level 4 being applicable. Ten discharges having a positive polarity and ten discharges having a negative polarity are applied at each preselected point.*

19.11.4.2 *The appliance is subjected to radiated fields in accordance with IEC 61000-4-3, test level 3 being applicable.*

The frequency ranges tested shall be 80 MHz to 1 000 MHz and 1,4 GHz to 2,0 GHz.

NOTE The dwell time for each frequency is to be sufficient to observe a possible malfunction of the protective electronic circuit.

19.11.4.3 *The appliance is subjected to fast transient bursts in accordance with IEC 61000-4-4. Test level 3 with a repetition rate of 5 kHz is applicable for signal and control lines. Test level 4 with a repetition rate of 5 kHz is applicable for the power supply lines. The bursts are applied for 2 min with a positive polarity and for 2 min with a negative polarity.*

19.11.4.4 *The power supply terminals of the appliance are subjected to voltage surges in accordance with IEC 61000-4-5, five positive impulses and five negative impulses being applied at the selected points. Test level 3 is applicable for the line-to-line coupling mode, a generator having a source impedance of 2 Ω being used. Test level 4 is applicable for the line-to-earth coupling mode, a generator having a source impedance of 12 Ω being used.*

*Earthed heating elements in **class I appliances** are disconnected during this test.*

NOTE If a feedback system depends on inputs related to a disconnected heating element, an artificial network may be needed.

For appliances having surge arresters incorporating spark gaps, the test is repeated at a level that is 95 % of the flashover voltage.

19.11.4.5 *The appliance is subjected to injected currents in accordance with IEC 61000-4-6, test level 3 being applicable. During the test, all frequencies between 0,15 MHz to 80 MHz are covered.*

NOTE The dwell time for each frequency is to be sufficient to observe a possible malfunction of the protective electronic circuit.

19.11.4.6 *For appliances having a **rated current** not exceeding 16 A, the appliance is subjected to the class 3 voltage dips and interruptions in accordance with IEC 61000-4-11. The values specified in Table 1 and Table 2 of IEC 61000-4-11 are applied at zero crossing of the supply voltage.*

*For appliances having a **rated current** exceeding 16 A, the appliance is subjected to the class 3 voltage dips and interruptions in accordance with IEC 61000-4-34. The values specified in Table 1 and Table 2 of IEC 61000-4-34 are applied at zero crossing of the supply voltage.*

19.11.4.7 *The appliance is subjected to mains signals in accordance with IEC 61000-4-13, Table 11 with test level class 2 using the frequency steps according to Table 10.*

19.11.4.8 *The appliance is supplied at **rated voltage** and operated under **normal operation**. After approximately 60 s, the power supply voltage is reduced to a level such that the appliance ceases to respond to user inputs or parts controlled by the programmable component cease to operate, whichever occurs first. This value of supply voltage is recorded. The appliance is supplied at **rated voltage** and operated under **normal operation**. The voltage is then reduced to a value of approximately 10 % less than the recorded voltage. It is held at this value for approximately 60 s and then increased to **rated voltage**. The rate of decrease and increase of the power supply voltage is to be approximately 10 V/s.*

The appliance shall continue to either operate normally from the same point in its operating cycle at which the voltage decrease occurred or a manual operation shall be required to restart it.

19.12 *If safety of the appliance depends upon the operation of a miniature fuse-link complying with IEC 60127 during any of the fault conditions specified in 19.11.2, the test is repeated but with the miniature fuse-link replaced by an ammeter. If the current measured*

- does not exceed 2,1 times the **rated current** of the fuse-link, the circuit is not considered to be adequately protected and the test is carried out with the fuse-link short-circuited;*
- is at least 2,75 times the **rated current** of the fuse-link, the circuit is considered to be adequately protected;*
- is between 2,1 times and 2,75 times the **rated current** of the fuse-link, the fuse link is short-circuited and the test is carried out*
 - for the relevant period or for 30 min, whichever is the shorter, for quick acting fuse-links;*
 - for the relevant period or for 2 min, whichever is the shorter, for time lag fuse-links.*

NOTE 1 In case of doubt, the maximum resistance of the fuse-link has to be taken into account when determining the current.

NOTE 2 The verification whether the fuse-link acts as a **protective device** is based on the fusing characteristics specified in IEC 60127, which also gives the information necessary to calculate the maximum resistance of the fuse-link.

NOTE 3 Other fuses are considered to be **intentionally weak parts** in accordance with 19.1.

19.13 *During the tests, the appliance shall not emit flames, molten metal, or poisonous or ignitable gas in hazardous amounts and temperature rises shall not exceed the values shown in Table 9.*

After the tests, and when the appliance has cooled to approximately room temperature, compliance with Clause 8 shall not be impaired and the appliance shall comply with 20.2 if it can still be operated.

Table 9 – Maximum abnormal temperature rise

Part	Temperature rise K
Wooden supports, walls, ceiling and floor of the test corner and wooden cabinets ^a	150
Insulation of the supply cord ^a without T marking, or with T marking up to 75 °C	150
Insulation of the supply cord ^a with T marking above 75 °C	T+75
Supplementary insulation and reinforced insulation other than thermoplastic materials ^b	1,5 times the relevant value specified in Table 3
^a For motor-operated appliances , these temperature rises are not determined.	
^b There is no specific limit for supplementary insulation and reinforced insulation of thermoplastic material. However, the temperature rise has to be determined so that the test of 30.1 can be carried out.	

*When the insulation, other than that of **class III appliances** or **class III constructions** that do not contain **live parts**, has cooled down to approximately room temperature, it shall withstand the electric strength test of 16.3, the test voltage, however, being as specified in Table 4.*

The humidity treatment of 15.3 is not applied before this electric strength test.

For appliances which are immersed in or filled with conducting liquid in normal use, the appliance is immersed in or filled with water for 24 h before the electric strength test is carried out.

*After the operation or interruption of a control, **clearances** and **creepage distances** across the **functional insulation** shall withstand the electric strength test of 16.3, the test voltage, however, being twice the **working voltage**.*

*The appliance shall not undergo a **dangerous malfunction**, and there shall be no failure of **protective electronic circuits** if the appliance is still operable.*

*Appliances tested with an electronic switch in the **off position**, or in the stand-by mode, shall*

- not become operational, or*
- if they become operational, not result in a **dangerous malfunction** during or after the tests of 19.11.4.*

NOTE Unintended operation that may impair safety, can result from careless use of appliances, such as:

- storage of small appliances while connected to the supply;
- placing flammable material on working surfaces of **heating appliances**; or
- placing objects in areas near motorized appliances that are not expected to start.

In an appliance containing lids or doors that are controlled by one or more interlocks, one of the interlocks may be released provided that both of the following conditions are fulfilled:

- the lid or door does not move automatically to an open position when the interlock is released;*
- the appliance will not restart after the cycle in which the interlock was released.*

19.14 *Appliances are operated under the conditions of Clause 11. Any contactor or relay contact that operates under the conditions of Clause 11 is short-circuited.*

If a relay or contactor with more than one contact is used, all contacts are short-circuited at the same time.

Any relay or contactor which operates only in order to ensure that the appliance is energized for normal use and that does not otherwise operate in normal use is not short-circuited.

If more than one relay or contactor operates in Clause 11, each such relay or contactor is short-circuited in turn.

NOTE If the appliance has several modes of operation, the tests are carried out with the appliance operating in each mode, if necessary.

19.15 *For appliances incorporating a mains voltage selector switch, this switch is set to the lowest **rated voltage** position and the highest value of **rated voltage** is applied.*

20 Stability and mechanical hazards

20.1 *Appliances, other than **fixed appliances** and **hand-held appliances**, intended to be used on a surface such as the floor or a table, shall have adequate stability.*

Compliance is checked by the following test, appliances incorporating an appliance inlet being fitted with an appropriate connector and flexible cord.

*The appliance, not connected to the supply mains, is placed in any normal position of use on a plane inclined at an angle of 10° to the horizontal, the **supply cord** resting on the inclined plane in the most unfavourable position. However, if part of an appliance comes into contact with the horizontal supporting surface when the appliance is tilted through an angle of 10°, the appliance is placed on a horizontal support and tilted in the most unfavourable direction through an angle of 10°.*

NOTE The test on the horizontal support may be necessary for appliances provided with rollers, castors or feet. In this case, castors or wheels may be blocked to prevent the appliance from rolling.

Appliances provided with doors are tested with the doors open or closed, whichever is the more unfavourable.

Appliances intended to be filled with liquid by the user in normal use are tested empty or filled with the most unfavourable quantity of water up to the capacity indicated in the instructions.

The appliance shall not overturn.

The test is repeated on appliances with heating elements with the angle of inclination increased to 15°. If the appliance overturns in one or more positions, it is subjected to the tests of Clause 11 in each of these overturned positions.

During this test, temperature rises shall not exceed the values shown in Table 9.

20.2 Moving parts of appliances shall, as far as is compatible with the use and working of the appliance, be positioned or enclosed to provide adequate protection against personal injury in normal use. This requirement does not apply to parts of an appliance that necessarily have to be exposed to allow the appliance to perform its working function.

NOTE 1 Examples of parts of appliances necessarily exposed to perform the working function include the needle of a sewing machine, rotating brushes of vacuum cleaner and the blade of an electrical knife.

Protective enclosures, guards and similar parts shall be **non-detachable parts** and shall have adequate mechanical strength. However, enclosures that can be opened by overriding an interlock by applying the test probe are considered to be **detachable parts**.

The unexpected closure of **self-resetting thermal cut-outs** and overcurrent **protective devices** shall not cause a hazard.

NOTE 2 An example of an appliance in which **self-resetting thermal cut-outs** and overcurrent **protective devices** could cause a hazard is a food mixer.

Compliance is checked by inspection, by the test of 21.1 and by applying a force not exceeding 5 N by means of a test probe that is similar to test probe B of IEC 61032 but having a circular stop face with a diameter of 50 mm, instead of the non-circular face.

For appliances provided with movable devices such as those intended for varying the tension of belts, the test with the test probe is carried out with these devices adjusted to the most unfavourable position within their range of adjustment. If necessary, belts are removed.

It shall not be possible to touch dangerous moving parts with this test probe.

21 Mechanical strength

21.1 Appliances shall have adequate mechanical strength and be constructed to withstand such rough handling that may be expected in normal use.

Compliance is checked by applying blows to the appliance in accordance with test Ehb of IEC 60068-2-75, the spring hammer test.

The appliance is rigidly supported and three blows, having an impact energy of 0,5 J, are applied to every point of the enclosure that is likely to be weak.

If necessary, the blows are also applied to handles, levers, knobs and similar parts and to signal lamps and their covers but only if the lamps or covers protrude from the enclosure by more than 10 mm or if their surface area exceeds 4 cm². Lamps within the appliance and their covers are only tested if they are likely to be damaged in normal use.

NOTE When applying the release cone to the guard of a **visibly glowing heating element**, care is to be taken that the hammer head passing through the guard does not strike the heating element.

*After the test, the appliance shall show no damage that could impair compliance with this standard and compliance with 8.1, 15.1 and Clause 29 shall not be impaired. In case of doubt, **supplementary insulation** and **reinforced insulation** are subjected to the electric strength test of 16.3.*

*Damage to the finish, small dents that do not reduce **clearances** or **creepage distances** below the values specified in Clause 29, and small chips that do not adversely affect protection against access to **live parts** or moisture, are ignored.*

If a decorative cover is protected by an inner cover, fracture of the decorative cover is ignored if the inner cover itself withstands the test.

If there is doubt as to whether a defect has occurred by the application of the preceding blows or the previous tests, this defect is neglected and the group of three blows is applied to the same place on a new sample which shall then withstand the test.

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

21.2 Accessible parts of solid insulation shall have sufficient strength to prevent penetration by sharp implements.

*Compliance is checked by subjecting the insulation to the following test, unless the thickness of **supplementary insulation** is at least 1 mm and that of **reinforced insulation** is at least 2 mm.*

The insulation is raised to the temperature measured during the test of Clause 11. The surface of the insulation is then scratched by means of a hardened steel pin, the end of which has the form of a cone with an angle of 40°. Its tip is rounded with a radius of 0,25 mm ± 0,02 mm. The pin is held at any angle from 80° to 85° to the horizontal and loaded so that the force exerted along its axis is 10 N ± 0,5 N. The scratches are made by drawing the pin along the surface of the insulation at a speed of approximately 20 mm/s. Two parallel scratches are made. They are spaced sufficiently apart so that they are not affected by each other, their length covering approximately 25 % of the length of the insulation. Two similar scratches are made at 90° to the first pair without crossing them.

The test fingernail of Figure 7 is then applied to the scratched surface with a force of approximately 10 N. No further damage, such as separation of the material, shall occur. The insulation shall then withstand the electric strength test of 16.3.

The hardened steel pin is then applied perpendicularly with a force of 30 N ± 0,5 N to an unscratched part of the surface. The insulation shall then withstand the electric strength test of 16.3 with the pin still applied and used as one of the electrodes.

22 Construction

22.1 If the appliance is marked with the first numeral of the IP system, the relevant requirements of IEC 60529 shall be fulfilled.

Compliance is checked by the relevant tests.

22.2 For **stationary appliances**, means shall be provided to ensure **all-pole disconnection** from the supply mains. Such means shall be one of the following:

- a **supply cord** fitted with a plug;
- a switch complying with 24.3;
- a statement in the instructions that a disconnection incorporated in the fixed wiring is to be provided;
- an appliance inlet.

Single-pole switches and single-pole **protective devices** that disconnect heating elements from the supply mains in single-phase, permanently connected **class 0I appliances** and **class I appliances** shall be connected to the phase conductor.

Compliance is checked by inspection.

22.3 Appliances with pins for insertion into socket-outlets shall not impose undue strain on these socket-outlets. The means for retaining the pins shall withstand the forces to which the pins are likely to be subjected in normal use.

Compliance is checked by inserting the pins of the appliance into a socket-outlet without earthing contact. The socket-outlet has a horizontal pivot at a distance of 8 mm behind the engagement face of the socket-outlet and in the plane of the contact tubes.

The torque that has to be applied to maintain the engagement face of the socket-outlet in the vertical plane shall not exceed 0,25 Nm.

NOTE The torque to keep the socket-outlet itself in the vertical plane is not included in this value.

A new sample of the appliance is firmly held so that the retention of the pins is not affected. The appliance is placed in a heating cabinet for 1 h at a temperature of $70\text{ °C} \pm 2\text{ °C}$. The appliance is then removed from the heating cabinet and a pull force of 50 N is immediately applied for 1 min to each pin along their longitudinal axes.

When the appliance has cooled down to room temperature, the pins shall not have been displaced by more than 1 mm.

Each pin is then subjected in turn to a torque of 0,4 Nm, which is applied for 1 min in each direction. The pins shall not rotate unless rotation does not impair compliance with this standard.

22.4 Appliances for heating liquids and appliances causing undue vibration shall not be provided with pins for insertion into socket-outlets.

Compliance is checked by inspection.

22.5 Appliances intended to be connected to the supply mains by means of a plug shall be constructed so that in normal use there is no risk of electric shock from charged capacitors having a rated capacitance exceeding 0,1 μF , when the pins of the plug are touched.

Compliance is checked by the following test.

*The appliance is supplied at **rated voltage**. Any switch is then placed in the **off position** and the appliance is disconnected from the supply mains at the instant of voltage peak. One second after disconnection, the voltage between the pins of the plug is measured with an instrument that does not appreciably affect the value to be measured.*

The voltage shall not exceed 34 V.

22.6 Appliances shall be constructed so that their electrical insulation cannot be affected by water that could condense on cold surfaces or by liquid that could leak from containers, hoses, couplings and similar parts of the appliance. The electrical insulation of **class II appliances** and **class II constructions** shall not be affected if a hose ruptures or a seal leaks.

Compliance is checked by inspection and, in case of doubt, by the following test.

Drops of coloured water solution are applied by a syringe to parts inside the appliance where leakage of a liquid could occur and affect electrical insulation. The appliance is in operation or at rest, whichever is the more unfavourable.

*After this test, inspection shall show that there is no trace of liquid on windings or insulation that could result in a reduction of **creepage distances** below the values specified in 29.2.*

22.7 Appliances containing liquid or gases in normal use or having steam-producing devices shall incorporate adequate safeguards against the risk of excessive pressure.

Compliance is checked by inspection and, if necessary, by an appropriate test.

22.8 For appliances having compartments to which access can be gained without the aid of a **tool** and that are likely to be cleaned in normal use, the electrical connections shall be arranged so that they are not subject to pulling during cleaning.

Compliance is checked by inspection and by manual test.

22.9 Appliances shall be constructed so that parts such as insulation, internal wiring, windings, commutators and slip rings are not exposed to oil, grease or similar substances, unless the substance has adequate insulating properties so that compliance with the standard is not impaired.

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

22.10 It shall not be possible to reset voltage-maintained **non-self-resetting thermal cut-outs** by the operation of an automatic switching device incorporated within the appliance. This requirement is only applicable if a **non-self-resetting thermal cut-out** is required by the standard and a voltage maintained **non-self-resetting thermal cut-out** is used to meet it.

NOTE 1 Voltage-maintained controls are intended to automatically reset if they become de-energized.

Non-self-resetting thermal motor protectors shall have a trip-free action unless they are voltage maintained.

NOTE 2 Trip-free is an automatic action that is independent of manipulation or position of the actuating member.

Reset buttons of **non-self-resetting controls** shall be located or protected so that their accidental resetting is unlikely to occur if this could result in a hazard.

NOTE 3 For example, this requirement precludes the location of reset buttons on the back of an appliance, which could result in them being reset by pushing the appliance against a wall.

Compliance is checked by inspection.

22.11 Non-detachable parts that protect against access to **live parts**, moisture or contact with moving parts shall be fixed in a reliable manner and withstand the mechanical stress occurring during 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 that are likely to be removed during installation or servicing shall be reliable.

Compliance is checked by the following tests.

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

NOTE Servicing includes replacement of the **supply cord**, except in appliances with a **Type Z attachment**.

The test is carried out at room temperature. However, if compliance may be affected by the temperature of the appliance, the test is also carried out immediately after it has been operated under the conditions specified in Clause 11.

The test is applied to all parts that 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 parts likely to be weak. The force is as follows:

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

The push force is applied by test probe 11 of IEC 61032.

The pull force is applied by a suitable means, such as a suction cup, so that the test results are not affected. While the force is being applied, the test fingernail of 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 but is not twisted or used as a lever.

If the shape of the part is such that an axial pull is unlikely, the pull force is not applied but the test fingernail 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 part is likely to be twisted, the following torque is applied at the same time as the pull or push force:

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

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 torque is reduced by 50 %.

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

22.12 Handles, knobs, grips, levers and similar parts shall be fixed in a reliable manner so that they will not work loose in normal use if loosening could result in a hazard. If these parts are used to indicate the position of switches or similar components, it shall not be possible to fix them incorrectly if this could result in a hazard.

NOTE Sealing compound and similar materials, other than self-hardening resins, are not considered to be adequate to prevent loosening.

Compliance is checked by inspection, by manual test and by trying to remove the part by applying an axial force of

- 15 N, if an axial pull is unlikely to be applied in normal use;
- 30 N, if an axial pull is likely to be applied in normal use.

The force is applied for 1 min.

22.13 Appliances shall be constructed so that when handles are gripped in normal use, contact is unlikely between the operator's hand and parts having a temperature rise exceeding the value specified in Table 3 for handles which are held for short periods only in normal use.

Compliance is checked by inspection and, if necessary, by determining the temperature rise.

22.14 Appliances shall have no ragged or sharp edges, other than those necessary for the functioning of the appliance, which could create a hazard for the user in normal use or during **user maintenance**.

Pointed ends of self-tapping screws or other fasteners shall be located so that they are unlikely to be touched by the user in normal use or during **user maintenance**.

Compliance is checked by inspection.

22.15 Storage hooks and similar devices for flexible cords shall be smooth and well-rounded.

Compliance is checked by inspection.

22.16 Automatic cord reels shall be constructed so that they do not cause

- undue abrasion or damage to the sheath of the flexible cord;
- breakage of conductor strands;
- undue wear of contacts.

Compliance is checked by the following test, which is carried out without passing current through the flexible cord.

Two-thirds of the length of the cord is unreeled. If the withdrawable length of the cord is less than 225 cm, the cord is unreeled so that a length of 75 cm remains on the reel. An additional length of 75 cm of the cord is then unreeled and pulled in a direction so that the greatest abrasion occurs to the sheath, taking into account the normal position of use of the appliance. Where the cord leaves the appliance, the angle between the axis of the cord during the test and the axis of the cord when it is unreeled without substantial resistance is approximately 60°. The cord is allowed to be recoiled by the reel.

If the cord does not recoil at the angle of 60°, this angle is adjusted to the maximum that will allow recoil.

The test is carried out 6 000 times at a rate of approximately 30 times per minute or at the maximum rate allowed by the construction of the cord reel if this is less.

NOTE It may be necessary to interrupt the test to allow the cord to cool.

After this test, the cord and cord reel are inspected. In case of doubt the cord is subjected to the electric strength test of 16.3, a test voltage of 1 000 V being applied between the conductors of the cord connected together and metal foil wrapped around the cord.

22.17 Spacers intended to prevent the appliance from overheating walls shall be fixed so that it is not possible to remove them from the outside of the appliance by hand or by means of a screwdriver or a spanner.

Compliance is checked by inspection and by manual test.

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

NOTE 1 Stainless steel and similar corrosion-resistant alloys and plated steel are considered to be satisfactory for the purpose of this requirement.

Compliance is checked by verifying that after the tests of Clause 19, the relevant parts show no sign of corrosion.

NOTE 2 Attention is to be paid to the compatibility of the materials of terminals and to the effect of heating.

22.19 Driving belts shall not be relied upon to provide the required level of insulation unless they are constructed to prevent inappropriate replacement.

Compliance is checked by inspection.

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

NOTE 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.

Compliance is checked by inspection and, if necessary, by appropriate tests.

22.21 Wood, cotton, silk, ordinary paper and similar fibrous or hygroscopic material shall not be used as insulation, unless impregnated. This requirement does not apply to magnesium oxide and mineral ceramic fibres used for the electrical insulation of heating elements.

NOTE 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.

22.22 Appliances shall not contain asbestos.

Compliance is checked by inspection.

22.23 Oils containing polychlorinated biphenyl (PCB) shall not be used in appliances.

Compliance is checked by inspection.

22.24 Bare heating elements, other than those in **class III appliances** or **class III constructions** that do not contain **live parts**, shall be supported so that the heating conductor is unlikely to come into contact with **accessible metal parts** if they rupture.

Compliance is checked by inspection after cutting the heating conductor in the most unfavourable place. No force is applied to the conductor after it has been cut.

22.25 Appliances shall be constructed so that sagging heating conductors cannot come into contact with **accessible metal parts**. This requirement does not apply to **class III appliances** or **class III constructions** that do not contain **live parts**.

Compliance is checked by inspection.

NOTE This requirement may be met by providing **supplementary insulation** or a core which effectively prevents the heating conductor from sagging.

22.26 Appliances having parts of **class III construction** shall be constructed so 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**.*

22.27 Parts connected by **protective impedance** shall be separated by **double insulation** or **reinforced insulation**.

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

22.28 For **class II appliances** connected in normal use to the gas mains or to the water mains, metal parts conductively connected to the gas pipes or in contact with the water shall be separated from **live parts** by **double insulation** or **reinforced insulation**.

Compliance is checked by inspection.

22.29 **Class II appliances** intended to be permanently connected to fixed wiring shall be constructed so that the required degree of access to **live parts** is maintained after installation.

NOTE The protection against access to **live parts** may be affected, for example, by the installation of metal conduits or cables provided with a metal sheath.

Compliance is checked by inspection.

22.30 Parts of **class II construction** which serve as **supplementary insulation** or **reinforced insulation**, and which could be omitted during reassembly after servicing, shall be

- fixed so that they cannot be removed without being seriously damaged,
- or
- constructed so that they cannot be replaced in an incorrect position and if they are omitted, the appliance is rendered inoperable or manifestly incomplete.

NOTE Servicing includes replacement of components such as **supply cords** except in appliances having a **Type Z attachment** and switches.

Compliance is checked by inspection and by manual test.

22.31 Neither **clearances** nor **creepage distances** over **supplementary insulation** and **reinforced insulation** shall be reduced below the values specified in Clause 29 as a result of wear.

If a part, such as a wire, screw, nut or spring, becomes loose or falls out of position, neither **clearances** nor **creepage distances** between **live parts** and **accessible parts** shall be reduced below the values specified for **supplementary insulation**. This requirement does not apply if:

- parts are fixed by means of screws or nuts and locking washers provided that these screws or nuts are not required to be removed during the replacement of the **supply cord** or other servicing;
- short rigid wires remain in position when the terminal screw is loosened;
- parts are held in place with two independent fixings that are not expected to become loose at the same time;
- wires connected by soldering are held in place near the terminals independently of the solder;
- wires connected to terminals have an additional fixing provided near the terminal, so that in the case of stranded conductors, the fixing clamps both the insulation and conductor.

With the appliance in its normal position of use, compliance is checked by inspection, by manual test and by measurement.

22.32 Supplementary insulation and reinforced insulation shall be constructed or protected so that the deposition of pollution resulting from wear of parts within the appliance does not reduce **clearances** or **creepage distances** below the values specified in Clause 29.

Parts of natural or synthetic rubber used as **supplementary insulation** shall be resistant to ageing or be located and dimensioned so that **creepage distances** are not reduced below the values specified in 29.2, even if cracks occur.

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

Insulating material in which heating conductors are embedded is considered to be **basic insulation** and not **reinforced insulation**. This requirement is not applicable to heating conductors in **PTC heating elements**.

Compliance is checked by inspection and by measurement.

If the rubber part has to be resistant to ageing, the following test is carried out.

The part is suspended freely in an oxygen bomb, the effective capacity of the bomb being at least 10 times the volume of the part. The bomb is filled with oxygen not less than 97 % pure, to a pressure of 2,1 MPa \pm 0,07 MPa and maintained at a temperature of 70 °C \pm 1 °C.

NOTE The use of the oxygen bomb presents some danger unless handled with care. Precautions should be taken to avoid the risk of explosion due to sudden oxidation.

The part is kept in the bomb for 96 h. It is then removed from the bomb and left at room temperature out of direct sunlight for at least 16 h.

The part is then examined and shall show no crack visible to the naked eye.

In case of doubt, the following test is carried out to determine if ceramic material is tightly sintered.

The ceramic material is broken into pieces that are immersed in a solution containing 1 g of fuchsine in each 100 g of methylated spirit. The solution is maintained at a pressure not less than 15 MPa for a period so that the product of the test duration in hours and the test pressure in megapascals is approximately 180.

The pieces are removed from the solution, rinsed, dried and broken into smaller pieces.

The freshly broken surfaces are examined and shall not show any trace of dye visible to the naked eye.

22.33 Conductive liquids that are or may become accessible in normal use and conductive liquids that are in contact with unearthed **accessible metal parts** shall not be in direct contact with **live parts**. Electrodes shall not be used for heating liquids.

For **class II construction**, conductive liquids that are or may become accessible in normal use and conductive liquids that are in contact with unearthed **accessible metal parts** shall not be in direct contact with **basic insulation** or **reinforced insulation** unless the **reinforced insulation** consists of at least 3 layers.

For **class II construction**, conductive liquids which are in contact with **live parts** shall not be in direct contact with **reinforced insulation** unless the **reinforced insulation** consists of at least 3 layers.

An air layer shall not be used as **basic insulation** or **supplementary insulation** in a **double insulation** system if it is likely to be bridged by leaking liquid.

Compliance is checked by inspection.

22.34 Shafts of operating knobs, handles, levers and similar parts shall not be live unless the shaft is inaccessible when the part is removed.

Compliance is checked by inspection and by applying the test probe as specified in 8.1 after removal of the part even with the aid of a tool.

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

For **stationary appliances**, this requirement does not apply to handles, levers and knobs, other than those of electrical components, provided that they are reliably connected to an earthing terminal or earthing contact or separated from **live parts** by earthed metal.

