IEC 60335-2-120

Edition 1.0 2024-02
EXTENDED VERSION

INTERNATIONAL STANDARD

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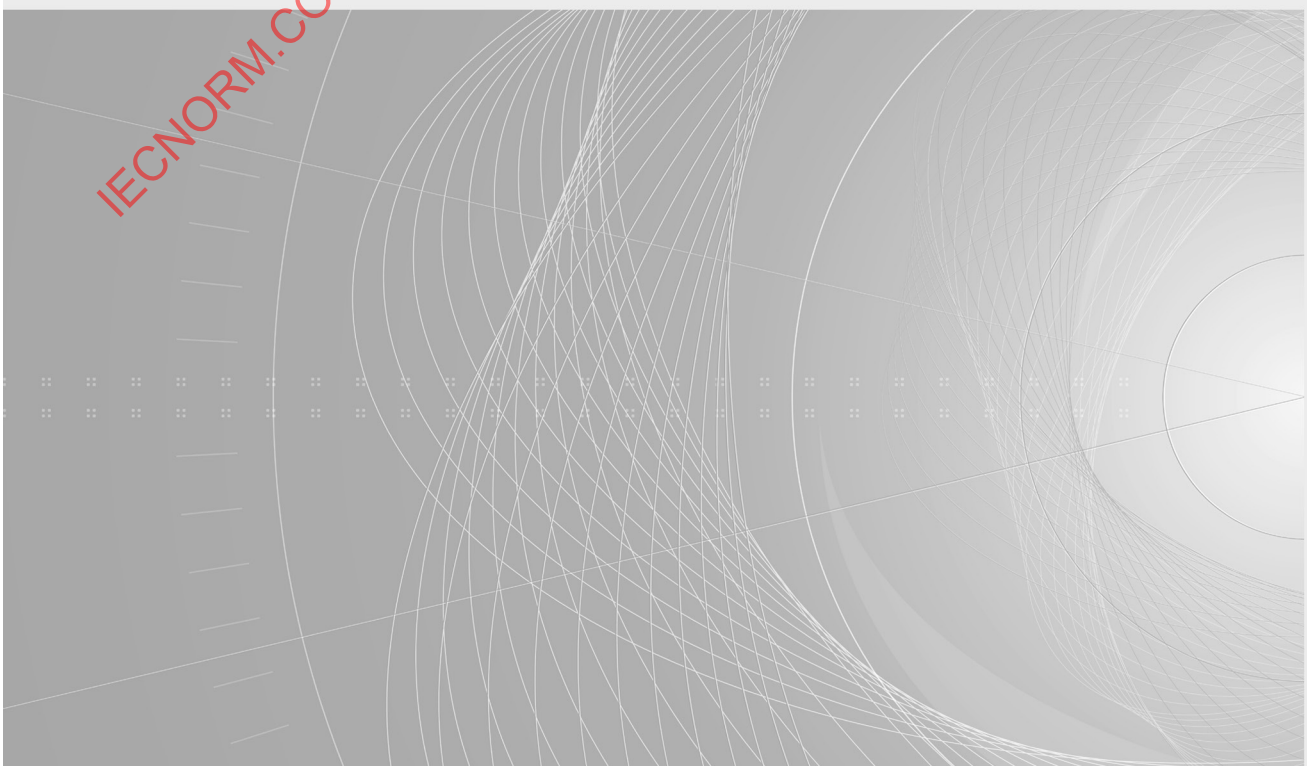
This extended version of IEC 60335-2-120:2024 includes the content of the references made to IEC 60335-1:2020

Household and similar electrical appliances – Safety – Part 2-120: Particular requirements for the safety of appliances for the generation of directly inhalable aerosols



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IEC Secretariat
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

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Household and similar electrical appliances – Safety –
Part 2-120: Particular requirements for the safety of appliances for the generation of directly inhalable aerosols

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ICS 13.120, 97.180

ISBN 978-2-8322-8273-1

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IEC 60335-1
Edition 6.0 2020-09

HOUSEHOLD AND SIMILAR ELECTRICAL APPLIANCES – SAFETY –

Part 1: General requirements

INTERPRETATION SHEET 1

This interpretation sheet has been prepared by IEC technical committee 61: Safety of household and similar electrical appliances.

The text of this Interpretation Sheet is based on the following documents:

Draft	Report on voting
61/5999/DISH	61/6009/RVDISH

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

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INTRODUCTION

Edition 6 of IEC 60335-1:2020 defines and introduces requirements for a detachable power supply part of an appliance. In the document, 24.2 prohibits the use of a power supply in a flexible cord.