Compliance is checked by inspection and if necessary by the relevant tests.

*Insulating material covering metal handles, levers and knobs shall withstand the electric strength test of 16.3 specified for **supplementary insulation**.*

22.36 For appliances other than those of **class III**, handles which are continuously held in the hand in normal use shall be constructed so that when gripped 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.

22.37 For **class II appliances**, 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 22.42.

Compliance is checked by inspection and by the relevant tests.

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

Compliance is checked by inspection.

22.39 Lampholders shall be used only for the connection of lamps.

Compliance is checked by inspection.

22.40 Motor-operated appliances and combined appliances which are intended to be moved while in operation, or which have **accessible moving parts**, shall be fitted with a switch to control the motor. The actuating member of this switch shall be easily visible and accessible.

Unless the appliance can operate continuously, automatically or remotely without giving rise to a hazard, appliances for **remote operation** shall be fitted with a switch for stopping the operation of the appliance. The actuating member of this switch shall be easily visible and accessible.

NOTE Examples of appliances that can operate continuously, automatically or remotely without giving rise to a hazard are fans, storage water heaters, air conditioners, refrigerators and drives for awnings, windows, doors, gates and rolling shutters.

Compliance is checked by inspection.

22.41 Appliances shall not incorporate components, other than lamps, containing mercury.

Compliance is checked by inspection.

22.42 Protective impedance shall consist of at least two separate components. If any one of the components is short-circuited or open-circuited, the values specified in 8.1.4 shall not be exceeded.

Component impedances shall be unlikely to change significantly during the lifetime of the appliance.

Compliance is checked by inspection and by measurement and if necessary, for resistors and capacitors by the following tests.

*Resistors are checked by the test of 14.1 a) in IEC 60065 and capacitors are checked by the tests for class Y capacitors in IEC 60384-14 appropriate to the **rated voltage** of the appliance.*

22.43 Appliances which can be adjusted for different voltages shall be constructed so that accidental changing of the setting is unlikely to occur.

Compliance is checked by manual test.

22.44 Appliances shall not have an enclosure that is shaped or decorated like a toy.

NOTE Examples of such enclosures are those representing animals, characters, persons or scale models.

Compliance is checked by inspection.

22.45 When air is used as **reinforced insulation**, the appliance shall be constructed so that **clearances** cannot be reduced below the values specified in 29.1.3 due to deformation as a result of an external force applied to the enclosure.

NOTE 1 A sufficiently rigid construction is considered to meet this requirement.

NOTE 2 Deformation due to manhandling the appliance has to be taken into account.

Compliance is checked by inspection and by manual test.

22.46 If programmable **protective electronic circuits** are used to ensure compliance with this standard, the software shall contain measures to control the fault/error conditions specified in Table R.1.

Software that contains measures to control the fault/error conditions specified in Table R.2 is to be specified in parts 2 for particular constructions or to address specific hazards, if necessary.

These requirements are not applicable to software used for functional purpose or for compliance with Clause 11.

Compliance is checked by evaluating the software in accordance with the relevant requirements of Annex R.

*If the software is modified, the evaluation and relevant tests are repeated if the modification influences the results of the test involving **protective electronic circuits**.*

NOTE Measures used for software to control the fault/error conditions specified in Table R.2 are inherently acceptable for measures used for software to control the fault/error conditions specified in Table R.1.

22.47 Appliances intended to be connected to the water mains shall withstand the water pressure expected in normal use.

Compliance is checked by connecting the appliance to a water supply having a static pressure equal to twice the maximum inlet water pressure or 1,2 MPa, whichever is higher, for a period of 5 min.

There shall be no leakage from any part, including any inlet water hose.

22.48 Appliances intended to be connected to the water mains shall be constructed to prevent backsiphonage of non-potable water into the water mains.

Compliance is checked by the relevant tests of IEC 61770.

22.49 For **remote operation**, the duration of operation shall be set before the appliance can be started unless the appliance switches off automatically at the end of a cycle or it can operate continuously without giving rise to a hazard.

Compliance is checked by inspection.

NOTE For appliances such as ovens, the duration of operation has to be set before the appliance can be started. Washing machines and dishwashers are examples of appliances that switch off automatically at the end of a cycle. Fans, storage water heaters, air conditioners and refrigerators are examples of appliances that can operate continuously without giving rise to a hazard.

22.50 Controls incorporated in the appliance, if any, shall take priority over controls actuated by **remote operation**.

Compliance is checked by inspection and by appropriate tests if necessary.

22.51 A control on the appliance shall be manually adjusted to the setting for **remote operation** before the appliance can be operated in this mode. There shall be a visual indication on the appliance showing that the appliance is adjusted for **remote operation**. The manual setting and the visual indication of the remote mode are not necessary on appliances that can

- operate continuously, or
- operate automatically, or
- be operated remotely,

without giving rise to a hazard.

Compliance is checked by inspection.

NOTE Examples of appliances that can operate continuously, automatically or remotely without giving rise to a hazard are fans, storage water heaters, air conditioners, refrigerators and drives for awnings, windows, doors, gates and rolling shutters.

22.52 Socket-outlets on appliances accessible to the user shall be in accordance with the socket-outlet system used in the country in which the appliance is sold.

Compliance is checked by inspection.

23 Internal wiring

23.1 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 or similar edges which may cause damage to their insulation.

Holes in metal through which insulated wires pass shall have smooth well-rounded surfaces or be provided with bushings.

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

Compliance is checked by inspection.

23.2 Beads and similar ceramic insulators on live wires shall be fixed or located so that they cannot change their position or rest on sharp edges. If beads are inside flexible metal conduits, they shall be contained within an insulating sleeve, unless the conduit cannot move in normal use.

Compliance is checked by inspection and by manual test.

23.3 Different parts of an appliance that can move relative to each other in normal use or during **user maintenance** shall not cause undue stress to electrical connections and internal conductors, including those providing earthing continuity. Flexible metallic tubes shall not cause damage to the insulation of the conductors contained within them. Open-coil springs shall not be used to protect the wiring. If a coiled spring, the turns of which touch one another, is used for this purpose, there shall be an adequate insulating lining in addition to the insulation of the conductors.

NOTE 1 The sheath of a flexible cord complying with IEC 60227 or IEC 60245 is regarded as an adequate insulating lining.

Compliance is checked by inspection and by the following test.

*If flexing occurs in normal use, the appliance is placed in the normal position of use and is supplied at **rated voltage** and operated under **normal operation**.*

The movable part is moved backwards and forwards, so that the conductor is flexed through the largest angle allowed by the construction, the rate of flexing being 30 per minute. The number of flexings is

- 10 000, for conductors flexed during normal use;*
- 100, for conductors flexed during **user maintenance**.*

NOTE 2 A flexing is one movement, either backwards or forwards.

*The appliance shall not be damaged to the extent that compliance with this standard is impaired and it shall be fit for further use. In particular, the wiring and its connections shall withstand the electric strength test of 16.3, the test voltage being reduced to 1 000 V and applied between **live parts** and **accessible metal parts** only. In addition, not more than 10 % of the strands of any conductor of the internal wiring between the main part of the appliance and the movable part shall be broken. However, if the wiring supplies circuits that consume no more than 15 W, then no more than 30 % of the strands shall be broken.*

23.4 Bare internal wiring shall be rigid and fixed so that, in normal use, **clearances** or **creepage distances** cannot be reduced below the values specified in Clause 29.

Compliance is checked during the tests of 29.1 and 29.2.

23.5 The insulation of internal wiring that is subjected to the supply mains voltage shall withstand the electrical stress likely to occur in normal use.

Compliance is checked as follows.

*The **basic insulation** shall be electrically equivalent to the **basic insulation** of cords complying with IEC 60227 or IEC 60245 or comply 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.

NOTE 1 If the **basic insulation** of the conductor does not fulfil one of these conditions, the conductor is considered to be bare.

NOTE 2 For **class II construction**, the requirements for **supplementary insulation** and **reinforced insulation** apply except that the sheath of a cord complying with IEC 60227 or IEC 60245 may provide **supplementary insulation**.

23.6 When sleeving is used as **supplementary insulation** on internal wiring, the sleeving shall be retained in position by clamping at both ends or be such that it can only be removed by breaking or cutting.

Compliance is checked by inspection and by manual test.

23.7 Conductors identified by the colour combination green/yellow shall only be used for earthing conductors.

Compliance is checked by inspection.

23.8 Aluminium wires shall not be used for internal wiring.

NOTE Windings are not considered to be internal wiring.

Compliance is checked by inspection.

23.9 Stranded conductors shall not be consolidated by soldering where they are subjected to contact pressure, unless the contact pressure is provided by spring terminals.

NOTE Soldering of the tip of a stranded conductor is allowed.

Compliance is checked by inspection.

23.10 The insulation and sheath of internal wiring, incorporated in external hoses for the connection of an appliance to the water mains, shall be at least equivalent to that of light polyvinyl chloride sheathed flexible cord (code designation 60227 IEC 52).

Compliance is checked by inspection.

NOTE The mechanical characteristics specified in IEC 60227 are not evaluated.

24 Components

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

NOTE 1 Compliance with the IEC standard for the relevant component does not necessarily ensure compliance with the requirements of this standard.

NOTE 2 Motors are not required to comply with IEC 60034-1.

NOTE 3 Unless otherwise specified, the requirements of Clause 29 of this standard apply between **live parts** of components and **accessible parts** of the appliance.

NOTE 4 Unless otherwise specified, the requirements of 30.2 of this standard apply to parts of non-metallic material in components including parts of non-metallic material supporting current-carrying connections inside components.

Components that have been previously tested and shown to comply with the resistance to fire requirements in the IEC standard for the relevant component need not be retested provided that

- the severity specified in the component standard is not less than the severity specified in 30.2 of this standard, and
- unless the preselection alternative is used, the test report for the component states whether it complied with the IEC standard for the relevant component with or without flame. Flames existing for a cumulative time not exceeding 2 s during the test are ignored.

If the above two conditions are not satisfied, the component is tested as part of the appliance.

There are two levels of severity specified for appliances for which 30.2.3 is applicable.

Components that have not been previously tested and shown to comply with the IEC standard for the relevant component are tested according to the requirements of 30.2 of this standard.

Unless components have been previously tested and found to comply with the relevant IEC standard for the number of cycles specified, they are tested in accordance with 24.1.1 to 24.1.9. For components mentioned in 24.1.1 to 24.1.9, no additional tests specified in the relevant IEC standard for the component are necessary other than those specified in 24.1.1 to 24.1.9.

Components that have not been separately tested and found to comply with the relevant IEC standard and components that are not marked or not used in accordance with their marking, are tested in accordance with the conditions occurring in the appliance, the number of samples being that required by the relevant standard.

NOTE 5 For automatic controls, marking includes documentation and declaration as specified in Clause 7 of IEC 60730-1.

Lampholders and starterholders that have not been previously tested and found to comply with the relevant IEC standard are tested as a part of the appliance and shall additionally comply with the gauging and interchangeability requirements of the relevant IEC standard under the conditions occurring in the appliance. Where the relevant IEC standard specifies these gauging and interchangeability requirements at elevated temperatures, the temperatures measured during the tests of Clause 11 are used.

There are no additional tests specified for nationally standardized plugs such as those detailed in IEC/TR 60083 or connectors complying with the standard sheets of IEC 60320-1 and IEC 60309, unless they are specifically mentioned in the text of this standard.

When an IEC standard does not exist for a component, there are no additional tests specified.

24.1.1 *The relevant standard for capacitors likely to be permanently subjected to the supply voltage and used for radio interference suppression or for voltage dividing is IEC 60384-14.*

Capacitors likely to be permanently subjected to the supply voltage are capacitors incorporated in appliances

- *for which 30.2.3 is applicable; or*
- *for which 30.2.2 is applicable, unless the capacitor is disconnected from the supply mains by an on-off switch. This switch shall provide **all-pole disconnection** if the capacitor is connected to earth.*

If the capacitors have to be tested, they are tested in accordance with Annex F.

24.1.2 *The relevant standard for **safety isolating transformers** is IEC 61558-2-6. If they have to be tested, they are tested in accordance with Annex G.*

24.1.3 *The relevant standard for switches is IEC 61058-1. The number of cycles of operation declared for 7.1.4 of IEC 61058-1 shall be at least 10 000. If they have to be tested, they are tested in accordance with Annex H.*

NOTE The declared number of operating cycles is only applicable for switches required for compliance with this standard.

If the switch operates a relay or contactor, the complete switching system is subjected to the test.

If the switch only operates a motor starting relay complying with IEC 60730-2-10 with the number of cycles of operation declared for 6.10 and 6.11 of IEC 60730-1 of at least 10 000 cycles, the complete switching system need not be tested.

24.1.4 *The relevant standard for automatic controls is IEC 60730-1 together with the relevant part 2.*

The number of cycles of operation declared for 6.10 and 6.11 of IEC 60730-1 shall not be less than the following:

– thermostats	10 000
– temperature limiters	1 000
– self-resetting thermal cut-outs	300
– voltage-maintained non-self-resetting thermal cut-outs	1 000

– other non-self-resetting thermal cut-outs	30
– <i>timers</i>	3 000
– <i>energy regulators</i>	10 000

The number of cycles of operation for automatic controls that operate during the test of Clause 11 need not be declared for 6.10 and 6.11 of IEC 60730-1, if the appliance meets the requirements of this standard when they are short-circuited.

If automatic controls have to be tested, they are also tested in accordance with Subclauses 11.3.5 to 11.3.8 and Clause 17 of IEC 60730-1 as type 1 controls.

NOTE The tests of Clauses 12, 13 and 14 of IEC 60730-1 are not carried out before carrying out the test of Clause 17.

The ambient temperature during the test of Clause 17 of IEC 60730-1 is that occurring during the test of Clause 11 in the appliance, as specified in footnote b of Table 3.

Thermal motor protectors are tested in combination with their motor under the conditions specified in Annex D.

*For water valves containing **live parts** and that are incorporated in external hoses for connection of an appliance to the water mains, the degree of protection provided by enclosures against harmful ingress of water declared for Subclause 6.5.2 of IEC 60730-2-8 shall be IPX7.*

24.1.5 *The relevant standard for appliance couplers is IEC 60320-1. However, for appliances classified higher than IPX0, the relevant standard is IEC 60320-2-3.*

The relevant standard for interconnection couplers is IEC 60320-2-2.

24.1.6 *The relevant standard for small lampholders similar to E10 lampholders is IEC 60238, the requirements for E10 lampholders being applicable. However, they need not accept a lamp with an E10 cap complying with the current edition of standard sheet 7004-22 of IEC 60061-1.*

24.1.7 *If the **remote operation** of the appliance is via a telecommunication network, the relevant standard for the telecommunication interface circuitry in the appliance is IEC 62151.*

24.1.8 *The relevant standard for **thermal links** is IEC 60691. **Thermal links** that do not comply with IEC 60691 are considered to be an **intentionally weak part** for the purposes of Clause 19.*

24.1.9 *Contactors and relays, other than motor starting relays, are tested as part of the appliance. However, they are also tested in accordance with Clause 17 of IEC 60730-1 under the maximum load conditions occurring in the appliance for at least the number of cycles of operation in 24.1.4 selected according to the contactor or relay function in the appliance.*

24.2 Appliances shall not be fitted with

- switches or automatic controls in flexible cords;
- devices that cause the **protective device** in the fixed wiring to operate in the event of a fault in the appliance;
- **thermal cut-outs** that can be reset by a soldering operation, unless the solder has a melting point of at least 230 °C.

Compliance is checked by inspection.

24.3 Switches intended to ensure **all-pole disconnection** of **stationary appliances**, as required in 22.2, shall be directly connected to the supply terminals and shall have a contact separation in all poles, providing full disconnection under overvoltage category III conditions.

NOTE 1 Full disconnection is contact separation of a pole to ensure the equivalent of **basic insulation**, in accordance with IEC 61058-1, between the supply mains and those parts that are intended to be disconnected.

NOTE 2 **Rated impulse voltages** for overvoltage categories are given in Table 15.

Compliance is checked by inspection and by measurement.

24.4 Plugs and socket-outlets for **extra-low voltage** circuits, and those used as terminal devices for heating elements, shall not be interchangeable with plugs and socket-outlets listed in IEC/TR 60083 or IEC 60906-1 or with connectors and appliance inlets complying with the standard sheets of IEC 60320-1.

Compliance is checked by inspection.

24.5 Capacitors in auxiliary windings of motors shall be marked with their **rated voltage** and their rated capacitance and shall be used in accordance with these markings.

*Compliance is checked by inspection and by the appropriate tests. In addition, for capacitors connected in series with a motor winding, it is verified that, when the appliance is supplied at 1,1 times **rated voltage** and under minimum load, the voltage across the capacitor does not exceed 1,1 times its **rated voltage**.*

24.6 The **working voltage** of motors directly connected to the supply mains and having **basic insulation** that is inadequate for the **rated voltage** of the appliance, shall not exceed 42 V. In addition, they shall comply with the requirements of Annex I.

Compliance is checked by measurement and by the tests of Annex I.

24.7 Detachable hose-sets for the connection of appliances to the water mains shall comply with IEC 61770. They shall be supplied with the appliance.

Appliances intended to be permanently connected to the water mains shall not be connected by a **detachable hose-set**.

NOTE Examples of appliances that are considered not intended to be permanently connected to the water mains are household appliances such as dishwashers, washing machines, tumble dryers, refrigerators, icemakers, steam ovens and the like.

Compliance is checked by inspection.

24.8 Motor running capacitors in appliances for which 30.2.3 is applicable and that are permanently connected in series with a motor winding shall not cause a hazard in the event of a capacitor failure.

The requirement is considered to be met by one or more of the following conditions:

- the capacitors are of class of safety protection P2 according to IEC 60252-1;
- the capacitors are housed within a metallic or ceramic enclosure that will prevent the emission of flame or molten material resulting from failure of the capacitor;

NOTE The enclosure may have an entry or exit hole for the wiring connecting the capacitor to the motor.

- the distance of separation of the outer surface of the capacitor to adjacent non-metallic parts exceeds 50 mm;

- adjacent non-metallic parts within 50 mm of the outer surface of the capacitor withstand the needle-flame test of Annex E;
- adjacent non-metallic parts within 50 mm of the outer surface of the capacitor are classified as at least V-1 according to IEC 60695-11-10, provided that the test sample used for the classification was no thicker than the relevant part of the appliance.

Compliance is checked by inspection, measurement or the appropriate flammability requirement.

25 Supply connection and external flexible cords

25.1 Appliances, other than those intended to be permanently connected to fixed wiring, shall be provided with one of the following means for connection to the supply mains:

- **supply cord** fitted with a plug;
- an appliance inlet having at least the same degree of protection against moisture as required for the appliance;
- pins for insertion into socket-outlets.

Compliance is checked by inspection.

25.2 Appliances, other than **stationary appliances** for multiple supply, shall not be provided with more than one means of connection to the supply mains. **Stationary appliances** for multiple supply may be provided with more than one means of connection provided that the relevant circuits are adequately insulated from each other.

NOTE 1 For example, a multiple supply may be required for appliances supplied with day and night tariffs.

Compliance is checked by inspection and by the following test.

A voltage of 1 250 V of substantially sinusoidal waveform and having a frequency of 50 Hz or 60 Hz is applied for 1 min between each means of connection to the supply mains.

NOTE 2 This test may be combined with that of 16.3.

During this test, no breakdown shall occur.

25.3 Appliances intended to be permanently connected to fixed wiring shall be provided with one of the following means for connection to the supply mains:

- a set of terminals allowing the connection of a flexible cord;
NOTE In this case, a cord anchorage must also be provided.
- a fitted **supply cord**;
- a set of **supply leads** accommodated in a suitable compartment;
- a set of terminals allowing the connection of cables of fixed wiring having the nominal cross-sectional areas specified in 26.6;
- a set of terminals and cable entries, conduit entries, knock-outs or glands, which allow the connection of the appropriate types of cable or conduit.

Appliances intended to be permanently connected to fixed wiring that are provided with

- a set of terminals allowing the connection of cables of fixed wiring having the nominal cross-sectional areas specified in 26.6, or
- a set of terminals and cable entries, conduit entries, knock-outs or glands, which allow the connection of the appropriate types of cable or conduit,

shall allow the connection of the supply conductors after the appliance has been fixed to its support.

If a **fixed appliance** is constructed so that parts can be removed to facilitate easy installation, this requirement is considered to be met if it is possible to connect the fixed wiring without difficulty after a part of the appliance has been fixed to its support. In this case, removable parts are to be constructed for ease of reassembly without risk of incorrect assembly or damage to the wiring or terminals.

Compliance is checked by inspection and, if necessary, by making the appropriate connections.

25.4 For appliances intended to be permanently connected to the fixed wiring and having a **rated current** not exceeding 16 A, cable and conduit entries shall be suitable for cables or conduits having a maximum overall dimension shown in Table 10.

Table 10 – Dimensions of cables and conduits

Number of conductors including earthing conductors	Maximum overall dimension mm	
	Cable	Conduit ^a
2	13,0	16,0 (23,0)
3	14,0	16,0 (23,0)
4	14,5	20,0 (23,0)
5	15,5	20,0 (29,0)
^a The dimensions in parentheses are for use in USA and Canada.		

Conduit entries, cable entries and knock-outs shall be constructed or located so that the introduction of the conduit or cable does not reduce **clearances** or **creepage distances** below the values specified in Clause 29.

Compliance is checked by inspection and by measurement.

25.5 **Supply cords** shall be assembled to the appliance by one of the following methods:

- **type X attachment**;
- **type Y attachment**;
- **type Z attachment**, if allowed in the relevant part 2.

Type X attachments, other than those having a specially prepared cord, shall not be used for flat twin tinsel cords.

For multi-phase appliances that are supplied with a **supply cord** and that are intended to be permanently connected to the fixed wiring, the **supply cord** shall be assembled to the appliance by a **type Y attachment**.

Compliance is checked by inspection.

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

Compliance is checked by inspection.

25.7 **Supply cords** for appliances other than **class III appliances** shall be one of the following types:

– Rubber sheathed

Their properties shall be at least those of ordinary tough rubber sheathed cords (code designation 60245 IEC 53).

NOTE 1 These cords are not suitable for appliances intended to be used outdoors or when they are liable to be exposed to significant amounts of ultraviolet radiation.

– Polychloroprene sheathed

Their properties shall be at least those of ordinary polychloroprene sheathed cords (code designation 60245 IEC 57).

NOTE 2 These cords are suitable for appliances intended to be used in low temperature applications.

– Cross-linked polyvinyl chloride sheathed

Their properties shall be at least those of cross-linked polyvinyl chloride sheathed cords (code designation 60245 IEC 88).

NOTE 3 These cords are suitable for appliances when they may come into contact with hot surfaces. Due to the composition of the conductors, the cords are suitable for applications where high flexibility is required.

– Polyvinyl chloride sheathed

These cords shall not be used if they are likely to touch metal parts having a temperature rise exceeding 75 K during the test of Clause 11. Their properties shall be at least those of

- light polyvinyl chloride sheathed cord (code designation 60227 IEC 52), for appliances having a mass not exceeding 3 kg;
- ordinary polyvinyl chloride sheathed cord (code designation 60227 IEC 53), for other appliances.

– Heat resistant polyvinyl chloride sheathed

These cords shall not be used for **type X attachment** other than specially prepared cords. Their properties shall be at least those of

- heat-resistant light polyvinyl chloride sheathed cord (code designation 60227 IEC 56), for appliances having a mass not exceeding 3 kg;
- heat-resistant polyvinyl chloride sheathed cord (code designation 60227 IEC 57), for other appliances.

Supply cords for class III appliances shall be adequately insulated.

*Compliance is checked by inspection, by measurement, and for **class III appliances** that contain **live parts** by the following test.*

A voltage of 500 V is applied for 2 min between the conductor and metal foil wrapped around the insulation, the insulation being at the temperature measured during the test of Clause 11. There shall be no breakdown during this test.

25.8 Conductors of **supply cords** shall have a nominal cross-sectional area not less than that shown in Table 11.

Table 11 – Minimum cross-sectional area of conductors

Rated current of appliance A			Nominal cross-sectional area mm ²
		≤0,2	Tinsel cord ^a
>0,2	and	≤3	0,5 ^a
>3	and	≤6	0,75
>6	and	≤10	1,0 (0,75) ^b
>10	and	≤16	1,5 (1,0) ^b
>16	and	≤25	2,5
>25	and	≤32	4
>32	and	≤40	6
>40	and	≤63	10

NOTE For **supply cords** supplied with multi-phase appliances, the nominal cross-sectional area of the conductors is based on the maximum cross-sectional area of the conductors per phase at the **supply cord** connection to the appliance terminals.

^a These cords may only be used if their length does not exceed 2 m between the point where the cord or cord guard enters the appliance and the entry to the plug.

^b Cords having the cross-sectional areas indicated in the parentheses may be used for **portable appliances** if their length does not exceed 2 m.

Compliance is checked by measurement.

25.9 Supply cords shall not be in contact with sharp points or edges of the appliance.

Compliance is checked by inspection.

25.10 The **supply cord** of **class I appliances** shall have a green/yellow core that is connected to the earthing terminal of the appliance and for appliances not intended for permanent connection to the fixed wiring, to the earthing contact of the plug.

Compliance is checked by inspection.

25.11 Conductors of **supply cords** shall not be consolidated by soldering where they are subjected to contact pressure, unless the contact pressure is provided by spring terminals.

NOTE Soldering of the tip of a stranded conductor is allowed.

Compliance is checked by inspection.

25.12 The insulation of the **supply cords** shall not be damaged when moulding the cord to part of the enclosure.

Compliance is checked by inspection.

25.13 Inlet openings for **supply cords** shall be constructed so that the sheath of the **supply cord** can be introduced without risk of damage. Unless the enclosure at the inlet opening is insulating material, a **non-detachable lining** or **non-detachable bushing** shall be provided that complies with 29.3 for **supplementary insulation**. If the **supply cord** is unsheathed, a

similar additional bushing or lining is required, unless the appliance is a **class 0 appliance** or a **class III appliance** that does not contain **live parts**.

Compliance is checked by inspection.

25.14 Appliances provided with a **supply cord** and that are moved while in operation shall be constructed so that the **supply cord** is adequately protected against excessive flexing where it enters the appliance.

NOTE 1 This does not apply to appliances with automatic cord reels that are tested by 22.16 instead.

Compliance is checked by the following test that is carried out on an apparatus having an oscillating member as shown in Figure 8.

*The part of the appliance that includes the inlet opening is fixed to the oscillating member so that, when the **supply cord** is at the middle of its travel, the axis of the cord where it enters the cord guard or inlet is vertical and passes through the axis of oscillation. The major axis of the section of flat cords shall be parallel to the axis of oscillation.*

The cord is loaded so that the force applied is

- 10 N, for cords having a nominal cross-sectional area exceeding 0,75 mm²;
- 5 N, for other cords.

The distance X, as shown in Figure 8, between the axis of oscillation and the point where the cord or cord guard enters the appliance, is adjusted so that when the oscillating member moves over its full range, the cord and load make the minimum lateral movement.

*The oscillating member is moved through an angle of 90° (45° on either side of the vertical), the number of flexings for **type Z attachments** being 20 000 and for other attachments 10 000. The rate of flexing is 60 per minute.*

NOTE 2 A flexing is one movement of 90°.

The cord and its associated parts are turned through an angle of 90° after half the number of flexings, unless a flat cord is fitted.

*During the test, the conductors are supplied at **rated voltage** and loaded with the **rated current** of the appliance. Current is not passed through the earthing conductor.*

The test shall not result in

- a short circuit between the conductors, such that the current exceeds a value equal to twice the **rated current** of the appliance;
- a breakage of more than 10 % of the strands of any conductor;
- separation of the conductor from its terminal;
- loosening of any cord guard;
- damage to the cord or cord guard which could impair compliance with this standard;
- broken strands piercing the insulation and becoming accessible.

25.15 Appliances provided with a **supply cord**, and appliances intended to be permanently connected to fixed wiring by a flexible cord, shall have a cord anchorage. The cord anchorage shall relieve conductors from strain, including twisting, at the terminals and protect the insulation of the conductors from abrasion.

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

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

A mark is made on the cord while it is subjected to the pull force shown in Table 12, at a distance of approximately 20 mm from the cord anchorage or other suitable point.

The cord is then pulled, without jerking, for 1 s in the most unfavourable direction with the force specified. The test is carried out 25 times.

The cord, unless on an automatic cord reel, is then subjected to a torque that is applied as close as possible to the appliance. The torque is specified in Table 12 and is applied for 1 min.

Table 12 – Pull force and torque

Mass of appliance <i>kg</i>	Pull force <i>N</i>	Torque <i>Nm</i>
≤ 1	30	0,1
$>1 \text{ and } \leq 4$	60	0,25
>4	100	0,35

During the tests, the cord shall not be damaged and shall show no appreciable strain at the terminals. The pull force is reapplied and the cord shall not be longitudinally displaced by more than 2 mm.

25.16 Cord anchorages for **type X attachments** shall be constructed and located so that

- replacement of the cord is easily possible;
- it is clear how the relief from strain and the prevention of twisting are obtained;
- they are suitable for the different types of **supply cord** that may be connected, unless the cord is specially prepared;
- the cord cannot touch the clamping screws of the cord anchorage if these screws are accessible, unless they are separated 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 appliance, unless it is part of a specially prepared cord;

NOTE 1 If the cord anchorage comprises one or more clamping members to which pressure is applied by means of nuts engaging with studs that are securely attached to the appliance, the cord anchorage is considered to have one part securely fixed to the appliance, even if the clamping member can be removed from the studs.

NOTE 2 If the pressure on the clamping members is applied by means of one or more screws engaging with separate nuts or with a thread in a part that is integral with the appliance, the cord anchorage is not considered to have one part securely fixed to the appliance. This does not apply if one of the clamping members is fixed to the appliance or the surface of the appliance is of insulating material and shaped so that it is obvious that this surface is one of the clamping members.

- screws which have to be operated when replacing the cord do not fix any other component. However, this does not apply if
 - after removal of the screws, or if the component is incorrectly repositioned, the appliance becomes inoperative or is obviously incomplete;

- the parts intended to be fastened by them cannot be removed without the aid of a **tool** during the replacement of the cord;
- if labyrinths can be bypassed, the test of 25.15 is nevertheless withstood;
- for **class 0 appliances**, **class 0I appliances** and **class I appliances**, they are of insulating material or are provided with an insulating lining, unless failure of the insulation of the cord does not make **accessible metal parts** live;
- for **class II appliances**, they are of insulating material or, if of metal, they are insulated from **accessible metal parts** by **supplementary insulation**.

NOTE 3 Examples of acceptable and unacceptable constructions of cord anchorages are shown in Figure 9.

Compliance is checked by inspection and by the test of 25.15 under the following conditions.

The tests are carried out with the lightest permissible type of cord of the smallest cross-sectional area specified in Table 13 and then with the next heavier type cord having the largest cross-sectional area specified. However, if the appliance is fitted with a specially prepared cord, the test is carried out with this cord.

The conductors are placed in the terminals and any terminal screws tightened just sufficiently to prevent the conductors from easily changing their position. The clamping screws of the cord anchorage are tightened with two-thirds of the torque specified in 28.1.

Screws of insulating material bearing directly on the cord are fastened with two-thirds of the torque specified in column I of Table 14, the length of the slot in the screw head being taken as the nominal diameter of the screw.

After the test, the conductors shall not have moved by more than 1 mm in the terminals.

25.17 For **type Y attachment** and **type Z attachment**, cord anchorages shall be adequate.

Compliance is checked by the test of 25.15 with the cord supplied with the appliance.

25.18 Cord anchorages shall be arranged so that they are only accessible with the aid of a **tool** or shall be constructed so that the cord can only be fitted with the aid of a **tool**.

Compliance is checked by inspection.

25.19 For **type X attachment**, glands shall not be used as cord anchorages in **portable appliances**. Tying the cord into a knot or tying the cord with string is not allowed.

Compliance is checked by inspection.

25.20 The insulated conductors of the **supply cord** for **type Y attachment** and **type Z attachment** shall be additionally insulated from **accessible metal parts** by **basic insulation** for **class 0 appliances**, **class 0I appliances** and **class I appliances**, and by **supplementary insulation** for **class II appliances**. This insulation may be provided by the sheath of the **supply cord** or by other means.

Compliance is checked by inspection and by the relevant tests.

25.21 The space for the connection of **supply cords** having **type X attachment**, or for the connection of fixed wiring, shall be constructed

- so that it is possible to check that the supply conductors are correctly positioned and connected before fitting any cover;

- so that any cover can be fitted without risk of damage to the conductors or their insulation;
- for **portable appliances**, so that the uninsulated end of a conductor, should it become free from the terminal, cannot come into contact with **accessible metal parts**.

Compliance is checked by inspection after fitting cables or flexible cords having the largest cross-sectional area specified in Table 13.

Portable appliances are subjected to the following additional test unless they are provided with pillar terminals and the **supply cord** is clamped within 30 mm of them.

NOTE The **supply cord** may be clamped by a cord anchorage.

*The clamping screws or nuts are loosened in turn. A force of 2 N is applied to the conductor in any direction at a position adjacent to the terminal. The uninsulated end of the conductor shall not come into contact with **accessible metal parts**.*

25.22 Appliance inlets shall

- be located or enclosed so that **live parts** are not accessible during insertion or removal of the connector. This requirement is not applicable to appliance inlets complying with IEC 60320-1;
- be located so that the connector can be inserted without difficulty;
- be located so that, after insertion of the connector, the appliance is not supported by the connector when it is placed in any position of normal use on a flat surface;
- not be an appliance inlet for cold conditions if the temperature rise of external metal parts of the appliance exceeds 75 K during the test of Clause 11, unless the **supply cord** is unlikely to touch such metal parts in normal use.

Compliance is checked by inspection.

25.23 Interconnection cords shall comply with the requirements for the **supply cord**, except that

- the cross-sectional area of the conductors of the **interconnection cord** is determined on the basis of the maximum current carried by the conductor during the test of Clause 11 and not by the **rated current** of the appliance;
- the thickness of the insulation of the conductor may be reduced if the voltage of the conductor is less than the **rated voltage**.

Compliance is checked by inspection, by measurement and if necessary by tests, such as the electric strength test of 16.3.

25.24 Interconnection cords shall not be detachable without the aid of a **tool** if compliance with this standard is impaired when they are disconnected.

Compliance is checked by inspection and if necessary by appropriate tests.

25.25 The dimensions of pins of appliances that are inserted into socket-outlets shall be compatible with the dimensions of the relevant socket-outlet. Dimensions of the pins and engagement face are to be in accordance with the dimensions of the relevant plug listed in IEC/TR 60083.

Compliance is checked by measurement.

26 Terminals for external conductors

26.1 Appliances shall be provided with terminals or equally effective devices for the connection of external conductors. The terminals, other than terminals in **class III appliances** that do not contain **live parts**, shall only be accessible after the removal of a **non-detachable cover**. However, earthing terminals may be accessible if a **tool** is required to make the connections and means are provided to clamp the wire independently from its connection.

NOTE 1 Screw type terminals in accordance with IEC 60998-2-1, screwless terminals in accordance with IEC 60998-2-2 and clamping units in accordance with IEC 60999-1 are considered to be effective devices.

NOTE 2 The terminals of a component such as a switch may be used as terminals for external conductors as long as they comply with the requirements of this clause.

Compliance is checked by inspection and by manual test.

26.2 Appliances having **type X attachment**, except those having a specially prepared cord, and appliances for the connection of cables of fixed wiring shall be provided with terminals in which the connections are made by means of screws, nuts or similar devices, unless the connections are soldered.

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

If soldered connections are used, the conductor shall be positioned or fixed so that reliance is not placed upon the soldering alone to maintain it in position. However, soldering alone may be used if barriers are provided so that neither **clearances** nor **creepage distances** between **live parts** and other metal parts can be reduced below the values specified for **supplementary insulation** if the conductor becomes free at the soldered joint.

Compliance is checked by inspection and by measurement.

26.3 Terminals for **type X attachment** and those for the connection of cables of fixed wiring shall be constructed so that they clamp the conductor between metal surfaces with sufficient contact pressure but without causing damage to the conductor.

The terminals shall be fixed so that when the clamping means is tightened or loosened

- the terminal does not become loose. This does not apply if the terminals are fixed with two screws, or are fixed with one screw in a recess so that there is no appreciable movement or if they are not subject to torsion in normal use and they are locked by a self-hardening resin;

NOTE Terminals may be prevented from loosening by other suitable means. The use of sealing compound without other means of locking is not considered to be sufficient.

- internal wiring is not subjected to stress;
- neither **clearances** nor **creepage distances** are reduced below the values specified in Clause 29.

Compliance is checked by inspection and by the test of Subclause 9.6 of IEC 60999-1, the torque applied being equal to two-thirds of the torque specified.

After the test, the conductors shall show no deep or sharp indentations.

26.4 Terminals for **type X attachment**, except **type X attachments** having a specially prepared cord, and terminals for the connection of cables of fixed wiring, shall not require special preparation of the conductor such as by soldering of the strands of the conductor, the

use of cable lugs, eyelets or similar devices. They shall be constructed or placed so that the conductor cannot slip out when clamping screws or nuts are tightened.

Compliance is checked by inspection of the terminals and conductors after the test of 26.3.

NOTE Reshaping of the conductor before its introduction into the terminal or twisting a stranded conductor to consolidate the end is allowed.

26.5 Terminals for **type X attachment** shall be located or shielded so that if a wire of a stranded conductor escapes when the conductors are fitted, there is no risk of accidental connection to other parts that could result in a hazard.

Compliance is checked by inspection and by the following test.

A 8 mm length of insulation is removed from the end of a flexible conductor having a nominal cross-sectional area as specified in Table 11. One wire of the stranded conductor is left free and the other wires are fully inserted 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.

NOTE The test is also applied to earthing conductors.

*There shall be no contact between **live parts** and **accessible metal parts** and, for **class II constructions**, between **live parts** and metal parts separated from **accessible metal parts** by **supplementary insulation** only.*

26.6 Terminals for **type X attachment** and for the connection of cables of fixed wiring shall allow the connection of conductors having the nominal cross-sectional areas shown in Table 13. However, if a specially prepared cord is used, the terminals need only be suitable for the connection of that cord.

Table 13 – Nominal cross-sectional area of conductors

Rated current of appliance A	Nominal cross-sectional area mm ²	
	Flexible cords	Cable for fixed wiring
≤3	0,5 and 0,75	1 to 2,5
>3 and ≤6	0,75 and 1	1 to 2,5
>6 and ≤10	1 and 1,5	1 to 2,5
>10 and ≤16	1,5 and 2,5	1,5 to 4
>16 and ≤25	2,5 and 4	2,5 to 6
>25 and ≤32	4 and 6	4 to 10
>32 and ≤50	6 and 10	6 to 16
>50 and ≤63	10 and 16	10 to 25

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

26.7 Terminals for **type X attachment**, other than those in **class III appliances** that do not contain **live parts**, shall be accessible after removal of a cover or part of the enclosure.

Compliance is checked by inspection.

26.8 Terminals for the connection of fixed wiring, including the earthing terminal, shall be located close to each other.

Compliance is checked by inspection.

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

Compliance is checked by inspection and by measurement.

26.10 Terminals with screw clamping and screwless terminals shall not be used for the connection of the conductors of flat twin tinsel cords unless the ends of the conductors are fitted with means suitable for use with screw terminals.

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

After the test, the connection shall show no damage that could impair compliance with this standard.

26.11 For appliances having **type Y attachment** or **type Z attachment**, soldered, welded, crimped or similar connections may be used for the connection of external conductors. For **class II appliances**, the conductor shall be positioned or fixed so that reliance is not placed upon the soldering, crimping or welding alone to maintain the conductor in position. However, these methods may be used alone if barriers are provided so that **clearances** and **creepage distances** between **live parts** and other metal parts cannot be reduced below the values specified for **supplementary insulation**, if the conductor becomes free at the soldered or welded joint or slips out of the crimped connection.

Compliance is checked by inspection and by measurement.

27 Provision for earthing

27.1 Accessible metal parts of **class 0I appliances** and **class I appliances** that may become live in the event of an insulation fault, shall be permanently and reliably connected to an earthing terminal within the appliance or to the earthing contact of the appliance inlet.

NOTE 1 If **accessible metal parts** are screened from **live parts** by metal parts that are connected to the earthing terminal or to the earthing contact, they are not regarded as likely to become live in the event of an insulation fault.

NOTE 2 Metal parts behind a decorative cover that does not withstand the test of 21.1 are considered to be **accessible metal parts**.

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

Class 0 appliances, **class II appliances** and **class III appliances** shall have no provision for earthing.

Safety extra-low voltage circuits shall not be earthed unless they are **protective extra-low voltage circuits**.

Compliance is checked by inspection.

27.2 The clamping means of earthing terminals shall be adequately secured against accidental loosening.

NOTE 1 In general, the constructions commonly used for current-carrying terminals, other than some terminals of the pillar type, provide sufficient resiliency to comply with this requirement. For other constructions, special provisions, such as the use of an adequately resilient part that is not likely to be removed inadvertently, may be necessary.

Terminals for the connection of external equipotential bonding conductors shall allow the connection of conductors having nominal cross-sectional areas of 2,5 mm² to 6 mm² and shall not be used to provide earthing continuity between different parts of the appliance. It shall not be possible to loosen the conductors without the aid of a **tool**.

NOTE 2 The earthing conductor in a **supply cord** is not considered to be an equipotential bonding conductor.

Compliance is checked by inspection and by manual test.

27.3 If a **detachable part** having an earth connection is plugged into another part of the appliance, the earth connection shall be made before the current-carrying connections are established. The current-carrying connections shall be separated before the earth connection when removing the part.

For appliances 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.

27.4 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 providing earthing continuity, other than parts of a metal frame or enclosure, shall be of metal having adequate resistance to corrosion, unless they are parts of copper or copper alloys containing at least 58 % copper for parts that are worked cold, and at least 50 % copper for other parts, or unless they are parts of stainless steel containing at least 13 % chrome. If these parts are of steel, they shall be provided with an electroplated coating having a thickness of at least 5 µm at essential areas such as those liable to transmit a fault current.

NOTE 1 In evaluating such essential 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.

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

NOTE 2 Examples of parts providing earthing continuity and parts that are only intended to provide or to transmit contact pressure are shown in Figure 10.

NOTE 3 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.

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.

Compliance is checked by inspection and by measurement.

27.5 The connection between the earthing terminal or earthing contact and earthed metal parts shall have low resistance.

If the **clearances** of **basic insulation** in a **protective extra-low voltage circuit** are based on the **rated voltage** of the appliance, this requirement does not apply to connections providing earthing continuity in the **protective extra-low voltage circuit**.

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 appliance or 25 A, whichever is higher, 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 appliance or the earthing contact of the appliance inlet and the **accessible metal part** is measured. The resistance calculated from the current and this voltage drop shall not exceed 0,1 Ω .*

NOTE 1 In case of doubt, the test is carried out until steady conditions have been established.

NOTE 2 The resistance of the **supply cord** is not included in the measurement.

NOTE 3 Care is to be taken to ensure that the contact resistance between the tip of the measuring probe and the metal part under test does not influence the test results.

27.6 The printed conductors of printed circuit boards shall not be used to provide earthing continuity in **hand-held appliances**. They may be used to provide earthing continuity in other appliances if at least two tracks are used with independent soldering points and the appliance complies with 27.5 for each circuit.

Compliance is checked by inspection and by the relevant tests.

28 Screws and connections

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

Screws used for these purposes shall not be of metal that is soft or liable to creep, such as zinc or aluminium. If they are of insulating material, they shall have a nominal diameter of at least 3 mm and they shall not be used for any electrical connections or connections providing earthing continuity.

Screws used for electrical connections or for connections providing earthing continuity 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 that 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**.

Compliance is checked by inspection and by the following test.

Screws and nuts are tested if they are

- *used for electrical connections;*
- *used for connections providing earthing continuity, unless at least two screws or nuts are used;*
- *likely to be tightened*

- during **user maintenance**;
- when replacing a **supply cord** having a **type X attachment**;
- during installation.

The screws or nuts are tightened and loosened without jerking:

- 10 times for screws in engagement with a thread of insulating material;
- 5 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 cable or flexible cord of the largest cross-sectional area specified in Table 13 is placed in the terminal. It is repositioned before each tightening.

The test is carried out by means of a suitable screwdriver, spanner or key and by applying a torque as shown in Table 14.

Column I is applicable for metal screws without heads if the screw does not protrude from the hole when tightened.

Column II is applicable

- for other metal screws and for nuts;
- for screws of insulating material
 - having a hexagonal head with the dimension across flats exceeding the overall thread diameter;
 - with a cylindrical head and a socket for a key, the socket having a cross-corner dimension exceeding the overall thread diameter;
 - with a head having a slot or cross-slots, the length of which exceeds 1,5 times the overall thread diameter.

Column III is applicable for other screws of insulating material.

Table 14 – Torque for testing screws and nuts

Nominal diameter of screw (outer thread diameter) mm	Torque Nm		
	I	II	III
≤2,8	0,2	0,4	0,4
>2,8 and ≤3,0	0,25	0,5	0,5
>3,0 and ≤3,2	0,3	0,6	0,5
>3,2 and ≤3,6	0,4	0,8	0,6
>3,6 and ≤4,1	0,7	1,2	0,6
>4,1 and ≤4,7	0,8	1,8	0,9
>4,7 and ≤5,3	0,8	2,0	1,0
>5,3	–	2,5	1,25

No damage impairing the further use of the fixings or connections shall occur.

28.2 Electrical connections and connections providing earthing continuity shall be constructed so that contact pressure is not transmitted through non-ceramic insulating

material that 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.

This requirement does not apply to electrical connections in circuits of appliances for which

- 30.2.2 is applicable and that carry a current not exceeding 0,5 A;
- 30.2.3 is applicable and that carry a current not exceeding 0,2 A.

Compliance is checked by inspection.

28.3 Space-threaded (sheet metal) screws shall only be used for electrical connections if they clamp the parts together.

Thread-cutting (self-tapping) screws and thread rolling screws shall only be used for electrical connections if they generate a full form standard machine screw thread. However, thread-cutting (self-tapping) screws shall not be used if they are likely to be operated by the user or installer.

Thread-cutting, thread rolling and space-threaded screws may be used in connections providing earthing continuity provided it is not necessary to disturb the connection

- in normal use,
- during **user maintenance**,
- when replacing a **supply cord** having a **type X attachment**, or
- during installation.

At least two screws must be used for each connection providing earthing continuity, unless the screw forms a thread having a length of at least half the diameter of the screw.

Compliance is checked by inspection.

28.4 Screws and nuts that make a mechanical connection between different parts of the appliance shall be secured against loosening if they also make electrical connections or connections providing earthing continuity. 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.

NOTE 1 Spring washers, lock washers and crown type locks as part of the screw head are means that may provide satisfactory security.

NOTE 2 Sealing compound that softens on heating provides satisfactory security only for screw connections not subject to torsion in normal use.

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

NOTE 3 This requirement does not imply that more than one rivet is necessary for providing earthing continuity.

NOTE 4 A non-circular shank or an appropriate notch may be sufficient.

Compliance is checked by inspection and by manual test.

29 Clearances, creepage distances and solid insulation

Appliances shall be constructed so that the **clearances**, **creepage distances** and solid insulation are adequate to withstand the electrical stresses to which the appliance is liable to be subjected.

Compliance is checked by the requirements and tests of 29.1 to 29.3.

*If coatings are used on printed circuit boards to protect the microenvironment (type 1 protection) or to provide **basic insulation** (type 2 protection), Annex J applies. The microenvironment is pollution degree 1 under type 1 protection. For type 2 protection, the spacing between the conductors before the protection is applied shall not be less than the values as specified in Table 1 of IEC 60664-3. These values apply to **functional insulation**, **basic insulation**, **supplementary insulation** as well as **reinforced insulation**.*

NOTE 1 The requirements and tests are based on IEC 60664-1 from which further information can be obtained.

NOTE 2 The assessment of **clearances**, **creepage distances** and solid insulation has to be carried out separately.

29.1 Clearances shall not be less than the values specified in Table 16, taking into account the **rated impulse voltage** for the overvoltage categories of Table 15, unless, for **basic insulation** and **functional insulation**, they comply with the impulse voltage test of Clause 14. However, if the construction is such that the distances could be affected by wear, by distortion, by movement of the parts or during assembly, the **clearances** for **rated impulse voltages** of 1 500 V and above are increased by 0,5 mm and the impulse voltage test is not applicable.

The impulse voltage test is not applicable when the microenvironment is pollution degree 3 or for **basic insulation** of **class 0 appliances** and **class 0I appliances**.

NOTE 1 Examples of constructions for which the test may be applicable are those having rigid parts or parts located by mouldings.

Examples of constructions in which distances are likely to be affected are those involving soldering, snap-on and screw terminals and **clearances** from motor windings.

Appliances are in overvoltage category II.

NOTE 2 Annex K gives information regarding overvoltage categories.

Table 15 – Rated impulse voltage

Rated voltage V	Rated impulse voltage V		
	Overvoltage category		
	I	II	III
≤50	330	500	800
>50 and ≤150	800	1 500	2 500
>150 and ≤300	1 500	2 500	4 000

NOTE 1 For multi-phase appliances, the line to neutral or line to earth voltage is used for **rated voltage**.

NOTE 2 The values are based on the assumption that the appliance will not generate higher overvoltages than those specified. If higher overvoltages are generated, the **clearances** have to be increased accordingly.

Table 16 – Minimum clearances

Rated impulse voltage V	Minimum clearance ^a mm
330	0,5 ^{b, c, d}
500	0,5 ^{b, c, d}
800	0,5 ^{b, c, d}
1 500	0,5 ^c
2 500	1,5
4 000	3,0
6 000	5,5
8 000	8,0
10 000	11,0
^a The distances specified apply only to clearances in air. ^b The smaller clearances specified in IEC 60664-1 have not been adopted for practical reasons, such as mass-production tolerances. ^c This value is increased to 0,8 mm for pollution degree 3. ^d For tracks of printed circuit boards this value is reduced to 0,2 mm for pollution degree 1 and pollution degree 2.	

Compliance is checked by inspection and by measurement.

Parts, such as hexagonal nuts that can be tightened to different positions during assembly, and movable parts are placed in the most unfavourable position.

*A force is applied to bare conductors, other than those of heating elements, and **accessible surfaces** to try to reduce **clearances** when making the measurement. The force is*

- 2 N, for bare conductors;
- 30 N, for **accessible surfaces**.

The force is applied by means of test probe B of IEC 61032. Apertures are assumed to be covered by a piece of flat metal.

NOTE 3 The way in which **clearances** are measured is specified in IEC 60664-1.

NOTE 4 The procedure for assessing **clearances** is given in Annex L.

NOTE 5 For appliances intended for use at altitudes exceeding 2 000 m, the altitude correction factors for **clearances** specified in Table A.2 of IEC 60664-1 should be taken into account.

29.1.1 The **clearances** of **basic insulation** shall be sufficient to withstand the overvoltages likely to occur during use, taking into account the **rated impulse voltage**. The values of Table 16, or the impulse voltage test of Clause 14, are applicable.

NOTE The overvoltages may be derived from external sources or due to switching.

The **clearance** at the terminals of tubular sheathed heating elements may be reduced to 1,0 mm if the microenvironment is pollution degree 1.

Lacquered conductors of windings are considered to be bare conductors.

Compliance is checked by measurement.

29.1.2 Clearances of supplementary insulation shall be not less than those specified for **basic insulation** in Table 16.

Compliance is checked by measurement.

29.1.3 Clearances of reinforced insulation shall be not less than those specified for **basic insulation** in Table 16, using the next higher step for **rated impulse voltage** as a reference.

*Compliance is checked by measurement. For **double insulation**, when there is no intermediate conductive part between the **basic insulation** and **supplementary insulation**, **clearances** are measured between **live parts** and the **accessible surface**, and the insulation system is treated as **reinforced insulation** as shown in Figure 11.*

29.1.4 The **clearances** for **functional insulation** are the largest values determined from

- Table 16 based on the **rated impulse voltage**;
- Table F.7a in IEC 60664-1 based on the steady-state voltage or recurring peak voltage expected to occur across it, if the frequency of the steady-state voltage or recurring peak voltage does not exceeds 30 kHz;
- Clause 4 of IEC 60664-4 based on the steady-state voltage or recurring peak voltage expected to occur across it, if the frequency of the steady-state voltage or recurring peak voltage exceeds 30 kHz.

If the values of Table 16 are largest, the impulse voltage test of Clause 14 may be applied instead unless the microenvironment is pollution degree 3 or the construction is such that the distances could be affected by wear, by distortion, by movement of the parts or during assembly.

However, **clearances** are not specified if the appliance complies with Clause 19 with the **functional insulation** short-circuited.

Lacquered conductors of windings are considered to be bare conductors. However, **clearances** at crossover points are not measured.

The **clearance** between surfaces of **PTC heating elements** may be reduced to 1 mm.

Compliance is checked by measurement and by a test if necessary.

29.1.5 For appliances having higher **working voltages** than **rated voltage**, for example on the secondary side of a step-up transformer, or if there is a resonant voltage, the **clearances** for **basic insulation** are the largest values determined from

- Table 16 based on the **rated impulse voltage**;
- Table F.7a in IEC 60664-1 based on the steady-state voltage or recurring peak voltage expected to occur across it, if the frequency of the steady-state voltage or recurring peak voltage does not exceed 30 kHz;
- Clause 4 of IEC 60664-4 based on the steady-state voltage or recurring peak voltage expected to occur across it, if the frequency of the steady-state voltage or recurring peak voltage exceeds 30 kHz.

NOTE 1 **Clearances** for intermediate values of Table 16 may be determined by interpolation.

If the **clearances** applied for **basic insulation** are selected from Table F.7a of IEC 60664-1 or Clause 4 of IEC 60664-4, then the **clearances** of **supplementary insulation** shall be not less than those specified for **basic insulation**.

If the **clearances** applied for **basic insulation** are selected from Table F.7a of IEC 60664-1, then the **clearances** of **reinforced insulation** shall be dimensioned as specified in Table F.7a to withstand 160 % of the withstand voltage required for **basic insulation**.

If the **clearances** applied for **basic insulation** are selected from Clause 4 of IEC 60664-4, then the **clearances** of **reinforced insulation** shall be twice the value required for **basic insulation**.

If the secondary winding of a step-down transformer is earthed, or if there is an earthed screen between the primary and secondary windings, **clearances** of **basic insulation** on the secondary side shall be not less than those specified in Table 16, using the next lower step for **rated impulse voltage** as a reference.

NOTE 2 The use of an isolating transformer without an earthed protective screen or earthed secondary does not allow a reduction in the **rated impulse voltage**.

For circuits supplied with a voltage lower than **rated voltage**, for example on the secondary side of a transformer, **clearances** of **functional insulation** are based on the **working voltage**, which is used as the **rated voltage** in Table 15.

Compliance is checked by measurement.

29.2 Appliances shall be constructed so that **creepage distances** are not less than those appropriate for the **working voltage**, taking into account the material group and the pollution degree.

NOTE 1 The **working voltage** for parts connected to the neutral is the same as for parts connected to the phase and this is the **working voltage** for **basic insulation**.

Pollution degree 2 applies unless

- precautions have been taken to protect the insulation, in which case pollution degree 1 applies;
- the insulation is subjected to conductive pollution, in which case pollution degree 3 applies.

NOTE 2 An explanation of pollution degree is given in Annex M.

Compliance is checked by measurement.

NOTE 3 The way in which **creepage distances** are measured is specified in IEC 60664-1.