QUESTION:

Does Subclause 24.2 prohibit the use of a detachable power supply part?

ANSWER

No, a "detachable power supply part" is a defined term and is not captured by the term "power supply" as used in Subclause 24.2.

NOTE A detachable power supply part is captured by the defined term when the output of the power supply part is detachable from the class III construction part of the appliance at:

– the power supply part, or

– the class III construction part of the appliance.

However, the supply cord (if any) does not have to be detachable from the detachable power supply part.

ICS 13.120; 97.030

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HOUSEHOLD AND SIMILAR ELECTRICAL APPLIANCES – SAFETY –

Part 2-120: Particular requirements for the safety of appliances for the generation of directly inhalable aerosols

FOREWORD

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This extended version (EXV) of the official IEC Standard provides the user with the comprehensive content of the Standard.

IEC 60335-2-120:2024 EXV includes the content of IEC 60335-2-120:2024, and the references made to IEC 60335-1:2020.

The specific content of IEC 60335-2-120:2024 is displayed on a blue background.

IEC 603335-2-120 has been prepared by IEC technical committee 61: Safety of household and similar electrical appliance. It is an International Standard.

The text of this International Standard is based on the following documents:

Draft	Report on voting
61/7076/FDIS	61/7099/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

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.

This part 2 is to be used in conjunction with the latest edition of IEC 60335-1 and its amendments unless that edition precludes it; in that case, the latest edition that does not preclude it is used. It was established on the basis of the sixth edition (2020) of that standard.

NOTE 1 When “Part 1” is mentioned in this standard, it refers to IEC 60335-1.

This part 2 supplements or modifies the corresponding clauses in IEC 60335-1, so as to convert that publication into the IEC standard: Particular requirements for the safety of appliances for the generation of directly inhalable aerosols.

When a particular subclause of Part 1 is not mentioned in this part 2, that subclause applies as far as is reasonable. When this standard states “addition”, “modification” or “replacement”, the relevant text in Part 1 is to be adapted accordingly.

NOTE 2 The following numbering system is used:

– subclauses, tables and figures that are numbered starting from 101 are additional to those in Part 1;
– unless notes are in a new subclause or involve notes in Part 1, they are numbered starting from 101, including those in a replaced clause or subclause;
– additional annexes are lettered AA, BB, etc.

NOTE 3 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 the associated noun are also in bold.

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The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

NOTE 4 The attention of National Committees is drawn to the fact that equipment manufacturers and testing organizations can need a transitional period following publication of a new, amended or revised IEC publication in 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.

– Clause 1: These devices are considered medical devices and are separately regulated by the Therapeutic Goods Administration. (Australia).

– Clause 1: Nicotine using products are required to comply with TGO 110 order 2021 (Australia)

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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.

Guidance documents concerning the application of the safety requirements for appliances can be accessed via TC 61 supporting documents on the IEC website

https://www.iec.ch/tc61/supportingdocuments

This information is given for the convenience of users of this International Standard and does not constitute a replacement for the normative text in this standard.

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 can differ.

If an appliance within the scope of this standard also incorporates functions that are covered by another part 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.

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

NOTE 1 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 2 Horizontal publications, basic safety publications and group safety publications 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.

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 that 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 3 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 and relevant IEC 61000-3 series standards concerning electromagnetic emissions;
– CISPR 14-2 concerning electromagnetic immunity;
– IEC standards published by TC 111 concerning environmental matters.

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HOUSEHOLD AND SIMILAR ELECTRICAL APPLIANCES – SAFETY –

Part 2-120: Particular requirements for the safety of appliances for the generation of directly inhalable aerosols

1 Scope

This part of IEC 60335 deals with the safety of appliances for generation of directly inhalable **aerosols**, their **rated voltage** being not more than 250 V for single-phase appliances, and other appliances including direct current (DC) supplied appliances and **battery-operated appliances**.

Examples of the appliances that are within the scope of this standard are:

– vapour and **aerosol** appliances;
– personal vaping appliances with or without nicotine;
– electronic cigarettes;
– electronic nicotine delivery systems (ENDS);
– electronic non-nicotine delivery systems (ENNDS);
– electronic tobacco **heating appliances** for heated tobacco products.

This standard does not apply to:

– medical ventilators,
– humidifiers (IEC 60335-2-98).

NOTE 101 Other safety aspects of appliances under the scope of this standard can be covered by standards developed by ISO/TC 126.

These requirements do not cover the **consumables**, such as **e-liquids** and other inhaled **aerosol** substances, wicks, and other particulate matter inhaled during use, nor do they cover substances in the emissions from the operation of the appliances.