Parts such as hexagonal nuts that can be tightened to different positions during assembly, and movable parts are placed in the most unfavourable position.

*A force is applied to bare conductors, other than those of heating elements, and **accessible surfaces** to try to reduce **creepage distances** when making the measurement. The force is*

- 2 N, for bare conductors;
- 30 N, for **accessible surfaces**.

The force is applied by means of test probe B of IEC 61032.

The relationship between the material group and the comparative tracking index (CTI) values, as given in Subclause 4.8.1.3 of IEC 60664-1, is as follows:

- material group I: $600 \leq CTI$;
- material group II: $400 \leq CTI < 600$;

- *material group IIIa: $175 \leq CTI < 400$;*
- *material group IIIb: $100 \leq CTI < 175$.*

These CTI values are obtained in accordance with IEC 60112 using solution A. If the CTI value of the material is unknown, a proof tracking index (PTI) test in accordance with Annex N is carried out at the CTI values specified, in order to establish the material group.

NOTE 4 The test for comparative tracking index (CTI) in accordance with IEC 60112 is designed to compare the performance of various insulating materials under test conditions, namely drops of an aqueous contaminant falling on a horizontal surface leading to electrolytic conduction. It gives a qualitative comparison but in the case of insulating materials having a tendency to form tracks, it can also give a quantitative comparison, namely the comparative tracking index.

NOTE 5 The procedure for assessing **creepage distances** is given in Annex L.

*In a **double insulation** system, the **working voltage** for both the **basic insulation** and **supplementary insulation** is taken as the **working voltage** across the complete **double insulation** system. It is not divided according to thickness and dielectric constants of the **basic insulation** and **supplementary insulation**.*

29.2.1 Creepage distances of basic insulation shall not be less than those specified in Table 17. However, if the **working voltage** is periodic and has a frequency that exceeds 30 kHz, the **creepage distances** shall also be determined from Table 2 of IEC 60664-4. These values shall be used instead if they exceed the values in Table 17.

Except for pollution degree 1, if the test of Clause 14 has been used to check a particular **clearance**, the corresponding **creepage distance** shall not be less than the minimum dimension specified for the **clearance** of Table 16.

Table 17 – Minimum creepage distances for basic insulation

Working voltage V	Creepage distance mm						
	Pollution degree						
	1	2			3		
		Material group			Material group		
		I	II	IIIa/IIIb	I	II	IIIa/IIIb ^a
≤ 50	0,18	0,6	0,85	1,2	1,5	1,7	1,9
125	0,28	0,75	1,05	1,5	1,9	2,1	2,4
250	0,56	1,25	1,8	2,5	3,2	3,6	4,0
400	1,0	2,0	2,8	4,0	5,0	5,6	6,3
500	1,3	2,5	3,6	5,0	6,3	7,1	8,0
>630 and ≤800	1,8	3,2	4,5	6,3	8,0	9,0	10,0
>800 and ≤1 000	2,4	4,0	5,6	8,0	10,0	11,0	12,5
>1 000 and ≤1 250	3,2	5,0	7,1	10,0	12,5	14,0	16,0
>1 250 and ≤1 600	4,2	6,3	9,0	12,5	16,0	18,0	20,0
>1 600 and ≤2 000	5,6	8,0	11,0	16,0	20,0	22,0	25,0
>2 000 and ≤2 500	7,5	10,0	14,0	20,0	25,0	28,0	32,0
>2 500 and ≤3 200	10,0	12,5	18,0	25,0	32,0	36,0	40,0
>3 200 and ≤4 000	12,5	16,0	22,0	32,0	40,0	45,0	50,0
>4 000 and ≤5 000	16,0	20,0	28,0	40,0	50,0	56,0	63,0
>5 000 and ≤6 300	20,0	25,0	36,0	50,0	63,0	71,0	80,0
>6 300 and ≤8 000	25,0	32,0	45,0	63,0	80,0	90,0	100,0
>8 000 and ≤10 000	32,0	40,0	56,0	80,0	100,0	110,0	125,0
>10 000 and ≤12 500	40,0	50,0	71,0	100,0	125,0	140,0	160,0

NOTE 1 Lacquered conductors of windings are considered to be bare conductors, but **creepage distances** need not be greater than the associated **clearance** specified in Table 16 taking into account 29.1.1.

NOTE 2 For glass, ceramics and other inorganic insulating materials that do not track, **creepage distances** need not be greater than the associated **clearance**.

NOTE 3 Except for circuits on the secondary side of an isolating transformer, the **working voltage** is considered to be not less than the **rated voltage** of the appliance.

NOTE 4 For **working voltages** > 50 V and ≤ 630 V, if the voltage is not specified in the table, the values of **creepage distances** may be found by interpolation.

^a Material group IIIb is allowed if the **working voltage** does not exceed 50 V.

Compliance is checked by measurement.

29.2.2 Creepage distances of supplementary insulation shall be at least those specified for **basic insulation** in Table 17 or Table 2 of IEC 60664-4, as applicable.

NOTE Notes 1 and 2 of Table 17 do not apply.

Compliance is checked by measurement.

29.2.3 Creepage distances of reinforced insulation shall be at least double those specified for **basic insulation** in Table 17 or Table 2 of IEC 60664-4, as applicable.

NOTE Notes 1 and 2 of Table 17 do not apply.

Compliance is checked by measurement.

29.2.4 Creepage distances of functional insulation shall be not less than those specified in Table 18. However, if the **working voltage** is periodic and has a frequency that exceeds 30 kHz, the **creepage distances** shall also be determined from Table 2 of IEC 60664-4. These values shall be used instead if they exceed the values in Table 18.

The **creepage distances** may be reduced if the appliance complies with Clause 19 with the **functional insulation** short-circuited.

Table 18 – Minimum creepage distances for functional insulation

Working voltage V	Creepage distance mm						
	Pollution degree						
	1	2			3		
		Material group			Material group		
		I	II	IIIa/IIIb	I	II	IIIa/IIIb ^a
≤ 10	0,08	0,4	0,4	0,4	1,0	1,0	1,0
50	0,16	0,56	0,8	1,1	1,4	1,6	1,8
125	0,25	0,71	1,0	1,4	1,8	2,0	2,2
250	0,42	1,0	1,4	2,0	2,5	2,8	3,2
400 ^b	0,75	1,6	2,2	3,2	4,0	4,5	5,0
500	1,0	2,0	2,8	4,0	5,0	5,6	6,3
>630 and ≤800	1,8	3,2	4,5	6,3	8,0	9,0	10,0
>800 and ≤1 000	2,4	4,0	5,6	8,0	10,0	11,0	12,5
>1 000 and ≤1 250	3,2	5,0	7,1	10,0	12,5	14,0	16,0
>1 250 and ≤1 600	4,2	6,3	9,0	12,5	16,0	18,0	20,0
>1 600 and ≤2 000	5,6	8,0	11,0	16,0	20,0	22,0	25,0
>2 000 and ≤2 500	7,5	10,0	14,0	20,0	25,0	28,0	32,0
>2 500 and ≤3 200	10,0	12,5	18,0	25,0	32,0	36,0	40,0
>3 200 and ≤4 000	12,5	16,0	22,0	32,0	40,0	45,0	50,0
>4 000 and ≤5 000	16,0	20,0	28,0	40,0	50,0	56,0	63,0
>5 000 and ≤6 300	20,0	25,0	36,0	50,0	63,0	71,0	80,0
>6 300 and ≤8 000	25,0	32,0	45,0	63,0	80,0	90,0	100,0
>8 000 and ≤10 000	32,0	40,0	56,0	80,0	100,0	110,0	125,0
>10 000 and ≤12 500	40,0	50,0	71,0	100,0	125,0	140,0	160,0

NOTE 1 For **PTC heating elements**, the **creepage distances** over the surface of the PTC material need not be greater than the associated **clearance** for **working voltages** less than 250 V and for pollution degrees 1 and 2. However, the **creepage distances** between terminations are those specified in the table.

NOTE 2 For glass, ceramics and other inorganic insulating materials that do not track, **creepage distances** need not be greater than the associated **clearance**.

NOTE 3 For tracks on printed wiring boards under pollution degree 1 and pollution degree 2 conditions, the values specified in Table F.4 of IEC 60664-1 apply. For voltages less than 100 V, the values must not be less than those specified for 100 V.

NOTE 4 For **working voltages** > 10 V and ≤ 630 V, if the voltage is not specified in the table, the values of **creepage distances** may be found by interpolation.

^a Material group IIIb is allowed if the **working voltage** does not exceed 50 V.

^b The **working voltage** between phases for appliances having a **rated voltage** in the range of 380 V to 415 V is considered to be 400 V.

Compliance is checked by measurement.

29.3 Supplementary insulation and reinforced insulation shall have adequate thickness, or have a sufficient number of layers, to withstand the electrical stresses that can be expected during the use of the appliance.

Compliance is checked

- *by measurement, in accordance with 29.3.1, or*
- *by an electric strength test in accordance with 29.3.2, if the insulation consists of more than one separate layer, other than natural mica or similar flaky material, or*
- *by an assessment of the thermal quality of the material combined with an electric strength test, in accordance with 29.3.3 and for **accessible parts of reinforced insulation** consisting of a single layer, by measurement in accordance with 29.3.4, or*
- *as specified in Subclause 6.3 of IEC 60664-4 for insulation that is subjected to any periodic voltage having a frequency that exceeds 30 kHz.*

29.3.1 *The thickness of the insulation shall be at least*

- *1 mm for **supplementary insulation**;*
- *2 mm for **reinforced insulation**.*

29.3.2 *Each layer of material shall withstand the electric strength test of 16.3 for **supplementary insulation**. **Supplementary insulation** shall consist of at least 2 layers of material and **reinforced insulation** of at least 3 layers.*

29.3.3 *The insulation is subjected to the dry heat test Bb of IEC 60068-2-2 for 48 h at a temperature of 50 K in excess of the maximum temperature rise measured during the test of Clause 19. At the end of the period, the insulation is subjected to the electric strength test of 16.3 at the conditioning temperature and also after it has cooled down to room temperature.*

If the temperature rise of the insulation measured during the tests of Clause 19 does not exceed the value specified in Table 3, the test of IEC 60068-2-2 is not carried out.

29.3.4 *The thickness of the **accessible parts of reinforced insulation** consisting of a single layer shall not be less than those specified in Table 19.*

Table 19 – Minimum thickness for accessible parts of reinforced insulation consisting of a single layer

Rated voltage V	Minimum thickness of single layers used for accessible parts of reinforced insulation mm		
	Overvoltage category		
	I	II	III
≤50	0,01	0,04	0,1
>50 and ≤150	0,1	0,3	0,6
>150 and ≤300	0,3	0,6	1,2

NOTE The values in Table 19 cover **clearances** through a possible hole in the insulation and align with IEC 60664-1 Table F.2 for homogenous field conditions. The **creepage distance** through a possible hole is not considered relevant because it is only stressed when the second electrode (human body) is present.

30 Resistance to heat and fire

30.1 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**, shall be sufficiently resistant to heat if their deterioration could cause the appliance to fail to comply with this standard.

This requirement does not apply to the insulation or sheath of flexible cords or internal wiring.

Compliance is checked by subjecting the relevant part to the ball pressure test of IEC 60695-10-2.

The test is carried out at a temperature of $40\text{ °C} \pm 2\text{ °C}$ plus the maximum temperature rise determined during the test of Clause 11, but it shall be at least

- $75\text{ °C} \pm 2\text{ °C}$, for external parts;*
- $125\text{ °C} \pm 2\text{ °C}$, for parts supporting **live parts**.*

*However, for parts of thermoplastic material providing **supplementary insulation** or **reinforced insulation**, the test is carried out at a temperature of $25\text{ °C} \pm 2\text{ °C}$ plus the maximum temperature rise determined during the tests of Clause 19, if this is higher. The temperature rises obtained during the test of 19.4 are not taken into account provided that the test is terminated by the operation of a **non-self-resetting protective device** and it is necessary to remove a cover or use a **tool** to reset it.*

NOTE 1 For coil formers, only those parts that support or retain terminals in position are subjected to the test.

NOTE 2 The test is not carried out on parts of ceramic material.

NOTE 3 The selection and sequence of tests for resistance to heat are shown in Figure O.1.

30.2 Parts of non-metallic material shall be resistant to ignition and spread of fire.

The requirement does not apply to parts having a mass not exceeding 0,5 g which are considered insignificant parts, provided the cumulative effect of insignificant parts located within 3 mm of each other is unlikely to propagate flames that originate inside the appliance by propagating flames from one insignificant part to another.

The requirement also does not apply to decorative trims, knobs and other parts unlikely to be ignited or to propagate flames that originate inside the appliance.

Compliance is checked by the test of 30.2.1. In addition,

- for attended appliances, 30.2.2 is applicable;*
- for unattended appliances, 30.2.3 is applicable.*

*Appliances for **remote operation** are considered to be appliances that are operated while unattended and consequently they are subjected to the test of 30.2.3.*

For the base material of printed circuit boards, compliance is checked by the test of 30.2.4.

The tests are carried out on parts of non-metallic material that have been removed from the appliance. When the glow-wire test is carried out, the parts are placed in the same orientation as they would be in normal use.

NOTE 1 For parts that have been removed, it is the intention that IEC 60695-2-11 Clause 4 item c) applies, which states “remove the part under examination in its entirety and test it separately”.

These tests are not carried out on the insulation of wires.

NOTE 2 The selection and sequence of tests for resistance to fire are shown in Figures O.2 to O.4.

30.2.1 *Parts of non-metallic material are subjected to the glow-wire test of IEC 60695-2-11, which is carried out at 550 °C. However, the glow-wire test is not carried out on parts of material classified as having a glow-wire flammability index (GWFI) according to IEC 60695-2-12 of at least 550 °C.*

If the glow-wire flammability index (GWFI) is not available for a sample with a thickness within $\pm 0,1$ mm of the relevant part, then the test sample shall have a thickness equal to the nearest preferred value specified in IEC 60695-2-12 that is no thicker than the relevant part.

NOTE The preferred values in IEC 60695-2-12 are 0,4 mm \pm 0,05 mm, 0,75 mm \pm 0,1 mm, 1,5 mm \pm 0,1 mm, 3,0 mm \pm 0,2 mm and 6,0 mm \pm 0,4 mm.

The glow-wire test is also not carried out on parts of material classified at least HB40 according to IEC 60695-11-10 provided that the test sample used for the classification was no thicker than the relevant part of the appliance.

Parts for which the glow-wire test cannot be carried out, such as those made of soft or foamy material, shall meet the requirements specified in ISO 9772 for material classified HBF, the test sample used for the classification being no thicker than the relevant part of the appliance.

30.2.2 *For appliances that are operated while attended, parts of non-metallic material supporting current-carrying connections and parts of non-metallic material within a distance of 3 mm of such connections are subjected to the glow-wire test of IEC 60695-2-11.*

NOTE 1 Contacts in components such as switch contacts are considered to be connections.

NOTE 2 The tip of the glow-wire should be applied to the part in the vicinity of the connection.

NOTE 3 Some applications of the term "within a distance of 3 mm" are shown in Figure O.5.

The test severity is

- 750 °C, for connections that carry a current exceeding 0,5 A during **normal operation**,
- 650 °C, for other connections.

Where a non-metallic material is within a distance of 3 mm of a current-carrying connection, but is shielded from the connection by a different material, the glow-wire test of IEC 60695-2-11 is carried out at the relevant test severity with the tip of the glow-wire applied to the interposed shielding material with the shielded material in place and not directly to the shielded material.

NOTE 4 Some applications of the term "within a distance of 3 mm" are shown in Figure O.5.

However, the glow-wire test of IEC 60695-2-11 is not carried out on parts of material classified as having a glow-wire flammability index (GWFI) according to IEC 60695-2-12 of at least

- 750 °C, for connections which carry a current exceeding 0,5 A during **normal operation**,
- 650 °C, for other connections.

The glow-wire test of IEC 60695-2-11 is also not carried out on **small parts**. These parts shall

- comprise material having a glow-wire flammability index (GWFI) of at least 750 °C, or 650 °C as appropriate, or
- comply with the needle-flame test (NFT) of Annex E, or
- comprise material classified as V-0 or V-1 according to IEC 60695-11-10 provided that the test sample used for the classification was no thicker than the relevant part of the appliance

If the glow-wire flammability index (GWFI) is not available for a sample with a thickness within $\pm 0,1$ mm of the relevant part, then the test sample shall have a thickness equal to the nearest preferred value specified in IEC 60695-2-12 that is no thicker than the relevant part.

NOTE 5 The preferred values in IEC 60695-2-12 are 0,4 mm \pm 0,05 mm, 0,75 mm \pm 0,1 mm, 1,5 mm \pm 0,1 mm, 3,0 mm \pm 0,2 mm and 6,0 mm \pm 0,4 mm.

The glow-wire test of IEC 60695-2-11 is not applicable to:

- **hand-held appliances**;
- appliances that have to be kept switched on by hand or foot;
- appliances that are continuously loaded by hand;
- parts supporting welded connections and parts within a distance of 3 mm of these connections;
- parts supporting connections in low-power circuits described in 19.11.1 and parts within a distance of 3 mm of these connections;
- soldered connections on printed circuit boards and parts within a distance of 3 mm of these connections;
- connections on small components on printed circuit boards, such as diodes, transistors, resistors, inductors, integrated circuits and capacitors not directly connected to the supply mains, and parts within a distance of 3 mm of these connections.

NOTE 6 Some applications of the term "within a distance of 3 mm" are shown in Figures O.5.

30.2.3 Appliances that are operated while unattended are tested as specified in 30.2.3.1 and 30.2.3.2. However, the tests are not applicable to:

- parts supporting welded connections and parts within a distance of 3 mm of these connections;
- parts supporting connections in low-power circuits described in 19.11.1 and parts within a distance of 3 mm of these connections;
- soldered connections on printed circuit boards and parts within a distance of 3 mm of these connections;
- connections on small components on printed circuit boards, such as diodes, transistors, resistors, inductors, integrated circuits and capacitors not directly connected to the supply mains, and parts within a distance of 3 mm of these connections.

NOTE Some applications of the term "within a distance of 3 mm" are shown in Figure O.5.

30.2.3.1 Parts of non-metallic material supporting connections that carry a current exceeding 0,2 A during **normal operation**, and parts of non-metallic material, other than **small parts**, within a distance of 3 mm of such connections, are subjected to the glow-wire test of IEC 60695-2-11 with a test severity of 850 °C.

NOTE 1 Contacts in components such as switch contacts are considered to be connections.

NOTE 2 The tip of the glow-wire should be applied to the part in the vicinity of the connection.

NOTE 3 Some applications of the term "within a distance of 3 mm" are shown in Figure O.5.

Where a non-metallic material is within a distance of 3 mm of a current-carrying connection, but is shielded from the connection by a different material, the glow-wire test of IEC 60695-2-11 is carried out at the relevant temperature with the tip of the glow-wire applied to the interposed shielding material with the shielded material in place and not directly to the shielded material.

NOTE 4 Some applications of the term "within a distance of 3 mm" are shown in Figure O.5.

However, the glow-wire test of IEC 60695-2-11 with a test severity of 850 °C is not carried out on parts of material classified as having a glow-wire flammability index (GWFI) of at least 850 °C according to IEC 60695-2-12.

If the glow-wire flammability index (GWFI) is not available for a sample with a thickness within $\pm 0,1$ mm of the relevant part, then the test sample shall have a thickness equal to the nearest preferred value specified in IEC 60695-2-12 that is no thicker than the relevant part.

NOTE 5 The preferred values in IEC 60695-2-12 are 0,4 mm \pm 0,05 mm, 0,75 mm \pm 0,1 mm, 1,5 mm \pm 0,1 mm, 3,0 mm \pm 0,2 mm and 6,0 mm \pm 0,4 mm.

30.2.3.2 *Parts of non-metallic material supporting connections and parts of non-metallic material within a distance of 3 mm of such connections are subjected to the glow-wire test of IEC 60695-2-11.*

NOTE 1 Contacts in components such as switch contacts are considered to be connections.

NOTE 2 The tip of the glow-wire should be applied to the part in the vicinity of the connection.

NOTE 3 Some applications of the term "within a distance of 3 mm" are shown in Figure O.5.

The test severity is

- 750 °C, for connections that carry a current exceeding 0,2 A during **normal operation**,
- 650 °C, for other connections.

Where a non-metallic material is within a distance of 3 mm of a current-carrying connection, but is shielded from the connection by a different material, the glow-wire test of IEC 60695-2-11 is carried out at the relevant test severity with the tip of the glow-wire applied to the interposed shielding material with the shielded material in place and not directly to the shielded material.

NOTE 4 Some applications of the term "within a distance of 3 mm" are shown in Figure O.5.

However, the glow-wire test with a test severity of 750 °C or 650 °C as appropriate, is not carried out on parts of material fulfilling both or either of the following classifications:

- a glow-wire ignition temperature (GWIT) according to IEC 60695-2-13 of at least;
 - 775 °C, for connections that carry a current exceeding 0,2 A during **normal operation**,
 - 675 °C, for other connections.
- a glow-wire flammability index (GWFI) according to IEC 60695-2-12 of at least;
 - 750 °C, for connections that carry a current exceeding 0,2 A during **normal operation**,
 - 650 °C, for other connections.

If the glow-wire ignition temperature (GWIT) is not available for a sample with a thickness within $\pm 0,1$ mm of the relevant part, then the test sample shall have a thickness equal to the nearest preferred value specified in IEC 60695-2-13 that is no thicker than the relevant part.

NOTE 5 The preferred values in IEC 60695-2-13 are 0,4 mm \pm 0,05 mm, 0,75 mm \pm 0,1 mm, 1,5 mm \pm 0,1 mm, 3,0 mm \pm 0,2 mm and 6,0 mm \pm 0,4 mm.

If the glow-wire flammability index (GWFI) is not available for a sample with a thickness within $\pm 0,1$ mm of the relevant part, then the test sample shall have a thickness equal to the nearest preferred value specified in IEC 60695-2-12 that is no thicker than the relevant part.

NOTE 6 The preferred values in IEC 60695-2-12 are $0,4 \text{ mm} \pm 0,05 \text{ mm}$, $0,75 \text{ mm} \pm 0,1 \text{ mm}$, $1,5 \text{ mm} \pm 0,1 \text{ mm}$, $3,0 \text{ mm} \pm 0,2 \text{ mm}$ and $6,0 \text{ mm} \pm 0,4 \text{ mm}$.

*The glow-wire test of IEC 60695-2-11 with a test severity of 750°C or 650°C as appropriate, is also not carried out on **small parts**. These parts shall*

- *comprise material having a glow-wire ignition temperature (GWIT) of at least 775°C or 675°C as appropriate, or*
- *comprise material having a glow-wire flammability index (GWFI) of at least 750°C or 650°C as appropriate, or*
- *comply with the needle-flame test (NFT) of Annex E, or*
- *comprise material classified as V-0 or V-1 according to IEC 60695-11-10 provided that the test sample used for the classification was no thicker than the relevant part of the appliance.*

A consequential needle-flame test (NFT) in accordance with Annex E is applied to non-metallic parts that encroach within the envelope of a vertical cylinder having a diameter of 20 mm and a height of 50 mm, placed above the centre of the connection zone and on top of the non-metallic parts that are supporting current-carrying connections, and parts of non-metallic material within a distance of 3 mm of such connections if these parts are those:

- *that withstood the glow-wire test of IEC 60695-2-11 with a test severity of 750°C or 650°C as appropriate, but that during the test produce a flame that persists for longer than 2 s, or*
- *that comprised material having a glow-wire flammability index (GWFI) of at least 750°C , or 650°C as appropriate, or*
- ***small parts**, that comprised material having a glow-wire flammability index (GWFI) of at least 750°C , or 650°C as appropriate, or*
- ***small parts** for which the needle-flame test (NFT) of Annex E was applied, or*
- ***small parts** for which a material classification of V-0 or V-1 was applied.*

NOTE 7 An example of the placement of the vertical cylinder is shown in Figure 12.

*However, the consequential needle-flame test is not carried out on non-metallic parts, including **small parts**, within the cylinder that are:*

- *parts having a glow-wire ignition temperature (GWIT) of at least 775°C , or 675°C as appropriate; or*
- *parts comprising material classified as V-0 or V-1 according to IEC 60695-11-10 provided that the test sample used for the classification was no thicker than the relevant part of the appliance; or*
- *parts shielded by a flame barrier that meets the needle-flame test (NFT) of Annex E or that comprises material classified as V-0 or V-1 according to IEC 60695-11-10 provided that the test sample used for the classification was no thicker than the relevant part of the appliance.*

30.2.4 *The base material of printed circuit boards is subjected to the needle-flame test (NFT) of Annex E. The flame is applied to the edge of the board where the heat sink effect is lowest when the board is positioned as in normal use.*

NOTE The test may be carried out on a printed circuit board on which components are mounted. However, ignition of a component is disregarded.

The needle-flame test (NFT) of Annex E is not carried out

- *on printed circuit boards of low-power circuits described in 19.11.1;*
- *on the printed circuit boards in*
 - *a metal enclosure that confines flames or burning droplets,*
 - ***hand-held appliances,***
 - *appliances that have to be kept switched on by hand or foot,*
 - *appliances that are continuously loaded by hand,*
- *on a base material classified as V-0 according to IEC 60695-11-10 or VTM-0 according to ISO 9773, provided that the test sample used for the classification was no thicker than the printed circuit board.*

31 Resistance to rusting

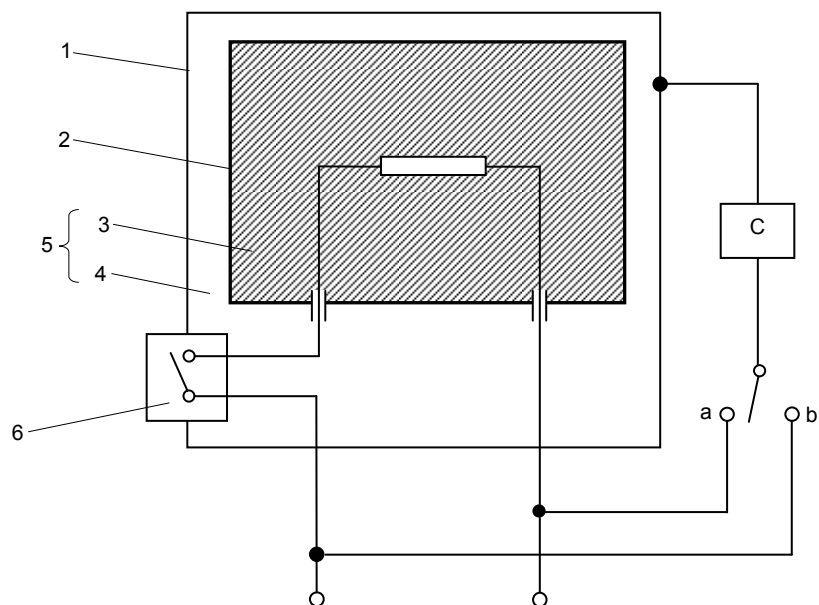
Ferrous parts, the rusting of which might cause the appliance to fail to comply with this standard, shall be adequately protected against rusting.

NOTE Tests are specified in part 2 when necessary.

32 Radiation, toxicity and similar hazards

Appliances shall not emit harmful radiation or present a toxic or similar hazard due to their operation in normal use.

Compliance is checked by the limits or tests specified in part 2. However, if no limits or tests are specified in part 2, then the appliance is deemed to comply with the requirement without testing.



Key

C circuit of Figure 4 of IEC 60990

1 **accessible part**

2 inaccessible metal part

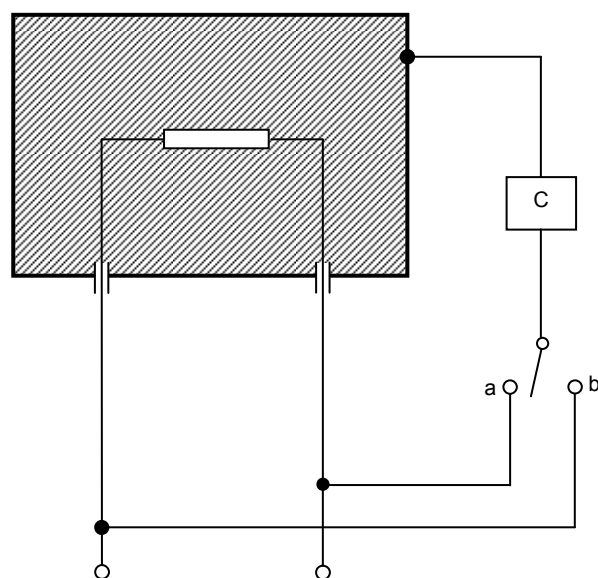
3 **basic insulation**

4 **supplementary insulation**

5 **double insulation**

6 **reinforced insulation**

Figure 1 – Circuit diagram for leakage current measurement at operating temperature for single-phase connection of class II appliances

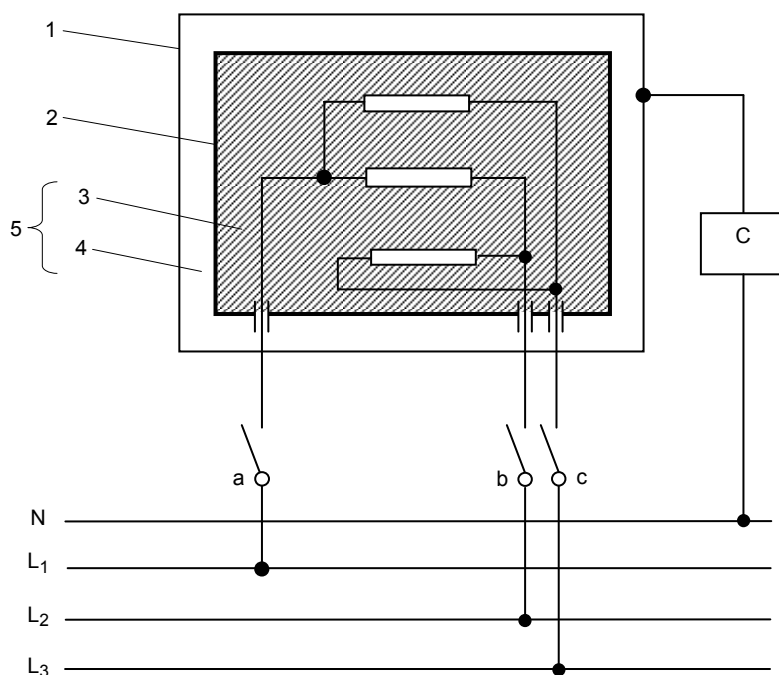


Key

C circuit of Figure 4 of IEC 60990

NOTE For **class 0I appliances** and **class I appliances**, C may be replaced by a low impedance ammeter.

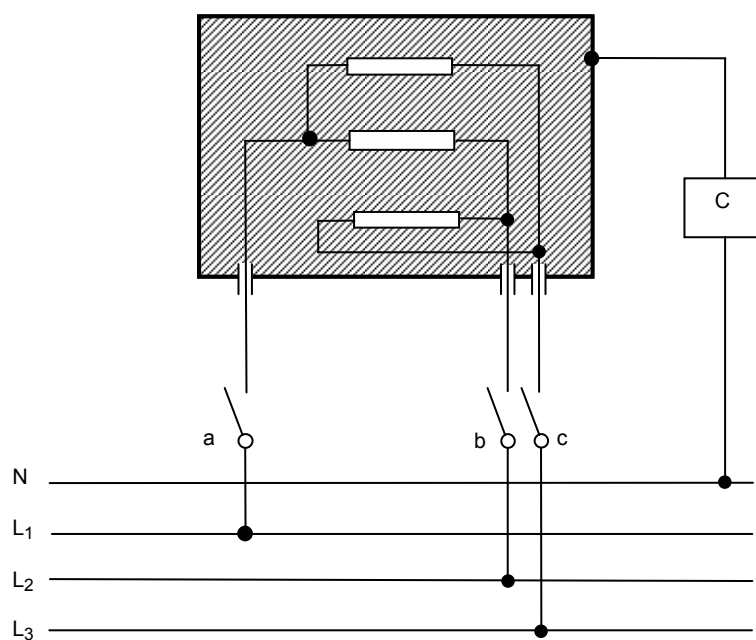
Figure 2 – Circuit diagram for leakage current measurement at operating temperature for single-phase connection of appliances, other than those of class II

**Key**

C circuit of Figure 4 of IEC 60990

1 **accessible part**2 **inaccessible metal part**3 **basic insulation**4 **supplementary insulation**5 **double insulation****Connections and supplies**L₁, L₂, L₃, N supply voltage with neutral

Figure 3 – Circuit diagram for leakage current measurement at operating temperature for three-phase connection of class II appliances



Key

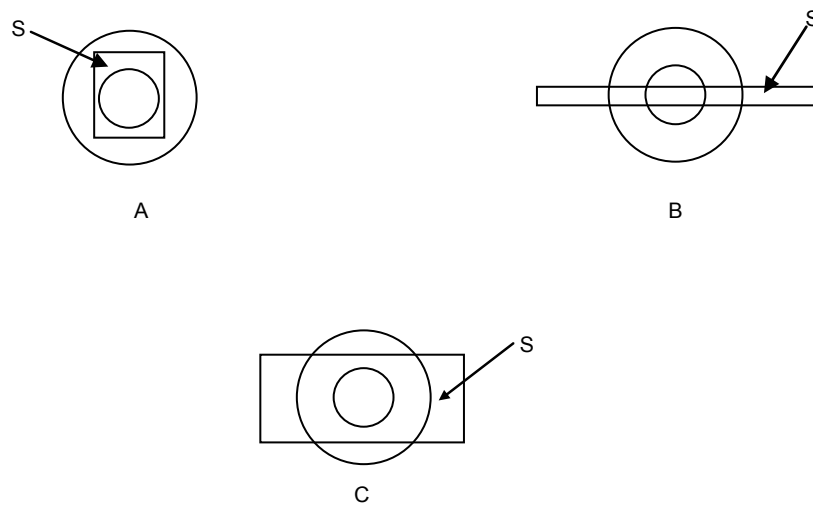
C circuit of Figure 4 of IEC 60990

Connections and supplies

L₁, L₂, L₃, N Supply voltage with neutral

NOTE For **class 0I appliances** and **class I appliances**, C may be replaced by a low impedance ammeter.

Figure 4 – Circuit diagram for leakage current measurement at operating temperature for three-phase connection of appliances other than those of class II

**Key**

A example of a **small part**

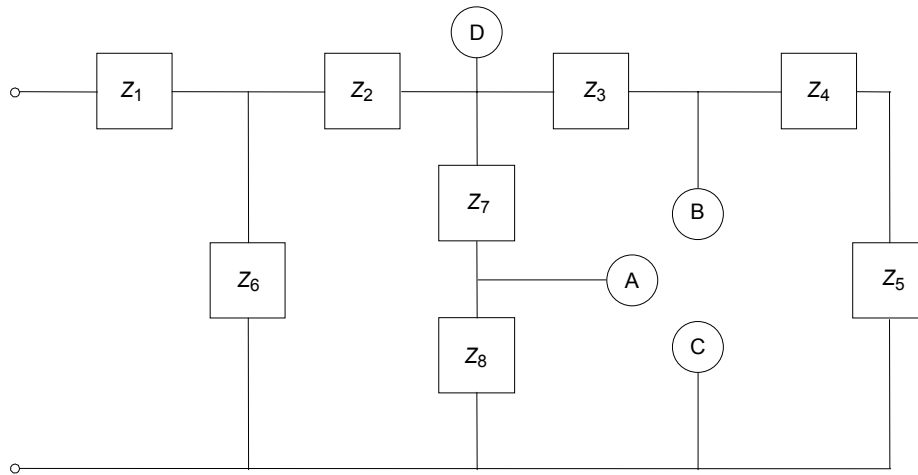
B example of a **small part**

C example of a part that is not a **small part**

S surface

NOTE The small and large circles in examples A, B and C are 8 mm and 15 mm in diameter respectively.

Figure 5 – Small part



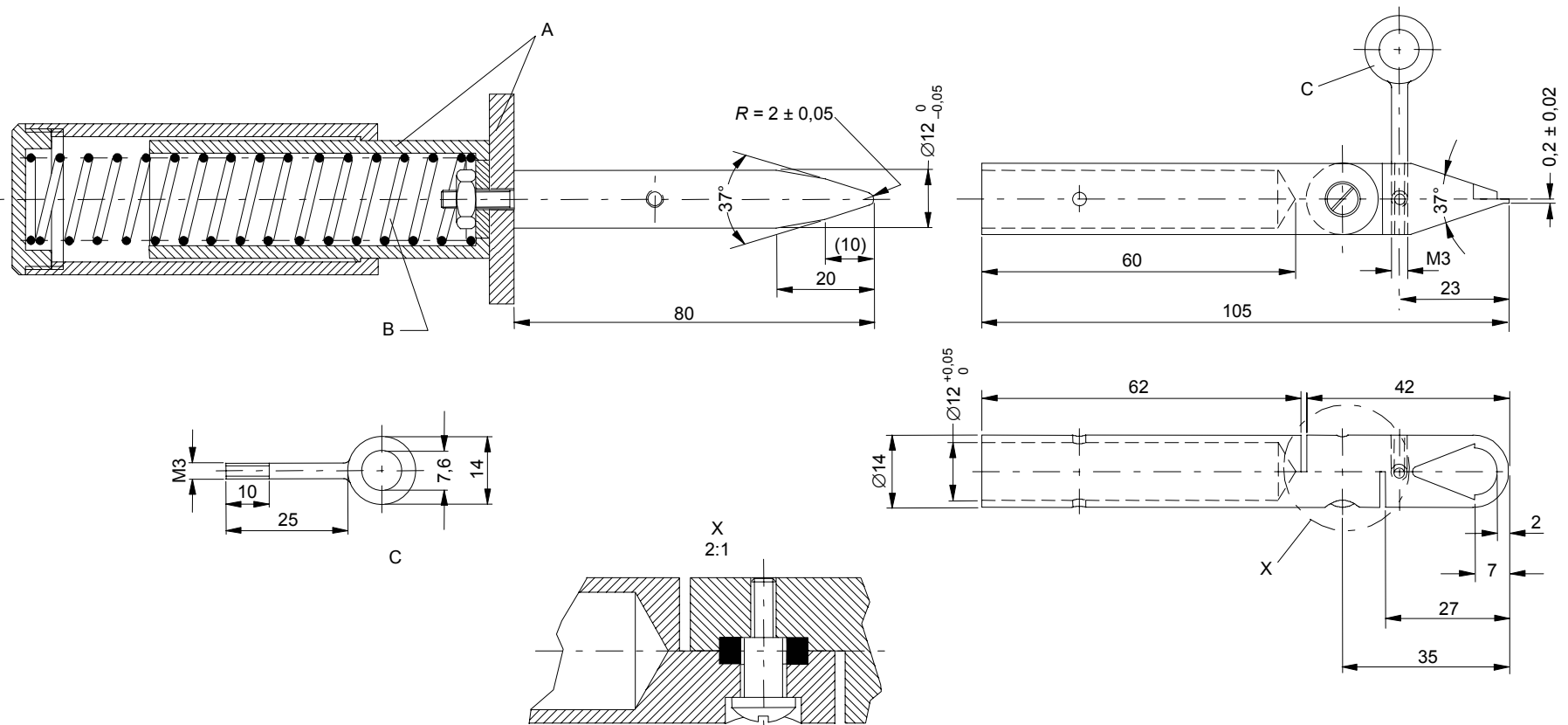
D is a point farthest from the supply source where the maximum power delivered to external load exceeds 15 W.

A and B are points closest to the supply source where the maximum power delivered to external load does not exceed 15 W. These are low-power points.

Points A and B are separately short-circuited to C.

The fault conditions a) to g) specified in 19.11.2 are applied individually to Z₁, Z₂, Z₃, Z₆ and Z₇, where applicable.

Figure 6 – Example of an electronic circuit with low-power points

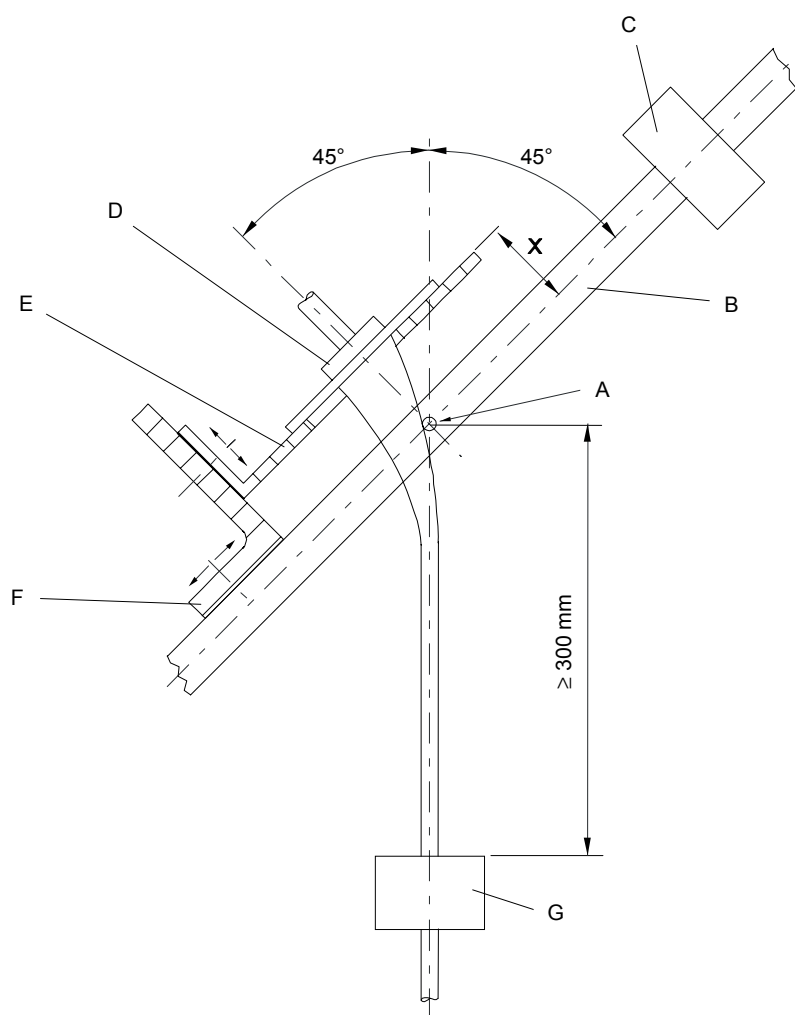


Dimensions in millimetres

Key

- A insulating material
- B spring with a constant suitable for providing a push force as specified in 22.11 on the test finger nail
- C loop

Figure 7 – Test finger nail

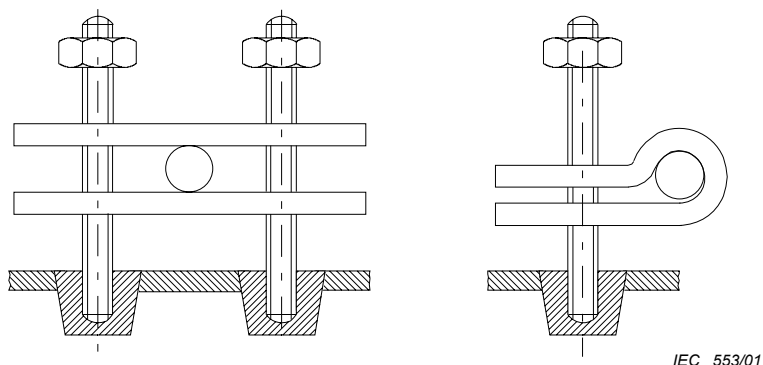


Key

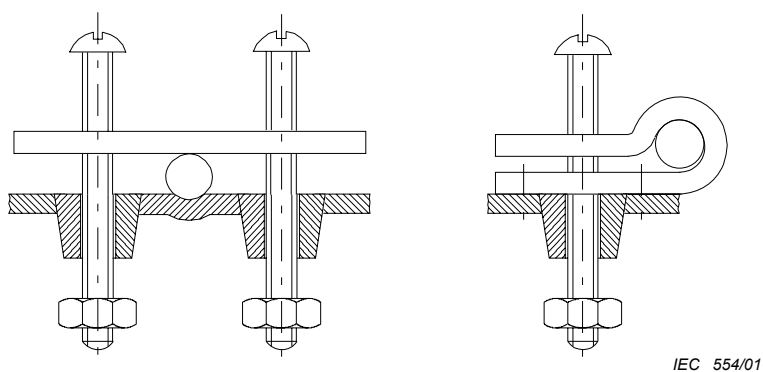
- A axis of oscillation
- B oscillating frame
- C counterweight
- D sample
- E adjustable carrier plate
- F adjustable bracket
- G load

Figure 8 – Flexing test apparatus

ACCEPTABLE CONSTRUCTIONS



Construction showing studs securely attached to the appliance

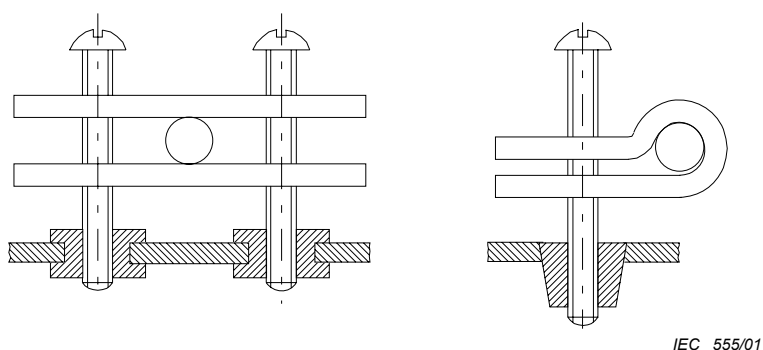


Construction showing part of appliance of insulating material and so shaped that it obviously forms part of a cord clamp.

Construction showing one of the clamping members is fixed to the appliance

NOTE Clamping screws may screw into threaded holes in the appliance or pass through holes where they are secured by nuts.

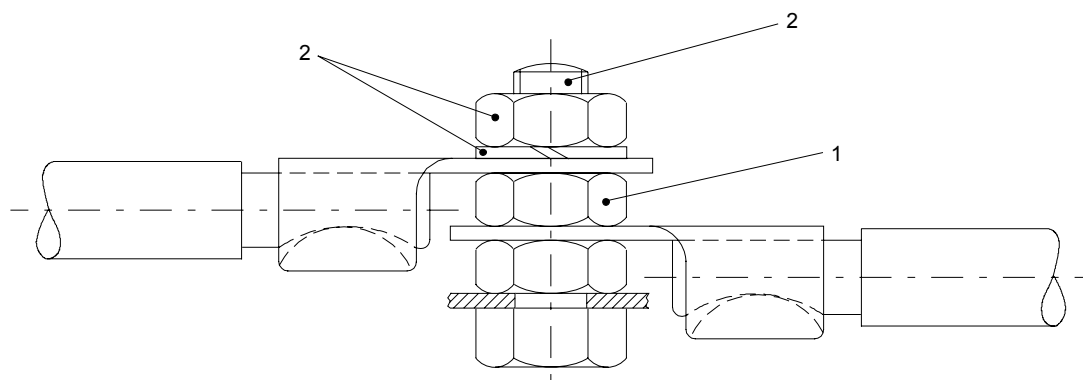
UNACCEPTABLE CONSTRUCTIONS



Construction showing no part securely fixed to the appliance

NOTE Clamping screws may screw into threaded holes in the appliance or pass through holes where they are secured by nuts.

Figure 9 – Constructions of cord anchorages

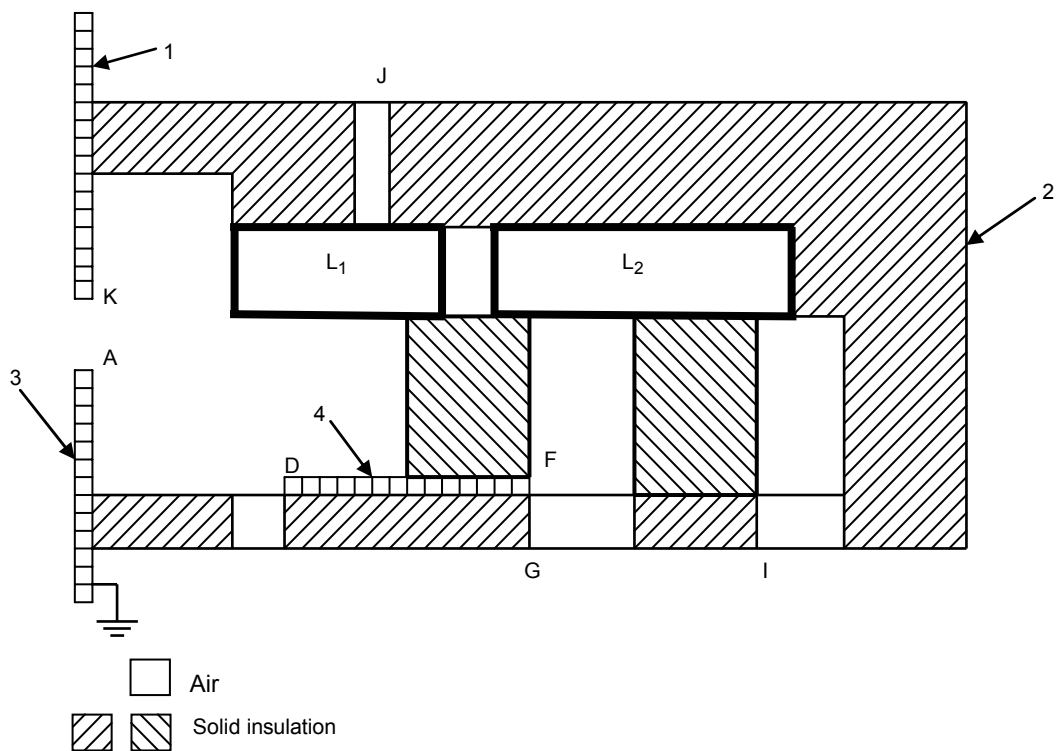


IEC 556/01

Key

- 1 part providing earthing continuity
- 2 part providing or transmitting contact pressure

Figure 10 – An example of parts of an earthing terminal



Key

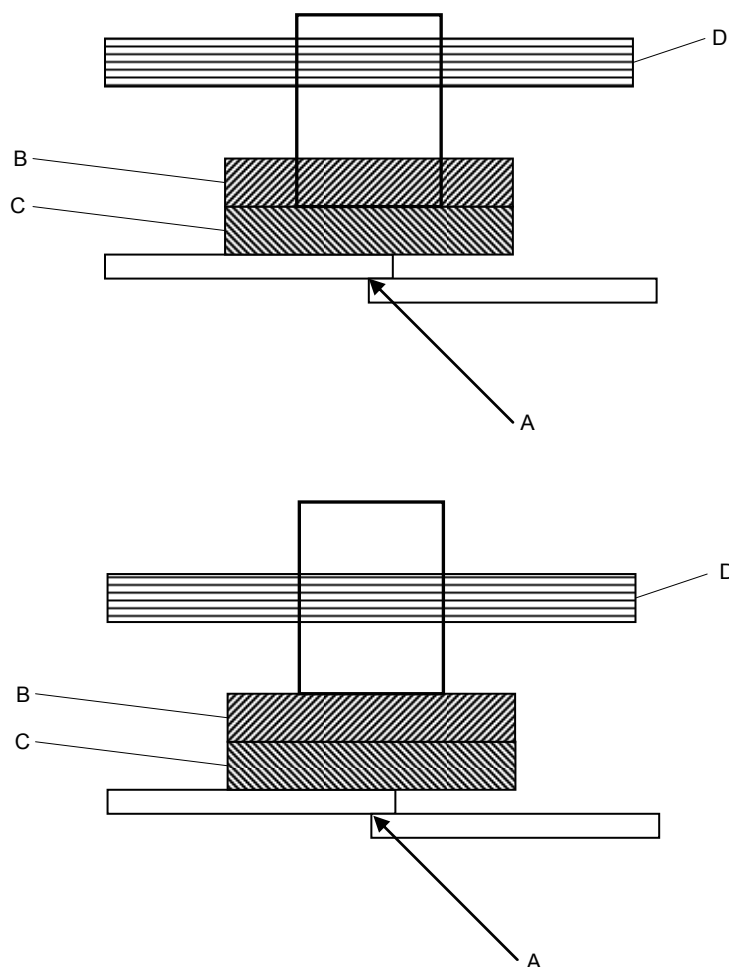
- 1 accessible unearthed metal part
- 2 enclosure
- 3 accessible earthed metal part
- 4 inaccessible unearthed metal part

The **live parts** L_1 and L_2 are separated from each other and partially surrounded by a plastic enclosure containing apertures, partially by air and are in contact with solid insulation. A piece of inaccessible metal is incorporated inside the construction. There are two metal covers, one of which is earthed.

Type of insulation	Clearance
Basic insulation	L_1A
	L_1D
	L_2F
Functional insulation	L_1L_2
Supplementary insulation	DE
	FG
Reinforced insulation	L_1K
	L_1J
	L_2I
	L_1C

NOTE If the clearances L_1D or L_2F meet the clearance requirements for reinforced insulation, the clearances DE or FG of supplementary insulation are not measured.

Figure 11 – Examples of clearances



Key

- A connection zone
- B non-metallic material
- C non-metallic material
- D non-metallic material

NOTE 1 The placement of the cylinder is shown with respect to example 1 in Figure O.5

NOTE 2 If C flames for longer than 2 s during the glow-wire test, then the cylinder is assumed to be located at the upper boundary of C. Consequently parts B and D are subjected to the needle-flame test.

If B flames for longer than 2 s during the glow-wire test, then the cylinder is assumed to be located on top of B. Consequently, D is subjected to the needle-flame test.

NOTE 3 In some constructions, D can be another part of the same moulding as B or C. Therefore, if B or C flame for longer than 2 s during the glow-wire test, the material used for B or C that is within the cylinder, represented by D, is also subjected to the needle-flame test.

Figure 12 – Example of the placement of the cylinder

Annex A (informative)

Routine tests

Introduction

Routine tests are intended to be carried out by the manufacturer on each appliance to detect a production variation that could impair safety. They are normally carried out on the complete appliance after assembly but the manufacturer may perform the tests at an appropriate stage during production, provided that later manufacturing processes do not affect the results.

NOTE Components are not subjected to these tests if they have been previously subjected to routine tests during their manufacture.

The manufacturer may use a different routine test procedure provided that the level of safety is equivalent to that provided by the tests specified in this annex.

These tests are the minimum considered necessary to cover essential safety aspects. It is the manufacturer's responsibility to decide if additional routine tests are necessary. It may be determined from engineering considerations that some of the tests are impracticable or inappropriate and therefore need not be carried out.

If a product fails any of the tests, it is to be retested after rework or adjustment.

A.1 Earth continuity test

*A current of at least 10 A, derived from a source having a no-load voltage not exceeding 12 V (a.c. or d.c.), is passed between each of the **accessible earthed metal parts** and*

- *for **class 0I appliances**, and for **class I appliances** intended to be permanently connected to fixed wiring, the earthing terminal;*
- *for other **class I appliances**,*
 - *the earthing pin or earthing contact of the plug;*
 - *the earthing pin of the appliance inlet.*

The voltage drop is measured and the resistance is calculated and shall not exceed

- *for appliances having a **supply cord**, 0,2 Ω , or 0,1 Ω plus the resistance of the **supply cord**;*
- *for other appliances, 0,1 Ω .*

NOTE 1 The test is only carried out for the duration necessary to enable the voltage drop to be measured.

NOTE 2 Care is to be taken to ensure that the contact resistance between the tip of the measuring probe and the metal part under test does not influence the test results.