NOTE 102 For example, heavy metal emissions in the **aerosol** and environmental exposure are not covered by this standard.

These requirements do not consider the physiological effects of any **consumable** used with the appliances.

This International Standard does not cover requirements or prohibitions of the labelling, packaging and contents of nicotine-containing or nicotine-consuming products that are strictly regulated by law of the relevant jurisdiction.

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2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 60034-1, *Rotating electrical machines – Part 1: Rating and performance*

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

IEC 60065:2014, *Audio, video and similar electronic apparatus – Safety requirements*

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*
IEC 60112:2003/AMD1:2009[1]

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 60227-5:2011, *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V – Part 5: Flexible cables (cords)*

IEC 60238, *Edison screw lampholders*

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

IEC 60252-1:2010, *AC motor capacitors – Part 1: General – Performance, testing and rating – Safety requirements – Guidance for installation and operation*
IEC 60252-1:2010/AMD1:2013[2]

IEC 60309-2, *Plugs, socket-outlets and couplers for industrial purposes – Part 2: Dimensional interchangeability requirements for pin and contact-tube accessories*

IEC 60320 (all parts), *Appliance couplers for household and similar general purposes*

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

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

IEC 60320-3, *Appliance couplers for household and similar general purposes – Part 3: Standard sheets and gauges*

IEC 60384-14:2013, *Fixed capacitors for use in electronic equipment – Part 14: Sectional specification – Fixed capacitors for electromagnetic interference suppression and connection*

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1 There exists a consolidated edition 4.1:2009 that includes edition 4 and its Amendment 1.

2 There exists a consolidated edition 2.1:2013 that includes edition 2 and its Amendment 1.

to the supply mains
IEC 60384-14:2013/AMD1:2016[3]

IEC 60417, *Graphical symbols for use on equipment*

IEC 60445:2017, *Basic and safety principles for man-machine interface, marking and identification – Identification of equipment terminals, conductor terminations and conductors*

IEC 60529:1989, *Degrees of protection provided by enclosures (IP Code)*
IEC 60529:1989/AMD1:1999
IEC 60529:1989/AMD2:2013[4]

IEC 60598-1:2014, *Luminaires – Part 1: General requirements and tests*
IEC 60598-1:2014/AMD1:2017[5]

IEC 60603-11, *Connectors for frequencies below 3 MHz for use with printed boards – Part 11: Detail specification for concentric connectors (dimensions for free connectors and fixed connectors)*

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

IEC 60664-3:2016, *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 60695-2-11:2014, *Fire hazard testing – Part 2-11: Glowing/hot-wire based test methods – Glow-wire flammability test method for end-products (GWEPT)*

IEC 60695-2-12, *Fire hazard testing – Part 2-12: Glowing/hot-wire based test methods – Glow-wire flammability index (GWFI) test method for materials*

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

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

IEC 60695-11-5:2016, *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*

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3 There exists a consolidated edition 4.1:2016 that includes edition 4 and its Amendment 1.

4 There exists a consolidated edition 2.2:2013 that includes edition 2 and its Amendment 1 and Amendment 2.

5 There exists a consolidated edition 8.1:2017 that includes edition 8 and its Amendment 1.

IEC 60730-1:2013, *Automatic electrical controls – Part 1: General requirements*
IEC 60730-1:2013/AMD1:2015[6]

IEC 60730-2-8:2018, *Automatic electrical controls – Part 2-8: Particular requirements for electrically operated water valves, including mechanical requirements*

IEC 60730-2-9:2015, *Automatic electrical controls – Part 2-9: Particular requirements for temperature sensing controls*
IEC 60730-2-9:2015/AMD1:2018[7]

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 60799, *Electrical accessories – Cord sets and interconnection cord sets*

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 60934, *Circuit-breakers for equipment (CBE)*

IEC 60990:2016, *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 mm^2 up to 35 mm^2 (included)*

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

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 61000-4-11:2020, *Electromagnetic compatibility (EMC) – Part 4-11: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations immunity tests for equipment with input current up to 16 A per phase*

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*

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6 There exists a consolidated edition 5.1:2015 that includes edition 5 and its Amendment 1.

7 There exists a consolidated edition 4.1:2018 that includes edition 4 and its Amendment 1.

IEC 61000-4-13:2002/AMD1:2009
IEC 61000-4-13:2002/AMD2:2015[8]

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*
IEC 61000-4-34:2005/AMD1:2009[9]

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

IEC 61058-1:2016, *Switches for appliances – Part 1: General requirements*

IEC 61058-1-1:2016, *Switches for appliances – Part 1-1: Requirements for mechanical switches*

IEC 61058-1-2:2016, *Switches for appliances – Part 1-2: Requirements for electronic switches*

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

IEC 61210, *Connecting devices – Flat quick-connect terminations for electrical copper conductors – Safety requirements*

IEC 61558-1:2017, *Safety of transformers, reactors, power supply units and combinations thereof – Part 1: General requirements and tests*

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 61558-2-16:2009, *Safety of transformers, reactors, power supply units and similar products for supply voltages up to 1 100 V – Part 2-16: Particular requirements and tests for switch mode power supply units and transformers for switch mode power supply units*
IEC 61558-2-16:2009/AMD1:2013[10]

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

IEC 62133-1:2017, *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for portable sealed secondary cells, and for batteries made from them, for use in portable applications – Part 1: Nickel systems*

IEC 62133-2:2017, *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for portable sealed secondary cells, and for batteries made from them, for use in portable applications – Part 2: Lithium systems*

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

IEC 62471:2006, *Photobiological safety of lamps and lamp systems*

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8 There exists a consolidated edition 1.2:2015 that includes edition 1 and its Amendment 1 and Amendment 2.

9 There exists a consolidated edition 1.1:2009 that includes edition 1 and its Amendment 1.

10 There exists a consolidated edition 1.1:2013 that includes edition 1 and its Amendment 1.

IEC 62477-1, *Safety requirements for power electronic converter systems and equipment – Part 1: General*

IEC 62821 (all parts), *Electric cables – Halogen-free, low smoke, thermoplastic insulated and sheathed cables of rated voltages up to and including 450/750 V*

ISO 178, *Plastics – Determination of flexural properties*

ISO 179-1, *Plastics – Determination of Charpy impact properties – Part 1: Non-instrumented impact test*

ISO 180, *Plastics – Determination of Izod impact strength*

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

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

ISO 4892-1:2016, *Plastics – Methods of exposure to laboratory light sources – Part 1: General guidance*

ISO 4892-2: 2013, *Plastics – Methods of exposure to laboratory light sources – Part 2: Xenon-arc lamps*

ISO 7000, *Graphical symbols for use on equipment – Registered symbols*

ISO 8256, *Plastics – Determination of tensile-impact strength*

ISO 9772, *Cellular plastics – Determination of horizontal burning characteristics of small specimens subjected to a small flame*

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

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3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

When the terms "voltage" and "current" are used, they are RMS values, unless otherwise specified.

When the term "earthing" is used, it means "protective earthing", 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 to entry: **Working voltage** takes into account resonant voltages.

Note 2 to entry: 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 1 to entry: 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 1 to entry: If no current is assigned to the appliance, the **rated current** is 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
operation as specified in B.3.1.1

Appliances operated with **integral batteries** or **separable batteries** not disconnected from the appliance for charging purposes:

– the **battery** that is **fully discharged** is charged with the **battery-operated appliance** performing its intended function, if allowed by the construction of the appliance;
– the **battery** that is **fully discharged** is charged without the **battery-operated appliance** performing its intended function

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Note 1 to entry: Operation of a **battery-operated appliance** to perform its intended function is considered to be **normal operation**.

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 overvoltages

3.1.11
dangerous malfunction
unintended operation of the appliance that may impair safety

3.1.12
outlet load
load that can be connected to appliance outlets accessible to the user and socket-outlets accessible to the user

Note 1 to entry: Outlets with a voltage not exceeding **SELV** are not considered to be an appliance outlet.

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 between two parts of an appliance, provided as part of a complete appliance for purposes other than connection to the supply mains

Note 1 to entry: In **battery-operated appliances**, if the **battery** is placed in a separate box, the flexible lead or flexible cord connecting the box with the appliance is considered to be an **interconnection cord**.

Note 2 to entry: The output cord from a **charging system** or a **detachable power supply part** is an **interconnection cord**.

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 1 to entry: 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

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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 1 to entry: 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 1 to entry: **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 1 to entry: This provision includes a protective earthing conductor in the **supply cord**.

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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 to entry: 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 to entry: 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 to entry: **Class II appliances** may incorporate an earth for functional purposes.

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

Note 2 to entry: **Class III appliances** may incorporate an earth for functional purposes.

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

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 or functional earth when the appliance is supplied at **rated voltage**

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3.4.2
safety extra-low voltage
voltage not exceeding 42 V between conductors and between conductors and earth or functional earth, the no-load voltage not exceeding 50 V

Note 1 to entry: 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 2 to entry: The voltage limits specified are based on the assumption that the **safety isolating transformer** is supplied at its **rated voltage**.