A.2 Electric strength test

The insulation of the appliance is subjected to a voltage of substantially sinusoidal waveform having a frequency of approximately 50 Hz or 60 Hz for 1 s. The value of the test voltage and the points of application are shown in Table A.1.

Table A.1 – Test voltages

Points of application	Test voltage V		
	Class 0 appliances, Class 0I appliances, Class I appliances and Class II appliances		Class III appliances
	Rated voltage		
	≤ 150 V	> 150 V	
Between live parts and accessible metal parts separated from live parts by • basic insulation only • double or reinforced insulation ^{a, b}	800 2 000	1 000 2 500	400 –
^a This test is not applicable for class 0 appliances . ^b For class 0I appliances and class I appliances , this test need not be carried out on parts of class II construction if the test is considered to be inappropriate.			

NOTE 1 It may be necessary for the appliance to be in operation during the test to ensure that the test voltage is applied to all relevant insulation, for example, heating elements controlled by a relay.

No breakdown shall occur. Breakdown is assumed to occur when the current in the test circuit exceeds 5 mA. However, this limit may be increased up to 30 mA for appliances with a high leakage current.

NOTE 2 The circuit used for the test incorporates a current sensing device that trips when the current exceeds the limit.

NOTE 3 The high voltage transformer is to be capable of maintaining the specified voltage at the limiting current.

NOTE 4 Instead of being subjected to an a.c. voltage, the insulation may be subjected to a d.c. voltage of 1,5 times the value shown in the table. An a.c. voltage having a frequency up to 5 Hz is considered to be a d.c. voltage.

A.3 Functional test

The correct functioning of an appliance is checked by inspection or by an appropriate test if the incorrect connection or adjustment of components has safety implications.

NOTE Examples are verification of the correct direction of motor rotation and the appropriate operation of interlock switches. This does not require testing of thermal controls or **protective devices**.

Annex B (normative)

Appliances powered by rechargeable batteries

The following modifications to this standard are applicable for appliances powered by batteries that are recharged in the appliance.

NOTE This annex does not apply to battery chargers (IEC 60335-2-29).

3 Terms and definitions

3.1.9

normal operation

operation of the appliance under the following conditions:

- the appliance, supplied by its fully charged battery, is operated as specified in the relevant part 2;
- the battery is charged, the battery being initially discharged to such an extent that the appliance cannot operate;
- if possible, the appliance is supplied from the supply mains through its battery charger, the battery being initially discharged to such an extent that the appliance cannot operate. The appliance is operated as specified in the relevant part 2;
- if the appliance incorporates inductive coupling between two parts that are detachable from each other, the appliance is supplied from the supply mains with the **detachable part** removed.

3.6.2

NOTE If a part has to be removed in order to discard the battery before scrapping the appliance, this part is not considered to be detachable even if the instructions state that it is to be removed.

5 General conditions for the tests

5.B.101 *When appliances are supplied from the supply mains, they are tested as specified for **motor-operated appliances**.*

7 Marking and instructions

7.1 The battery compartment of appliances incorporating batteries that are intended to be replaced by the user shall be marked with the battery voltage and the polarity of the terminals.

The positive terminal shall be indicated by symbol IEC 60417-5005 (2002-10) and the negative terminal by symbol IEC 60417-5006 (2002-10).

7.6



Symbol IEC 60417-5005 (2002-10) Plus; positive polarity



Symbol IEC 60417-5006 (2002-10) Minus; negative polarity

7.12 The instructions shall give information regarding charging.

The instructions for appliances incorporating batteries that are intended to be replaced by the user shall include the following:

- the type reference of the battery;
- the orientation of the battery with regard to polarity;
- the method of replacing batteries;
- details regarding safe disposal of used batteries;
- warning against using non-rechargeable batteries;
- how to deal with leaking batteries.

The instructions for appliances incorporating a battery that contains materials that are hazardous to the environment shall give details on how to remove the battery and shall state that

- the battery must be removed from the appliance before it is scrapped;
- the appliance must be disconnected from the supply mains when removing the battery;
- the battery is to be disposed of safely.

7.15 Markings, other than those associated with the battery, shall be placed on the part of the appliance that is connected to the supply mains.

8 Protection against access to live parts

8.2 Appliances having batteries that according to the instructions may be replaced by the user need only have **basic insulation** between **live parts** and the inner surface of the battery compartment. If the appliance can be operated without the batteries, **double insulation** or **reinforced insulation** is required.

11 Heating

11.7 *The battery is charged for the period stated in the instructions or for 24 h, whichever is longer.*

19 Abnormal operation

19.1 *Appliances are also subjected to the tests of 19.B.101, 19.B.102, and 19.B.103.*

19.10 Not applicable.

19.B.101 *Appliances are supplied at **rated voltage** for 168 h, the battery being continually charged during this period.*

19.B.102 *For appliances having batteries that can be removed without the aid of a **tool**, and having terminals that can be short-circuited by a thin straight bar, the terminals of the battery are short-circuited, the battery being fully charged.*

19.B.103 *Appliances having batteries that are replaceable by the user are supplied at **rated voltage** and operated under **normal operation** but with the battery removed or in any position allowed by the construction.*

21 Mechanical strength

21.B.101 Appliances having pins for insertion into socket-outlets shall have adequate mechanical strength.

Compliance is checked by subjecting the part of the appliance incorporating the pins to the test, Free fall repeated, procedure 2, of IEC 60068-2-31.

The number of falls is

- 100, if the mass of the part does not exceed 250 g;
- 50, if the mass of the part exceeds 250 g.

The height of the falls is 500 mm.

After the test, the requirements of 8.1, 15.1.1, 16.3 and Clause 29 shall be met.

22 Construction

22.3

NOTE Appliances having pins for insertion into socket-outlets are tested as fully assembled as possible.

25 Supply connection and external flexible cords

25.13 An additional lining or bushing is not necessary for **interconnection cords** in **class III appliances** or **class III constructions** that do not contain **live parts**.

30 Resistance to heat and fire

30.2 *For parts of the appliance that are connected to the supply mains during the charging period, 30.2.3 applies. For other parts, 30.2.2 applies.*

Annex C (normative)

Ageing test on motors

This annex is applicable when there is doubt with regard to the temperature classification of the insulation of a motor winding, for example

- if the temperature rise of the motor winding exceeds the values specified in Table 3;
- when well-known insulating materials are used in an unconventional way;
- when combinations of materials of different temperature classes are used at a temperature higher than that allowed for the lowest class;
- when materials are used for which sufficient experience is not available, for instance in motors having integral core insulation.

This test is carried out on six samples of the motor.

The rotor of each motor is locked and a current is passed individually through the rotor winding and the stator winding, this current being such that the temperature of the relevant winding is equal to the maximum temperature rise measured during the test of Clause 11, increased by 25 K. This temperature is further increased by one of the values chosen from Table C.1. The corresponding total time during which the current is passed is indicated in the table.

Table C.1 – Test conditions

Temperature increase K	Total time h
0 ± 3	p^a
10 ± 3	$0,5 p$
20 ± 3	$0,25 p$
30 ± 3	$0,125 p$
NOTE The temperature increase chosen is selected by the manufacturer.	
^a p is 8 000 unless otherwise specified in the relevant part 2.	

The total time is divided into four equal periods, each being followed by a period of 48 h during which the motor is subjected to the humidity test of 15.3. After the final humidity test, the insulation shall withstand the electric strength test of 16.3, but with the test voltage reduced to 50 % of the value specified.

After each of the four periods and before the subsequent humidity test, the leakage current of the insulating system is measured as specified in 13.2, any component not forming part of the insulation system under test being disconnected before the measurement is made.

The leakage current shall not exceed 0,5 mA.

Failure of only one of the six motors during the first of the four periods of the test is ignored.

If one of the six motors fails during the second, third or fourth period of the test, the remaining five motors are subjected to a fifth period followed by the humidity test and the electric strength test.

The remaining five motors shall complete the test.

Annex D (normative)

Thermal motor protectors

This annex is applicable to appliances having motors that incorporate thermal motor protectors that are necessary for compliance with the standard.

*The appliance is supplied at **rated voltage** and is operated under stalled conditions by*

- locking the rotor of appliances for which the locked rotor torque is smaller than the full load torque;*
- locking moving parts of other appliances.*

The duration of the test is as follows:

- motors having self-resetting thermal motor protectors are operated for 300 cycles or for 72 h, whichever occurs first, unless they are likely to be permanently subjected to the supply voltage, in which case the duration is 432 h;*
- motors having non-self-resetting thermal motor protectors are operated for 30 cycles, the thermal motor protector being reset as soon as possible after each operation, but in not less than 30 s.*

During the test, temperatures shall not exceed the values specified in 19.7 and the appliance shall comply with 19.13.

Annex E (normative)

Needle-flame test

The needle-flame test is carried out in accordance with IEC 60695-11-5 with the following modifications.

7 Severities

Replacement:

The duration of application of the test flame is $30\text{ s} \pm 1\text{ s}$.

9 Test procedure

9.1 Position of test specimen

Modification:

The specimen is arranged so that the flame can be applied to a vertical or horizontal edge as shown in the examples of Figure 1.

9.2 Application of needle-flame

Modification:

The first paragraph does not apply.

Addition:

If possible, the flame is applied at least 10 mm from a corner.

9.3 Number of test specimens

Replacement:

The test is carried out on one specimen. If the specimen does not withstand the test, the test may be repeated on two additional specimens, both of which shall then withstand the test.

11 Evaluation of test results

Addition:

The duration of burning (t_b) shall not exceed 30 s. However, for printed circuit boards, the duration of burning shall not exceed 15 s.

Annex F (normative)

Capacitors

Capacitors likely to be permanently subjected to the supply voltage, and used for radio interference suppression or for voltage dividing, shall comply with the following clauses of IEC 60384-14, as modified below.

1.5 Terms and definitions

1.5.3 This subclause is applicable.

Class X capacitors are tested according to subclass X2.

1.5.4 This subclause is applicable.

1.6 Marking

Items a) and b) of this subclause are applicable.

3.4 Approval testing

3.4.3.2 Tests

Table 3 is applicable as follows:

- group 0: Subclauses 4.1, 4.2.1 and 4.2.5;
- group 1A: Subclause 4.1.1;
- group 2: Subclause 4.12;
- group 3: Subclauses 4.13 and 4.14;
- group 6: Subclause 4.17;
- group 7: Subclause 4.18.

4.1 Visual examination and check of dimensions

This subclause is applicable.

4.2 Electrical tests

4.2.1 This subclause is applicable.

4.2.5 This subclause is applicable.

4.2.5.2 Only Table 11 is applicable. The values for test A apply; however, for capacitors in **heating appliances**, the values for test B or test C apply.

4.12 Damp heat, steady state

This subclause is applicable.

NOTE Only insulation resistance and voltage proof are checked (see Table 15).

4.13 Impulse voltage

This subclause is applicable.

4.14 Endurance

Subclauses 4.14.1, 4.14.3, 4.14.4 and 4.14.7 are applicable.

4.14.7 Add:

NOTE Only insulation resistance and voltage proof are checked (see Table 16) together with a visual examination to ensure that there is no visible damage.

4.17 Passive flammability test

This subclause is applicable.

4.18 Active flammability test

This subclause is applicable.

Annex G (normative)

Safety isolating transformers

The following modifications to this standard are applicable for **safety isolating transformers**.

7 Marking and instructions

7.1 Transformers for specific use shall be marked with

- name, trademark or identification mark of the manufacturer or responsible vendor;
- model or type reference.

NOTE The definition of transformers for specific use is given in IEC 61558-1.

17 Overload protection of transformers and associated circuits

Fail-safe transformers shall comply with Subclause 15.5 of IEC 61558-1.

NOTE This test is carried out on three transformers.

22 Construction

Subclauses 19.1 and 19.1.2 of IEC 61558-2-6 are applicable.

29 Clearances, creepage distances and solid insulation

29.1, 29.2 and 29.3 The distances specified in items 2a, 2c and 3 in Table 13 of IEC 61558-1 apply.

NOTE The values stated for pollution degree 2 are applicable.

For insulated winding wires complying with Subclause 19.12.3 of IEC 61558-1 there are no requirements for **clearances** or **creepage distances**. In addition, for windings providing **reinforced insulation**, the distance specified in item 2c of Table 13 of IEC 61558-1 is not assessed.

For **safety isolating transformers** subjected to periodic voltages with a frequency exceeding 30 kHz, the **clearances**, **creepage distances** and **solid insulation** values specified in IEC 60664-4 are applicable, if these values are greater than the values specified in items 2a, 2c and 3 in Table 13 of IEC 61558-1.

Annex H **(normative)**

Switches

Switches shall comply with the following clauses of IEC 61058-1, as modified below.

The tests of IEC 61058-1 are carried out under the conditions occurring in the appliance.

Before being tested, switches are operated 20 times without load.

8 Marking and documentation

Switches are not required to be marked. However, a switch that can be tested separately from the appliance shall be marked with the manufacturer's name or trademark and the type reference.

13 Mechanism

NOTE The tests may be carried out on a separate sample.

15 Insulation resistance and dielectric strength

Subclause 15.1 is not applicable.

Subclause 15.2 is not applicable.

Subclause 15.3 is applicable for full disconnection and micro-disconnection.

NOTE This test is carried out immediately after the humidity test of subclause 15.3 of IEC 60335-1.

17 Endurance

Compliance is checked on three separate appliances or switches.

For 17.2.4.4, the number of cycles of actuation declared according to 7.1.4 is 10 000 unless otherwise specified in subclause 24.1.3 of the relevant part 2 of IEC 60335.

*Switches intended for operation under no load and which can be operated only with the aid of a **tool** are not subjected to the tests. This applies also for such switches operated by hand that are interlocked so that they cannot be operated under load. However, switches without this interlock are subjected to the test of 17.2.4.4 for 100 cycles of operation.*

Subclauses 17.2.2 and 17.2.5.2 are not applicable. The ambient temperature during the test is that occurring in the appliance during the test of Clause 11 in IEC 60335-1, as specified in footnote b of Table 3.

At the end of the tests, the temperature rise of the terminals shall not have increased by more than 30 K above the temperature rise measured in Clause 11 of IEC 60335-1.

20 Clearances, creepage distances, solid insulation and coatings of rigid printed board assemblies

This clause is applicable to **clearances** and **creepage distances** for **functional insulation**, across full disconnection and micro-disconnection, as stated in Table 24.

Annex I (normative)

Motors having basic insulation that is inadequate for the rated voltage of the appliance

The following modifications to this standard are applicable for motors having **basic insulation** that is inadequate for the **rated voltage** of the appliance.

8 Protection against access to live parts

8.1 NOTE Metal parts of the motor are considered to be bare **live parts**.

11 Heating

11.3 *The temperature rise of the body of the motor is determined instead of the temperature rise of the windings.*

11.8 *The temperature rise of the body of the motor, where it is in contact with insulating material, shall not exceed the values shown in Table 3 for the relevant insulating material.*

16 Leakage current and electric strength

16.3 *The insulation between **live parts** of the motor and its other metal parts is not subjected to this test.*

19 Abnormal operation

19.1 *The tests of 19.7 to 19.9 are not carried out.*

Appliances are also subjected to the test of 19.1.101.

19.1.101 *The appliance is operated at **rated voltage** with each of the following fault conditions:*

- *short circuit of the terminals of the motor, including any capacitor incorporated in the motor circuit;*
- *short circuit of each diode of the rectifier;*
- *open circuit of the supply to the motor;*
- *open circuit of any parallel resistor, the motor being in operation.*

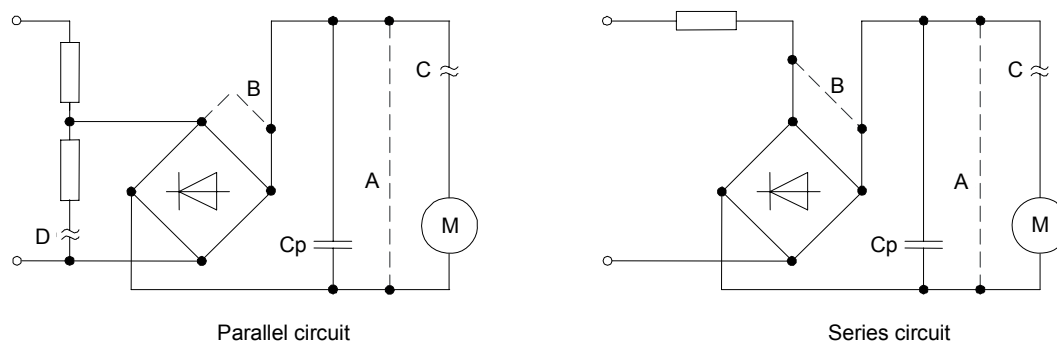
Only one fault is simulated at a time, the tests being carried out consecutively.

NOTE The faults are simulated as shown in Figure I.1.

22 Construction

22.1.101 For **class I appliances** incorporating a motor supplied by a rectifier circuit, the d.c. circuit shall be insulated from **accessible parts** of the appliance by **double insulation** or **reinforced insulation**.

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

**Key**

—	original connection
- - -	short-circuit
≈	open circuit
A	short-circuit of the terminals of the motor
B	short-circuit of a diode
C	open circuit of the supply to the motor
D	open circuit of the parallel resistor

Figure I.1 – Simulation of faults

Annex J (normative)

Coated printed circuit boards

The testing of protective coatings of printed circuit boards is carried out in accordance with IEC 60664-3 with the following modifications.

5.7 Conditioning of the test specimens

When production samples are used, three samples of the printed circuit board are tested.

5.7.1 Cold

The test is carried out at –25 °C.

5.7.3 Rapid change of temperature

Severity 1 is specified.

5.9 Additional tests

This subclause is not applicable.

Annex K (normative)

Overvoltage categories

The following information on overvoltage categories is extracted from IEC 60664-1.

Overvoltage category is a numeral defining a transient overvoltage condition.

Equipment of overvoltage category IV is for use at the origin of the installation.

NOTE 1 Examples of such equipment are electricity meters and primary overcurrent protection equipment.

Equipment of overvoltage category III is equipment in fixed installations and for cases where the reliability and the availability of the equipment is subject to special requirements.

NOTE 2 Examples of such equipment are switches in the fixed installation and equipment for industrial use with permanent connection to the fixed installation.

Equipment of overvoltage category II is energy consuming equipment to be supplied from the fixed installation.

NOTE 3 Examples of such equipment are appliances, portable tools and other household and similar loads.

If such equipment is subjected to special requirements with regard to reliability and availability, overvoltage category III applies.

Equipment of overvoltage category I is equipment for connection to circuits in which measures are taken to limit transient overvoltages to an appropriately low level.

Annex L (informative)

Guidance for the measurement of clearances and creepage distances

L.1 When measuring **clearances**, the following applies.

The **rated voltage** and overvoltage category are determined (see Annex K).

NOTE 1 In general, appliances are in overvoltage category II.

The **rated impulse voltage** is determined from Table 15.

If pollution degree 3 is applicable, or if the appliance is **class 0** or **class 01**, the **clearances** for **basic insulation** and **functional insulation** are measured and compared with the minimum values specified in Table 16. For other cases, the impulse voltage test may be carried out if the rigidity requirements of 29.1 are met, otherwise the values specified in Table 16 apply. However, for **functional insulation** that is subjected to a steady-state voltage or recurring peak voltage with a frequency not exceeding 30 kHz, the **clearances** are also obtained from Table F.7a in IEC 60664-1 or if the frequency exceeds 30 kHz, Clause 4 in IEC 60664-4. The larger of the values so obtained is applied if they exceed the minimum values specified in Table 16.

Clearances of **supplementary insulation** and **reinforced insulation** are measured and compared with the minimum values specified in Table 16.

NOTE 2 Special considerations apply for **clearances** subjected to higher **working voltages** than **rated voltage**. For these requirements, refer to the text in 29.1.5.

NOTE 3 The sequence for determining **clearances** is shown in Figure L.1.

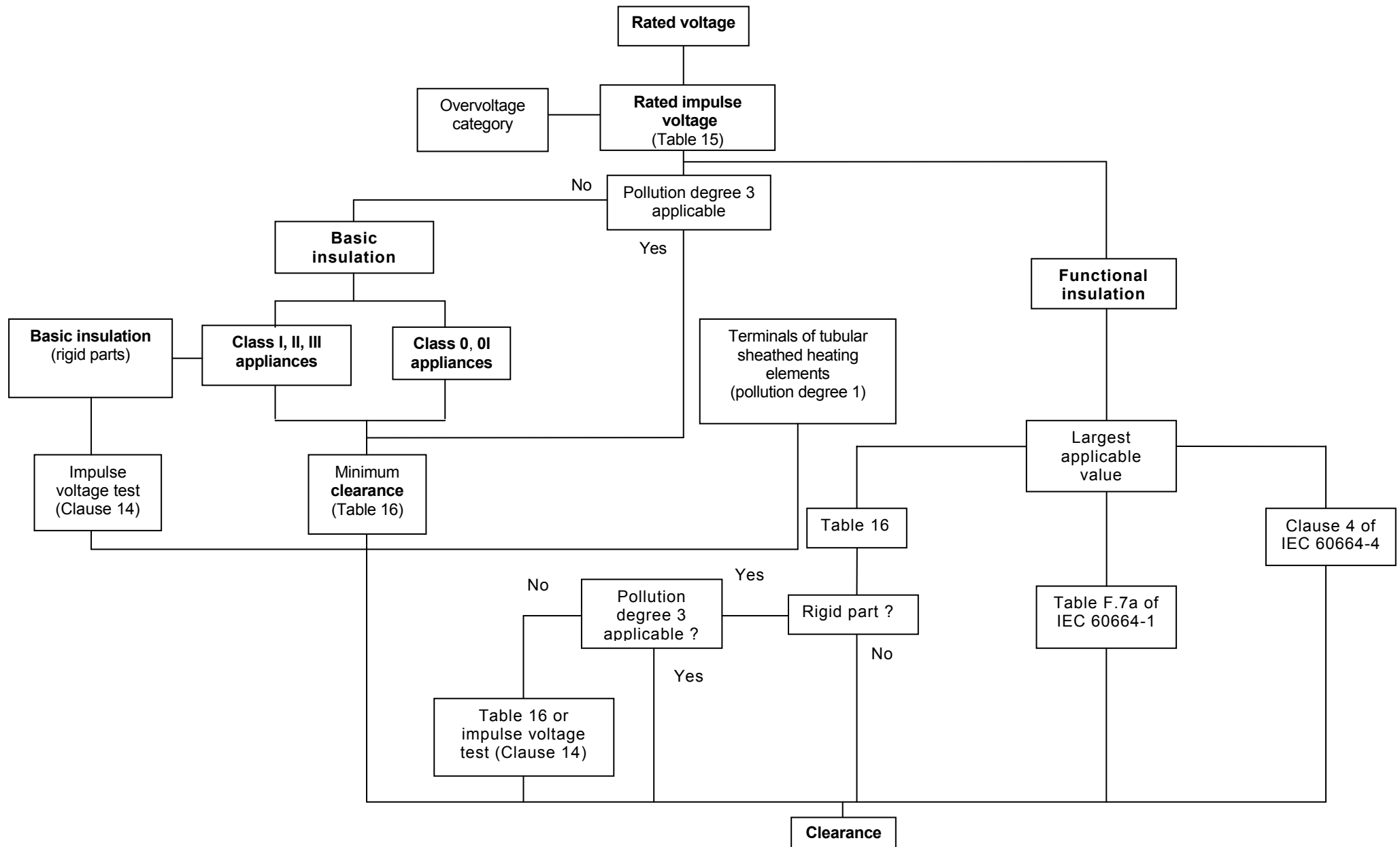


Figure L.1 – Sequence for the determination of clearances

L.2 When measuring **creepage distances**, the following applies.

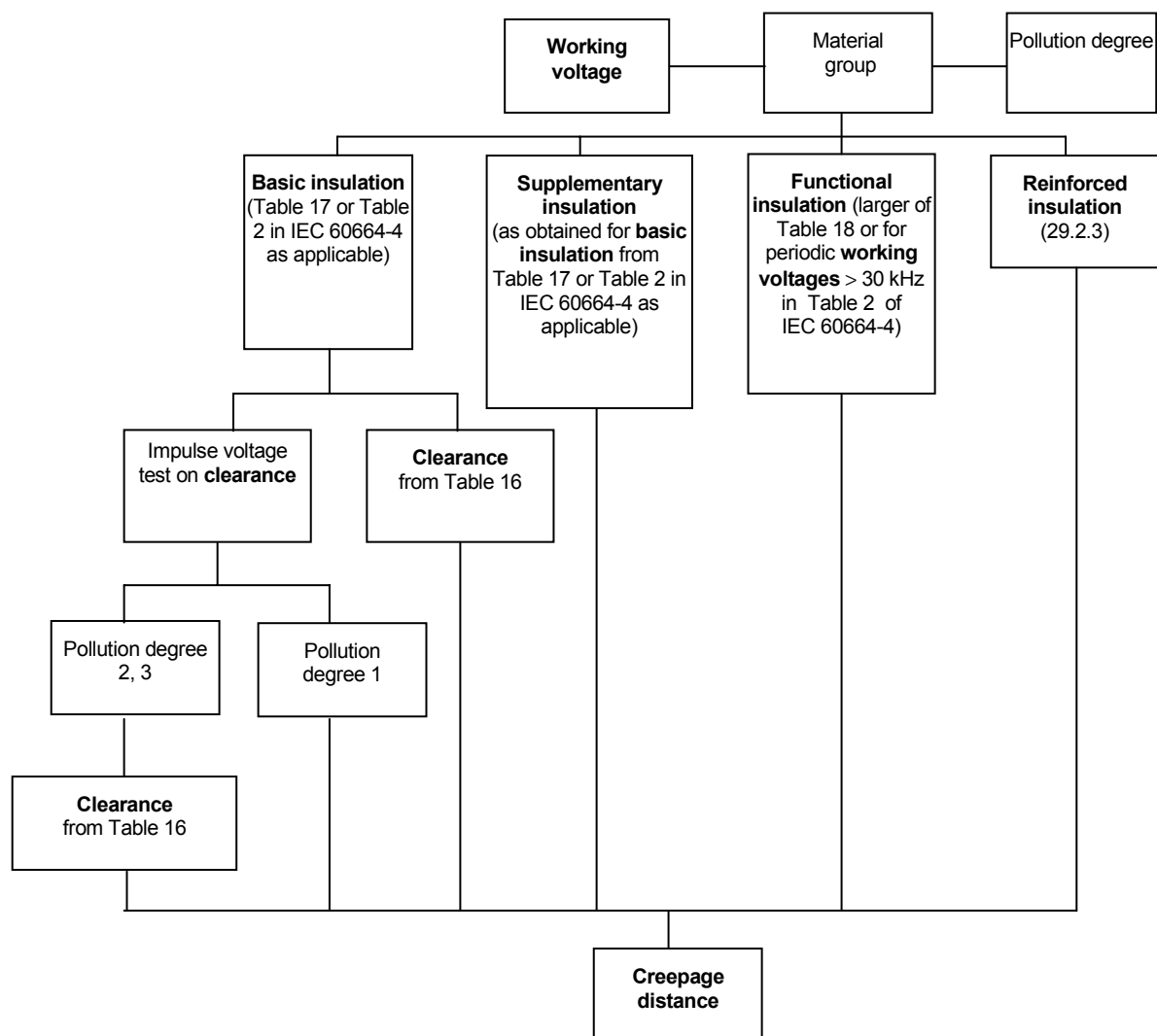
The **working voltage**, pollution degree and material group are determined.

The **creepage distances** of **basic insulation** and **supplementary insulation** are measured and compared with the minimum values specified in Table 17 or Table 2 in IEC 60664-4 as appropriate. A particular **creepage distance** is then compared with the corresponding **clearance** of Table 16 and enlarged if necessary in order not to be less than the **clearance**. For pollution degree 1, the reduced **clearance** based on the impulse voltage test can be used. However, the **creepage distance** can not be less than the values of Table 17.

The **creepage distances** of **functional insulation** are measured and compared with the minimum values specified in Table 18 or for periodic **working voltages** exceeding 30 kV Table 2 of IEC 60664-4.

The **creepage distances** of **reinforced insulation** are measured and compared with twice the minimum values specified in Table 17.

NOTE The sequence for determining **creepage distances** is shown in Figure L.2.



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Figure L.2 – Sequence for the determination of creepage distances

Annex M (normative)

Pollution degree

The following information on pollution degrees is extracted from IEC 60664-1.

- **Pollution**

The microenvironment determines the effect of pollution on the insulation. The macro-environment, however, has to be taken into account when considering the microenvironment.

Means may be provided to reduce pollution at the insulation under consideration by effective use of enclosures, encapsulation or hermetic sealing. Such means to reduce pollution may not be effective when the equipment is subjected to condensation or if in normal use, it generates pollutants itself.

Small **clearances** can be bridged completely by solid particles, dust and water and therefore minimum **clearances** are specified where pollution may be present in the microenvironment.

NOTE 1 Pollution will become conductive in the presence of humidity. Pollution caused by contaminated water, soot, metal or carbon dust is inherently conductive.

NOTE 2 Conductive pollution by ionized gases and metallic depositions occur only in specific instances, for example in arc chambers of switchgear or controlgear and is not covered by IEC 60664-1.

- **Degrees of pollution in the microenvironment**

For the purpose of evaluating **creepage distances**, the following four degrees of pollution in the microenvironment are established:

- pollution degree 1: no pollution or only dry, non-conductive pollution occurs. The pollution has no influence;
- pollution degree 2: only non-conductive pollution occurs, except that occasionally a temporary conductivity caused by condensation is to be expected;
- pollution degree 3: conductive pollution occurs or dry non-conductive pollution occurs that becomes conductive due to condensation that is to be expected;
- pollution degree 4: the pollution generates persistent conductivity caused by conductive dust or by rain or snow.

NOTE 3 Pollution degree 4 is not applicable to appliances.

Annex N

(normative)

Proof tracking test

The proof tracking test is carried out in accordance with IEC 60112 with the following modifications.

7 Test apparatus

7.3 Test solutions

Test solution A is used.

10 Determination of proof tracking index (PTI)

10.1 Procedure

Modification:

The proof voltage is 100 V, 175 V, 400 V or 600 V, as appropriate.

The test is carried out on five specimens.

In case of doubt, a material is considered to have a PTI of the specified value if it withstands the test at a voltage equal to the proof voltage reduced by 25 V, the number of drops being increased to 100.

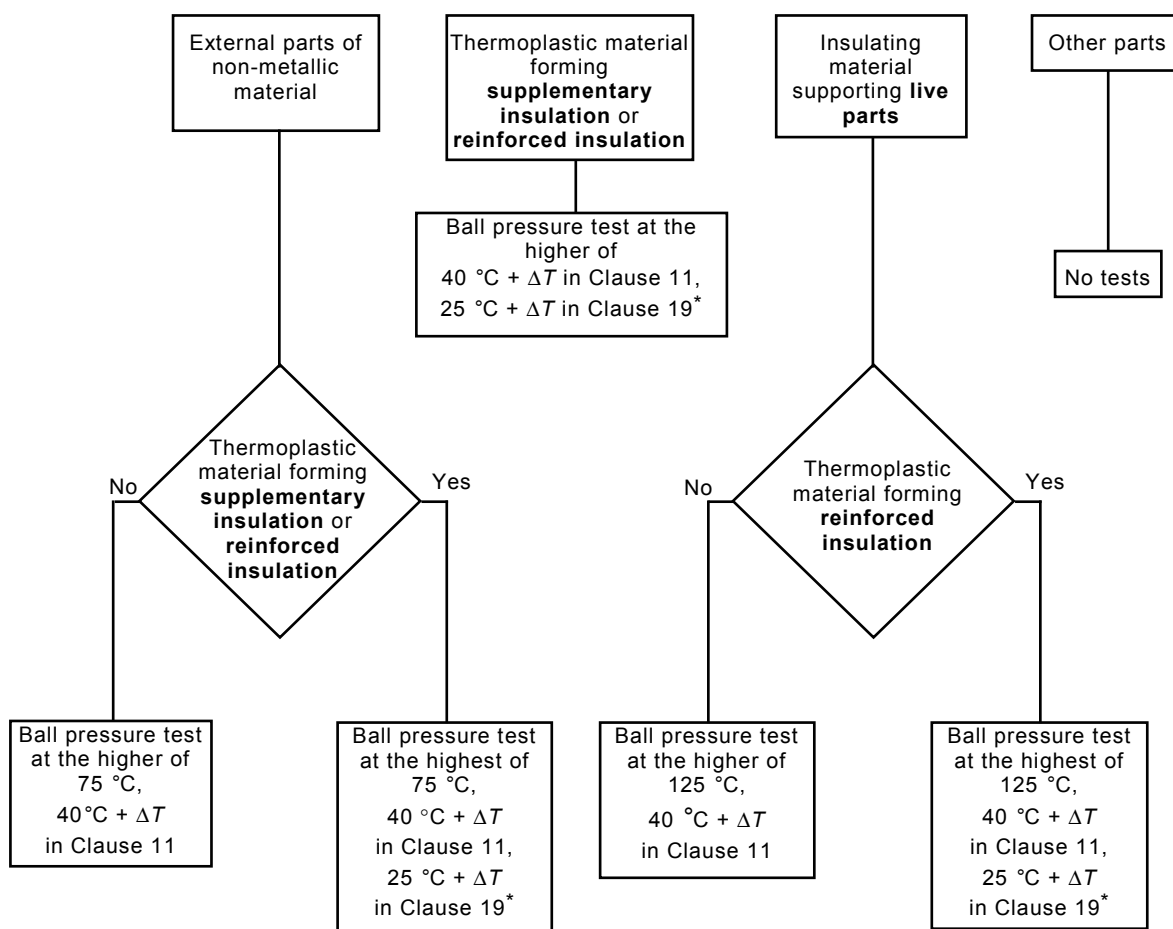
10.2 Report

Addition:

The report shall state if the PTI value was based on a test using 100 drops with a test voltage of (PTI-25) V.

Annex O (informative)

Selection and sequence of the tests of Clause 30



IEC 562/01

* ΔT is not taken into account if the test of 19.4 is terminated by the operation of a **non-self-resetting protective device** requiring the use of a **tool** or removal of a cover to reset it.

Figure O.1 – Tests for resistance to heat

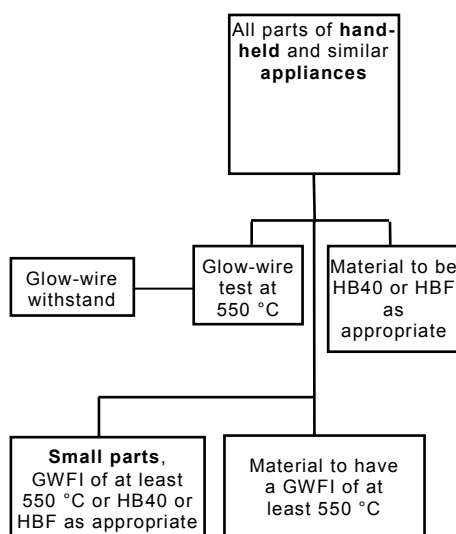


Figure O.2 – Selection and sequence of tests for resistance to fire in hand-held appliances

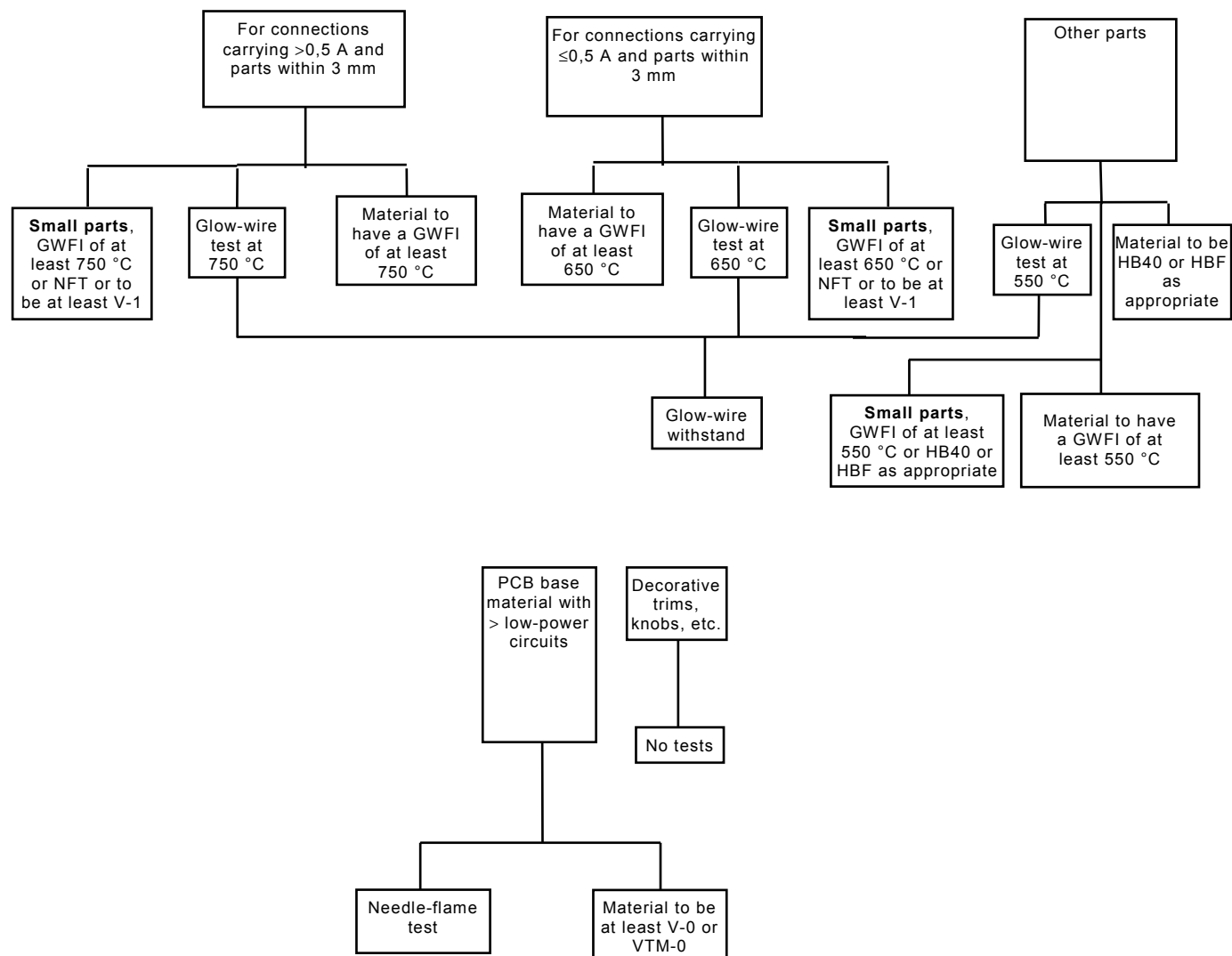


Figure O.3 – Selection and sequence of tests for resistance to fire in attended appliances

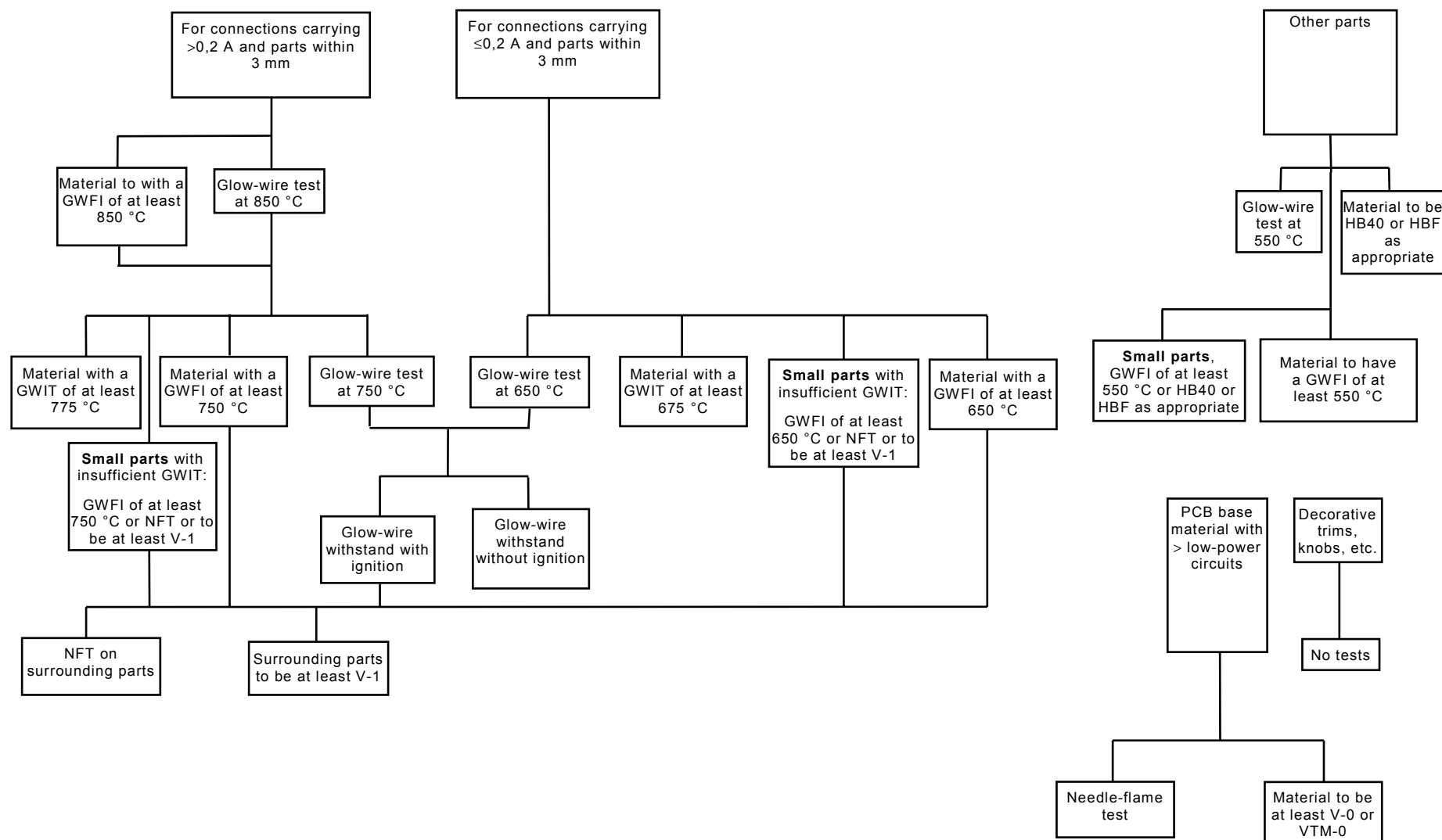
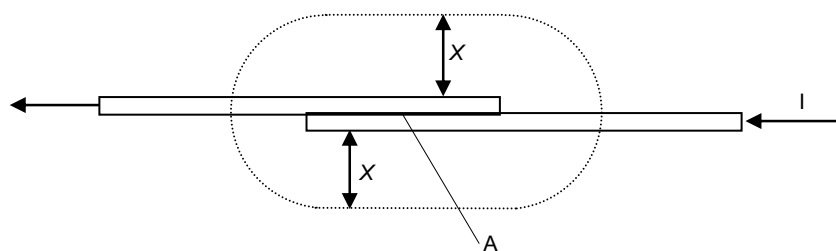
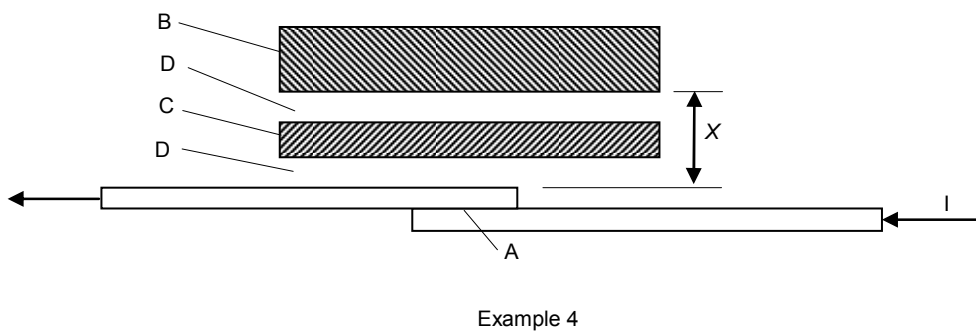
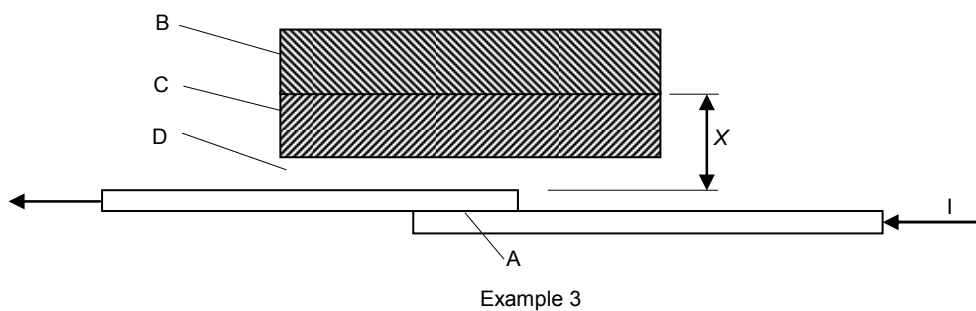
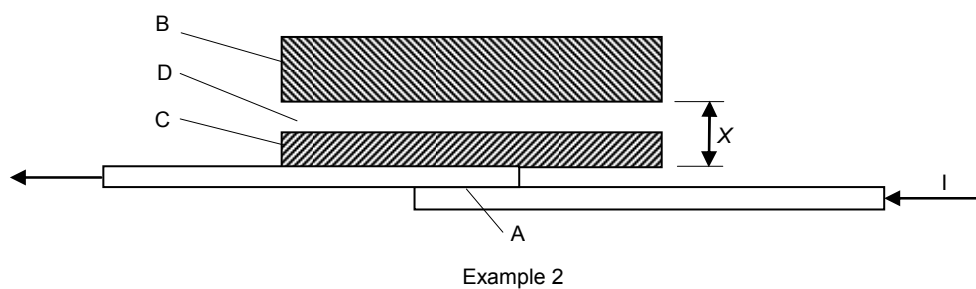
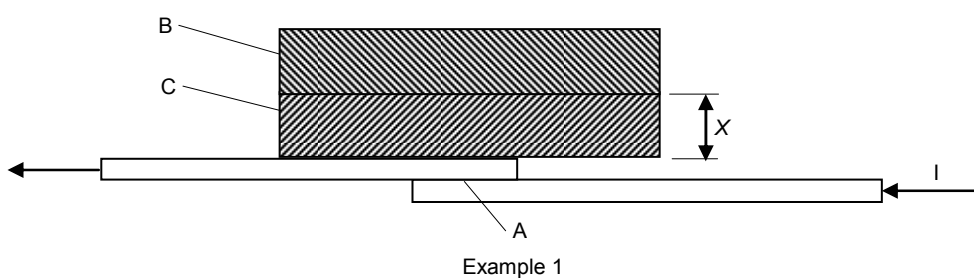


Figure O.4 – Selection and sequence of tests for resistance to fire in unattended appliances



“Within a distance of 3 mm” means falling within the dotted boundary formed by the cylinder with hemispherical ends, as shown in the above drawing.

Some examples:



Key

- A connection zone
 B non-metallic material
 C non-metallic material
 D air gap
 I current greater than 0,5 A in attended appliances and greater than 0, 2 A in unattended appliances
 X distance from the connection

NOTE The distance X is not measured from the point of the connection since there is little or no temperature gradient across the current-carrying conductors.

Explanation

Example	$X \leq 3 \text{ mm}$		$X > 3 \text{ mm}$	
	Material subjected to glow-wire test		Material subjected to glow-wire test	
	B	C	B	C
1	Yes	Yes	No	Yes
2	Yes	Yes	No	Yes
3	Yes	Yes	No	Yes
4	Yes	Yes	No	Yes

Consequential test

In unattended appliances, B is also subjected to the needle-flame if C produces a flame that persists for longer than 2 s during the glow-wire test of 30.2.3.2.

Figure O.5 – Some applications of the term "within a distance of 3 mm"

Annex P (informative)

Guidance for the application of this standard to appliances used in warm damp equable climates

The following modifications to this standard are applicable for **class 0 appliances** and **class OI appliances** having a **rated voltage** exceeding 150 V, that are intended to be used in countries having a warm damp equable climate and that are marked WDaE.

NOTE Warm damp equable climates are characterized by high humidity and high ambient temperatures with little variation, as specified in IEC 60721-2-1.

They may also be applied to **class I appliances** having a **rated voltage** exceeding 150 V that are intended to be used in countries having a warm damp equable climate and that are marked WDaE, if they are liable to be connected to a supply mains that excludes the protective earthing conductor due to deficiencies in the fixed wiring system.

5 General conditions for the tests

5.7 *The ambient temperature for the tests of Clauses 11 and 13 is 40^{+3}_0 °C.*

7 Marking and instructions

7.1 The appliance shall be marked with the letters WDaE.

7.12 The instructions shall state that the appliance is to be supplied through a residual current device (RCD) having a rated residual operating current not exceeding 30 mA.

The instructions shall state the substance of the following:

This appliance is considered to be suitable for use in countries having a warm damp equable climate. It may also be used in other countries.

11 Heating

11.8 *The values of Table 3 are reduced by 15 K.*

13 Leakage current and electric strength at operating temperature

13.2 *The leakage current for **class I appliances** shall not exceed 0,5 mA.*

15 Moisture resistance

15.3 *The value of t is 37 °C.*

16 Leakage current and electric strength

16.2 *The leakage current for **class I appliances** shall not exceed 0,5 mA.*

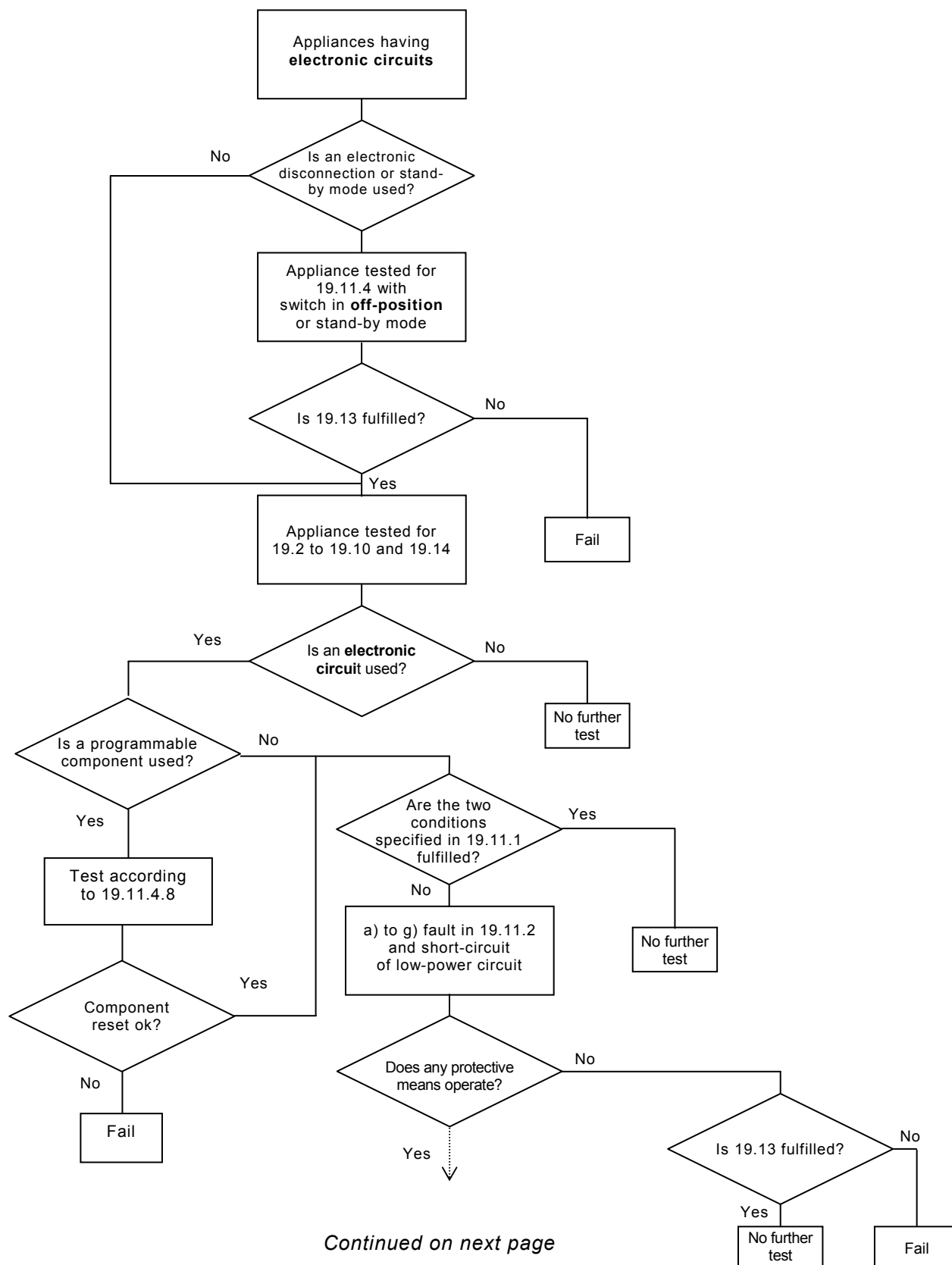
19 Abnormal operation

19.13 *The leakage current test of 16.2 is applied in addition to the electric strength test of 16.3.*

Annex Q (informative)

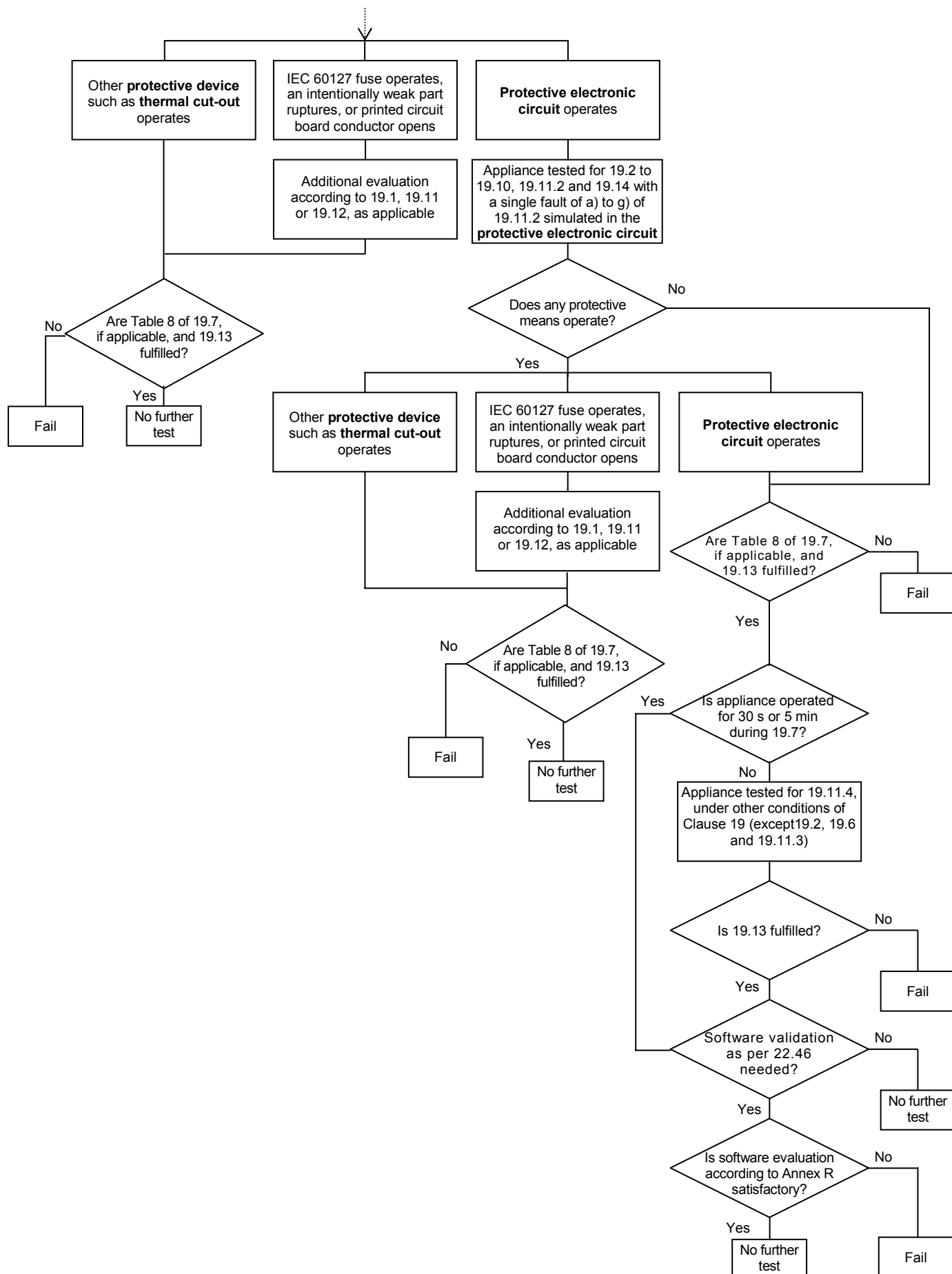
Sequence of tests for the evaluation of electronic circuits

NOTE For correct application of the standard, the normative text takes precedence over the guidance given in this annex and reliance should not be placed on this flow chart.



Continued on next page

Sequence of tests for the evaluation of electronic circuits (continued)



Annex R (normative)

Software evaluation

Programmable **electronic circuits** requiring software incorporating measures to control the fault/error conditions specified in Table R.1 or Table R.2 shall be validated in accordance with the requirements in this annex.

NOTE Tables R.1 and R.2 are based on Table H.11.12.7 of IEC 60730-1 that is, for the purpose of this annex, divided in two tables, Table R.1 for general fault/error conditions and Table R.2 for specific fault/error conditions.

R.1 Programmable electronic circuits using software

Programmable **electronic circuits** requiring software incorporating measures to control the fault/error conditions specified in Table R.1 or Table R.2 shall be constructed so that the software does not impair compliance with the requirements of this standard.

Compliance is checked by the inspections and tests, according to the requirements of this annex, and by examination of the documentation as required by this annex.

R.2 Requirements for the architecture

R.2.1 General

Programmable **electronic circuits** requiring software incorporating measures to control the fault/error conditions specified in Table R.1 or Table R.2 shall use measures to control and avoid software-related faults/errors in safety-related data and safety-related segments of the software.

Compliance is checked by the inspections and tests in R.2.2 to R.3.3.3 inclusive.

R.2.1.1 Programmable **electronic circuits** requiring software incorporating measures to control the fault/error conditions specified in Table R.2 shall have one of the following structures:

- single channel with periodic self-test and monitoring (see IEC 60730-1, H.2.16.7);
- dual channel (homogenous) with comparison (see IEC 60730-1, H.2.16.3);
- dual channel (diverse) with comparison (see IEC 60730-1, H.2.16.2).

NOTE 1 Comparison between dual channel structures may be performed by:

- use of a comparator (see IEC 60730-1 H.2.18.3), or
- reciprocal comparison (see IEC 60730-1 H.2.18.15).

Programmable **electronic circuits** requiring software incorporating measures to control the fault/error conditions specified in Table R.1 shall have one of the following structures:

- single channel with functional test (see IEC 60730-1, H.2.16.5);
- single channel with periodic self-test (see IEC 60730-1, H.2.16.6);
- dual channel without comparison (see IEC 60730-1, H.2.16.1).

NOTE 2 Software structures incorporating measures to control the fault/error conditions specified in Table R.2 are also acceptable for programmable **electronic circuits** with functions requiring software measures to control the fault/error conditions specified in Table R.1.

Compliance is checked by the inspections and tests of the software architecture in R.3.2.2.

R.2.2 Measures to control faults/errors

R.2.2.1 When redundant memory with comparison is provided on two areas of the same component, the data in one area shall be stored in a different format from that in the other area (see software diversity, IEC 60730-1 H.2.18.19).

Compliance is checked by inspection of the source code.

R.2.2.2 Programmable **electronic circuits** with functions requiring software incorporating measures to control the fault/error conditions specified in Table R.2 and that use dual channel structures with comparison shall have additional fault/error detection means (such as periodic functional tests, periodic self tests, or independent monitoring) for any fault/errors not detected by the comparison.

Compliance is checked by inspection of the source code.

R.2.2.3 For programmable **electronic circuits** with functions requiring software incorporating measures to control the fault/error conditions specified in Table R.1 or Table R.2, means shall be provided for the recognition and control of errors in transmissions to external safety-related data paths. Such means shall take into account errors in data, addressing, transmission timing and sequence of protocol.

Compliance is checked by inspection of the source code.

R.2.2.4 For programmable **electronic circuits** with functions requiring software incorporating measures to control the fault/error conditions specified in Table R.1 or Table R.2, the programmable **electronic circuits** shall incorporate measures to address the fault/errors in safety-related segments and data indicated in Table R.1 or Table R.2 as appropriate.

Compliance is checked by inspection of the source code.

Table R.1^e – General fault/error conditions

Component^a	Fault/error	Acceptable measures^{b, c}	Definitions See IEC 60730-1
1 Central processing unit (CPU)			
1.1 Registers	Stuck at	Functional test, or periodic self-test using either: – static memory test, or – word protection with single bit redundancy	H.2.16.5 H.2.16.6 H.2.19.6 H.2.19.8.2
1.2 VOID			
1.3 Programme counter	Stuck at	Functional test, or periodic self-test, or independent time-slot monitoring, or logical monitoring of the programme sequence	H.2.16.5 H.2.16.6 H.2.18.10.4 H.2.18.10.2
2 Interrupt handling and execution	No interrupt or too frequent interrupt	Functional test, or time-slot monitoring	H.2.16.5 H.2.18.10.4
3 Clock	Wrong frequency (for quartz synchronized clock: harmonics/ sub-harmonics only)	Frequency monitoring, or time slot monitoring	H.2.18.10.1 H.2.18.10.4
4 Memory			
4.1 Invariable memory	All single bit faults	Periodic modified checksum, or multiple checksum, or word protection with single bit redundancy	H.2.19.3.1 H.2.19.3.2 H.2.19.8.2

Table R.1 (continued)^e

Component^a	Fault/error	Acceptable measures^{b, c}	Definitions See IEC 60730-1
4.2 Variable memory	DC fault	Periodic static memory test, or word protection with single bit redundancy	H.2.19.6 H.2.19.8.2
4.3 Addressing (relevant to variable and invariable memory)	Stuck at	Word protection with single bit redundancy including the address	H.2.19.8.2
5 Internal data path	Stuck at	Word protection with single bit redundancy	H.2.19.8.2
5.1 VOID			
5.2 Addressing	Wrong address	Word protection with single bit redundancy including the address	H.2.19.8.2
6 External communication	Hamming distance 3	Word protection with multi-bit redundancy, or CRC – single word , or transfer redundancy, or protocol test	H.2.19.8.1 H.2.19.4.1 H.2.18.2.2 H.2.18.14
6.1 VOID			
6.2 VOID			
6.3 Timing	Wrong point in time Wrong sequence	Time-slot monitoring, or scheduled transmission Time-slot and logical monitoring, or comparison of redundant communication channels by either: – reciprocal comparison – independent hardware comparator Logical monitoring, or time-slot monitoring, or scheduled transmission	H.2.18.10.4 H.2.18.18 H.2.18.10.3 H.2.18.15 H.2.18.3 H.2.18.10.2 H.2.18.10.4 H.2.18.18

Table R.1 (concluded)^e

Component^a	Fault/error	Acceptable measures^{b, c}	Definitions See IEC 60730-1
7 Input/output periphery	Fault conditions specified in 19.11.2	Plausibility check	H.2.18.13
7.1 VOID			
7.2 Analog I/O			
7.2.1 A/D- and D/A- convertor	Fault conditions specified in 19.11.2	Plausibility check	H.2.18.13
7.2.2 Analog multiplexer	Wrong addressing	Plausibility check	H.2.18.13
8 VOID			
9 Custom chips^d e.g. ASIC, GAL, gate array	Any output outside the static and dynamic functional specification	Periodic self test	H.2.16.6
NOTE A Stuck-at fault model denotes a fault model representing an open circuit or a non-varying signal level. A DC fault model denotes a stuck-at fault model incorporating short circuits between signal lines.			
^a For fault/error assessment, some components are divided into their sub-functions. ^b For each sub-function in the table, the Table R.2 measure will cover the software fault/error. ^c Where more than one measure is given for a sub-function, these are alternatives. ^d To be divided as necessary by the manufacturer into sub-functions. ^e Table R.1 is applied according to the requirements of R.1 to R.2.2.9 inclusive.			

Table R.2^e – Specific fault/error conditions

Component^a	Fault/error	Acceptable measures^{b, c}	Definitions See IEC 60730-1
1 Central Processing Unit (CPU)			
1.1 Registers	DC fault	Comparison of redundant CPUs by either: <ul style="list-style-type: none"> – reciprocal comparison – independent hardware comparator, or internal error detection, or redundant memory with comparison, or periodic self-tests using either <ul style="list-style-type: none"> – walkpat memory test – Abraham test – transparent GALPAT test; or word protection with multi-bit redundancy, or static memory test and word protection with single bit redundancy 	H.2.18.15 H.2.18.3 H.2.18.9 H.2.19.5 H.2.19.7 H.2.19.1 H.2.19.2.1 H.2.19.8.1 H.2.19.6 H.2.19.8.2
1.2 Instruction decoding and execution	Wrong decoding and execution	Comparison of redundant CPUs by either: <ul style="list-style-type: none"> – reciprocal comparison – independent hardware comparator, or internal error detection, or periodic self-test using equivalence class test 	H.2.18.15 H.2.18.3 H.2.18.9 H.2.18.5
1.3 Programme counter	DC fault	Periodic self-test and monitoring using either: <ul style="list-style-type: none"> – independent time-slot and logical monitoring – internal error detection, or comparison of redundant functional channels by either: <ul style="list-style-type: none"> – reciprocal comparison – independent hardware comparator 	H.2.16.7 H.2.18.10.3 H.2.18.9 H.2.18.15 H.2.18.3
1.4 Addressing	DC fault	Comparison of redundant CPUs by either: <ul style="list-style-type: none"> – reciprocal comparison – independent hardware comparator; or internal error detection; or periodic self-test using <ul style="list-style-type: none"> – a testing pattern of the address lines; or – a full bus redundancy – a multi bus parity including the address 	H.2.18.15 H.2.18.3 H.2.18.9 H.2.16.7 H.2.18.22 H.2.18.1.1 H.2.18.1.2

Table R.2 (continued)^e

Component^a	Fault/error	Acceptable measures^{b, c}	Definitions See IEC 60730-1
1.5 Data paths instruction decoding	DC fault and execution	Comparison of redundant CPUs by either: – reciprocal comparison, or – independent hardware comparator, or – internal error detection, or – periodic self-test using a testing pattern, or – data redundancy, or – multi-bit bus parity	H.2.18.15 H.2.18.3 H.2.18.9 H.2.16.7 H.2.18.2.1 H.2.18.1.2
2 Interrupt handling and execution	No interrupt or too frequent interrupt related to different sources	Comparison of redundant functional channels by either – reciprocal comparison, – independent hardware comparator, or – independent time-slot and logical monitoring	H.2.18.15 H.2.18.3 H.2.18.10.3
3 Clock	Wrong frequency (for quartz synchronized clock: harmonics/ subharmonics only)	Frequency monitoring, or time-slot monitoring, or comparison of redundant functional channels by either: – reciprocal comparison – independent hardware comparator	H.2.18.10.1 H.2.18.10.4 H.2.18.15 H.2.18.3
4. Memory			
4.1 Invariable memory	99,6 % coverage of all information errors	Comparison of redundant CPUs by either: – reciprocal comparison – independent hardware comparator, or redundant memory with comparison, or periodic cyclic redundancy check, either – single word – double word, or word protection with multi-bit redundancy	H.2.18.15 H.2.18.3 H.2.19.5 H.2.19.4.1 H.2.19.4.2 H.2.19.8.1
4.2 Variable memory	DC fault and dynamic cross links	Comparison of redundant CPUs by either: – reciprocal comparison – independent hardware comparator, or redundant memory with comparison, or periodic self tests using either: – walkpat memory test – Abraham test – transparent GALPAT test, or word protection with multi-bit redundancy	H.2.18.15 H.2.18.3 H.2.19.5 H.2.19.7 H.2.19.1 H.2.19.2.1 H.2.19.8.1

Table R.2 (continued)^e

Component^a	Fault/error	Acceptable measures^{b, c}	Definitions See IEC 60730-1
4.3 Addressing (relevant to variable and invariable memory)	DC fault	Comparison of redundant CPUs by either: – reciprocal comparison, or – independent hardware comparator, or full bus redundancy testing pattern, or periodic cyclic redundancy check, either: – single word – double word, or word protection with multi-bit redundancy including the address	H.2.18.15 H.2.18.3 H.2.18.1.1 H.2.18.22 H.2.19.4.1 H.2.19.4.2 H.2.19.8.1
5 Internal data path			
5.1 Data	DC fault	Comparison of redundant CPUs by either – reciprocal comparison – independent hardware comparator, or word protection with multi-bit redundancy including the address, or data redundancy, or testing pattern, or protocol test	H.2.18.15 H.2.18.3 H.2.19.8.1 H.2.18.2.1 H.2.18.22 H.2.18.14
5.2 Addressing	Wrong address and multiple addressing	Comparison of redundant CPUs by: – reciprocal comparison – independent hardware comparator, or word protection with multi-bit redundancy, including the address, or full bus redundancy; or testing pattern including the address	H.2.18.15 H.2.18.3 H.2.19.8.1 H.2.18.1.1 H.2.18.22
6 External communication			
6.1 Data	Hamming distance 4	CRC – double word, or data redundancy or comparison of redundant functional channels by either: – reciprocal comparison – independent hardware comparator	H.2.19.4.2 H.2.18.2.1 H.2.18.15 H.2.18.3

Table R.2 (continued)^e

Component^a	Fault/error	Acceptable measures^{b, c}	Definitions See IEC 60730-1
6.2 Addressing	Wrong address Wrong and multiple addressing	Word protection with multi-bit redundancy, including the address, or CRC single word including the addresses, or transfer redundancy or protocol test CRC – double word, including the address, or full bus redundancy of data and address, or comparison of redundant communication channels by either: – reciprocal comparison – independent hardware comparator	H.2.19.8.1 H.2.19.4.1 H.2.18.2.2 H.2.18.14 H.2.19.4.2 H.2.18.1.1 H.2.18.15 H.2.18.3
6.3 Timing	Wrong point in time	Time-slot monitoring, or scheduled transmission	H.2.18.10.4 H.2.18.18
7 Input/output periphery			
7.1 Digital I/O	Fault conditions specified in 19.11.2	Comparison of redundant CPUs by either: – reciprocal comparison – independent hardware comparator, or input comparison, or multiple parallel outputs, or output verification, or testing pattern, or code safety	H.2.18.15 H.2.18.3 H.2.18.8 H.2.18.11 H.2.18.12 H.2.18.22 H.2.18.2
7.2 Analog I/O			
7.2.1 A/D- and D/A- convertor	Fault conditions specified in 19.11.2	Comparison of redundant CPUs by either: – reciprocal comparison – independent hardware comparator, or input comparison, or multiple parallel outputs, or output verification, or testing pattern	H.2.18.15 H.2.18.3 H.2.18.8 H.2.18.11 H.2.18.12 H.2.18.22

Table R.2 (concluded)^e

Component^a	Fault/error	Acceptable measures^{b, c}	Definitions See IEC 60730-1
7.2.2 Analog multiplexer	Wrong addressing	Comparison of redundant CPUs by either: <ul style="list-style-type: none"> – reciprocal comparison – independent hardware comparator, or input comparison or testing pattern	H.2.18.15 H.2.18.3 H.2.18.8 H.2.18.22
8 Monitoring devices and comparators	Any output outside the static and dynamic functional specification	Tested monitoring, or redundant monitoring and comparison, or error recognizing means	H.2.18.21 H.2.18.17 H.2.18.6
9 Custom chips^d e.g. ASIC, GAL, gate array	Any output outside the static and dynamic functional specification	Periodic self-test and monitoring, or dual channel (diverse) with comparison, or error recognizing means	H.2.16.7 H.2.16.2 H.2.18.6
NOTE A DC fault model denotes a stuck-at fault model incorporating short circuits between signal lines.			
^a For fault/error assessment, some components are divided into their sub-functions. ^b For each sub-function in the table, the software measure will cover the Table R.1 fault/error. ^c Where more than one measure is given for a sub-function, these are alternatives. ^d To be divided as necessary by the manufacturer into sub-functions. ^e Table R.2 is applied according to the requirements of R.1 to R.2.2.9 inclusive, only if required by a part 2.			

R.2.2.5 For programmable **electronic circuits** with functions requiring software incorporating measures to control the fault/error conditions specified in Table R.1 or Table R.2, detection of a fault/error shall occur before compliance with Clause 19 is impaired.

Compliance is checked by inspection and testing of the source code.

NOTE The loss of dual channel capability is deemed to be an error in a programmable **electronic circuit** using a dual channel structure required for software to control the fault/error conditions specified in Table R.2.

R.2.2.6 The software shall be referenced to relevant parts of the operating sequence and the associated hardware functions.

Compliance is checked by inspection of the source code.

R.2.2.7 Where labels are used for memory locations, these labels shall be unique.

Compliance is checked by inspection of the source code.

R.2.2.8 The software shall be protected from user alteration of safety-related segments and data.

Compliance is checked by inspection of the source code.

R.2.2.9 The software and safety-related hardware under its control shall be initialized and shall terminate before compliance with Clause 19 is impaired.

Compliance is checked by testing of the source code.

R.3 Measures to avoid errors

R.3.1 General

For programmable **electronic circuits** with functions requiring software incorporating measures to control the fault/error conditions specified in Table R.1 or Table R.2, the following measures to avoid systematic faults in the software shall be applied.

Software that incorporates measures used to control the fault/error conditions specified in Table R.2 is inherently acceptable for software required to control the fault/error conditions specified in Table R.1.

NOTE The content of these requirements is extracted from IEC 61508-3 and adapted to the needs of this Standard.

R.3.2 Specification

R.3.2.1 Software safety requirements

The specification of the software safety requirements shall include:

- a description of each safety related function to be implemented, including its response time(s):
 - functions related to the application including their related software faults required to be controlled;
 - functions related to the detection, annunciation and management of software or hardware faults;
- a description of interfaces between software and hardware;
- a description of interfaces between any safety and non-safety related functions;
- a description of any compiler used to generate the object code from the source code, including details of any compiler switch settings used such as library function options, memory model, optimization, SRAM details, clock rate and chip details;
- a description of any linker used to link the object code to executable library routines.

Compliance is checked by inspection of the documentation and as specified in R.3.2.2.2.

NOTE Examples of some techniques/measures to meet these requirements can be found in Table R.3.

Table R.3 – Semi-formal methods

Technique / Measure	Informative references
<i>Semi-formal methods</i>	
<i>Logical/functional block diagrams</i>	
<i>Sequence diagrams</i>	
<i>Finite state machines/state transition diagrams</i>	<i>IEC 61508-7, B.2.3.2</i>
<i>Decision/truth tables</i>	<i>IEC 61508-7, C.6.1</i>

R.3.2.2 Software architecture

R.3.2.2.1 The specification of the software architecture shall include the following aspects:

- techniques and measures to control software faults/errors (refer to R.2.2);
- interactions between hardware and software;
- partitioning into modules and their allocation to the specified safety functions;
- hierarchy and call structure of the modules (control flow);
- interrupt handling;
- data flow and restrictions on data access;
- architecture and storage of data;
- time-based dependencies of sequences and data.

Compliance is checked by inspection of the documentation and as specified in R.3.2.2.2.

NOTE Examples of some techniques/measures to meet these requirements can be found in Table R.4.

Table R.4 – Software architecture specification

Technique / Measure	Informative references
<i>Fault detection and diagnosis</i>	<i>IEC 61508-7, C.3.1</i>
<i>Semi-formal methods:</i> <ul style="list-style-type: none"> • <i>Logic/function block diagrams</i> • <i>Sequence diagrams</i> • <i>Finite state machines / state transition diagrams</i> • <i>Data flow diagrams</i> 	<i>IEC 61508-7, B.2.3.2</i> <i>IEC 61508-7, C.2.2</i>

R.3.2.2.2 *The architecture specification shall be validated against the specification of the software safety requirements by static analysis.*

NOTE Example methods for static analysis are:

- control flow analysis; (IEC 61508-7, C.5.9);
- data flow analysis; (IEC 61508-7, C.5.10);
- walk-throughs/design reviews. (IEC 61508-7, C.5.16).

R.3.2.3 Module design and coding

R.3.2.3.1 Based on the architecture design, software shall be suitably refined into modules. Software module design and coding shall be implemented in a way that is traceable to the software architecture and requirements.

Compliance is checked by R.3.2.3.3 and by inspection of the documentation.

NOTE 1 The use of computer aided design tools is accepted.

NOTE 2 Defensive programming (IEC 61508-7, Subclause C.2.5) is recommended (e.g. range checks, check for division by 0, plausibility checks).

NOTE 3 The module design shall specify:

- function(s),
- interfaces to other modules,
- data.

NOTE 4 Examples of some techniques/measures to meet these requirements can be found in Table R.5.

Table R.5 – Module design specification

Technique / Measure	Informative references
<i>Limited size of software modules</i>	<i>IEC 61508-7, C.2.9</i>
<i>Information hiding / encapsulation</i>	<i>IEC 61508-7, C.2.8</i>
<i>One entry / one exit point in subroutines and functions</i>	<i>IEC 61508-7, C.2.9</i>
<i>Fully defined interface</i>	<i>IEC 61508-7, C.2.9</i>
<i>Semi-formal methods:</i> <ul style="list-style-type: none"> • <i>Logic/function block diagrams</i> • <i>Sequence diagrams</i> • <i>Finite state machines / state transition diagrams</i> • <i>Data flow diagrams</i> 	<i>IEC 61508-7, B.2.3.2</i> <i>IEC 61508-7, C.2.2</i>

R.3.2.3.2 Software code shall be structured.

Compliance is checked by R.3.2.3.3 and by inspection of the documentation.

NOTE 1 Structural complexity can be minimized by applying the following principles:

- keep the number of possible paths through a software module small, and the relation between the input and output parameters as simple as possible;
- avoid complicated branching and, in particular, avoid unconditional jumps (GOTO) in higher level languages;
- where possible, relate loop constraints and branching to input parameters;
- avoid using complex calculations as the basis of branching and loop decisions.

NOTE 2 Examples of some techniques/measures to meet these requirements can be found in Table R.6.

Table R.6 – Design and coding standards

Technique / Measure	Informative references
<i>Use of coding standard (see NOTE)</i>	<i>IEC 61508-7, C.2.6.2</i>
<i>No use of dynamic objects and variables (see NOTE)</i>	<i>IEC 61508-7, C.2.6.3</i>
<i>Limited use of interrupts</i>	<i>IEC 61508-7, C.2.6.5</i>
<i>Limited use of pointers</i>	<i>IEC 61508-7, C.2.6.6</i>
<i>Limited use of recursion</i>	<i>IEC 61508-7, C.2.6.7</i>
<i>No unconditional jumps in programs in higher level languages</i>	<i>IEC 61508-7, C.2.6.2</i>
NOTE Dynamic objects and/or variables are allowed if a compiler is used which ensures that sufficient memory for all dynamic objects and/or variables will be allocated before runtime, or which inserts runtime checks for the correct online allocation of memory.	

R.3.2.3.3 Coded software shall be validated against the module specification by static analysis. The module specification shall be validated against the architecture specification by static analysis.

R.3.3.3 Software validation

The software shall be validated with reference to the requirements of the software safety requirements specification.

NOTE 1 Validation is confirmation by examination and provision of objective evidence that the particular requirements for a specific intended use are fulfilled. Therefore, for example, software validation means confirming by examination and provision of objective evidence that the software satisfies the software safety requirements specification.

Compliance is checked by simulation of

- *input signals present during **normal operation**,*
- *anticipated occurrences,*
- *undesired conditions requiring system action.*

Test cases, test data and test results shall be reported.

NOTE 2 Examples of some techniques/measures to meet these requirements can be found in Table R.7.

Table R.7 – Software safety validation

Technique / Measure	Informative references
<i>Functional and black-box testing:</i> <ul style="list-style-type: none"> • <i>Boundary value analysis</i> • <i>Process simulation</i> 	<i>IEC 61508-7, B.5.1, B.5.2</i> <i>IEC 61508-7, C.5.4</i> <i>IEC 61508-7, C.5.18</i>
<i>Simulation, modelling:</i> <ul style="list-style-type: none"> • <i>Finite state machines</i> • <i>Performance modelling</i> 	<i>IEC 61508-7, B.2.3.2</i> <i>IEC 61508-7, C.5.20</i>

NOTE 3 Testing should be the main validation method for software; modelling may be used to supplement the validation activities.

Bibliography

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

IEC 60335-2-29, *Household and similar electrical appliances – Safety – Part 2-29: Particular requirements for battery chargers*

IEC 60364 (all parts), *Electrical installations of buildings*

IEC 60601 (all parts), *Medical electrical equipment*

IEC 60721-2-1, *Classification of environmental conditions – Part 2-1: Environmental conditions appearing in nature – Temperature and humidity*

IEC 60730 (all parts), *Automatic electrical controls for household and similar use*

IEC 60745 (all parts), *Hand-held motor-operated electric tools – Safety*

IEC 60950-1, *Information technology equipment – Safety*

IEC 60998-2-1, *Connecting devices for low-voltage circuits for household and similar purposes – Part 2-1: Particular requirements for connecting devices as separate entities with screw-type clamping units*

IEC 60998-2-2, *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 61000-3-2, *Electromagnetic compatibility (EMC) – Part 3-2: Limits – Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)*

IEC 61000-3-3, *Electromagnetic compatibility (EMC) – Part 3-3: Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤ 16 A per phase and not subject to conditional connection*

IEC 61029 (all parts), *Safety of transportable motor-operated electric tools*

IEC 61508-3:1998, *Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 3: Software requirements*

IEC 61508-7:2000, *Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 7: Overview of techniques and measures*

CISPR 11, *Industrial, scientific and medical equipment – Radio-frequency disturbance characteristics – Limits and methods of measurement*

CISPR 14-1, *Electromagnetic compatibility – Requirements for household appliances, electric tools and similar apparatus – Part 1: Emission*

CISPR 14-2, *Electromagnetic compatibility – Requirements for household appliances, electric tools and similar apparatus – Part 2: Immunity – Product family standard*

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

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

ISO 13732-1 *Ergonomics of the thermal environment – Methods for the assessment of human responses to contact with surfaces – Part 1: Hot surfaces*

IEC Guide 104, *The preparation of safety publications and the use of basic safety publications and group safety publications*

IEC Guide 110, *Home control systems – Guidelines relating to safety*

ISO/IEC Guide 14, *Purchase information on goods and services intended for consumers*

ISO/IEC Guide 37, *Instructions for use of products of consumer interest*

ISO/IEC Guide 50, *Safety aspects – Guidelines for child safety*

ISO/IEC Guide 51, *Safety aspects – Guidelines for their inclusion in standards*

ISO/IEC Guide 71, *Guidelines for standards developers to address the needs of older persons and persons with disabilities*

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