Note 3 to entry: **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 **extra-low voltage** that is separated from other circuits, except circuits operating at **safety extra-low voltage**, by **basic insulation** and protective screening, **double insulation** or **reinforced insulation**

Note 1 to entry: Protective screening is the separation of circuits from **live parts** by means of an earthed screen.

Note 2 to entry: 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

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3.5.7
motor-operated appliance
appliance incorporating motors but without any heating element

Note 1 to entry: Magnetically driven appliances are considered to be **motor-operated appliances**.

3.5.8
combined appliance
appliance incorporating heating elements and motors

3.5.9
battery-operated appliance
appliance deriving its energy from **batteries** enabling the appliance to perform its intended function without a supply connection

Note 1 to entry: A **battery-operated appliance** can have a supply connection.

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 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**, part that is removed or opened in accordance with the instructions for use, even if a **tool** is needed for removal, or part that does not fulfil the test of 22.11

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

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

Note 3 to entry: If a part has to be removed solely to discard a **battery** before scrapping the appliance, this part is not considered to be a **detachable part** even if the instructions state that it is to be removed.

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

Note 2 to entry: A PEN conductor is a protective earthed neutral conductor combining the functions of both a protective conductor and a neutral conductor.

Note 3 to entry: Parts, whether they are **accessible parts** or not, of **battery-operated appliances** and **batteries** not exceeding the electrical limits of B.22.3 and B.22.4, are not considered to be **live parts**.

3.6.5
tool
screwdriver, coin or any other object that may be used to operate a screw or similar fixing means

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3.6.6
small part
part, where each surface lies completely within a circle of 15 mm diameter, or 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 1 to entry: 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.

3.6.7
detachable power supply part
part of the appliance the output of which is intended to be detachable from the **class III construction** part of the appliance

Note 1 to entry: Means of detachment are a flexible cord and connector or an appliance outlet fitted to the **detachable power supply part**.

3.6.8
cell
basic functional unit, consisting of an assembly of electrodes, electrolyte, container, terminals, and usually separators that is a source of electric energy obtained by direct conversion of chemical energy

[SOURCE: IEC 60050-482:2004, 482-01-01]

3.6.9
battery
assembly of one or more **cells** ready for use as a source of electrical energy, characterised by its voltage, size, terminal arrangement, capacity and rate capability

Note 1 to entry: A **detachable battery** and **separable battery** have an enclosure that is equivalent in properties to that of the appliance itself, but **integral batteries** may have no enclosure or an enclosure less substantial than that of the appliance, as they are protected by the enclosure of the appliance.

3.6.10
detachable battery
rechargeable **battery** in an enclosure separate from the **battery-operated appliance**, intended for use with specific appliances and intended to be removed from the appliance for charging purposes

Note 1 to entry: A standard automotive **battery** is not considered a **detachable battery**.

Note 2 to entry: A **detachable battery** is not considered a **battery** that is replaceable.

3.6.11
separable battery
battery contained in an enclosure separate from the **battery-operated appliance,** intended for use with specific appliances and connected to the appliance by a cord external to the enclosure of the appliance

Note 1 to entry: A standard automotive **battery** is not considered a **separable battery**.

Note 2 to entry: A **separable battery** is not considered a **battery** that is replaceable.

3.6.12
integral battery
battery contained within the **battery-operated appliance** and not removed from the appliance for charging purposes

Note 1 to entry: A **battery** that is only to be removed from the **battery-operated appliance** for disposal or recycling is still considered to be an **integral battery**.

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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 pre-determined value

Note 1 to entry: 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 1 to entry: 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 1 to entry: 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 a **thermal link** that is not an **accessible part** 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 1 to entry: For multi-phase appliances, the neutral conductor is not considered to be a supply conductor.

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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 1 to entry: 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

3.8.6
room temperature
ambient temperature specified in the general conditions for the tests

Note 1 to entry: The ambient temperature is specified in 5.7.

3.8.101
aerosol
suspension of particles in air or gas

Note 1 to entry: The particles can be comprised of only liquids or a mixture of liquids and solids.

3.8.102
consumable
substrate or receptacle containing a substrate, intended to be used in combination with an appliance to generate an inhalable **aerosol**, and which is consumed or depleted through single or multiple use

EXAMPLE 1 Sealed cartridge containing **e-liquid.**

EXAMPLE 2 Tobacco or non-tobacco stick.

EXAMPLE 3 Tobacco or non-tobacco capsule.

EXAMPLE 4 Tablets or similar solid formats that will be depleted during use.

EXAMPLE 5 Loose solid materials such as tobacco.

3.8.103
e-liquid
liquid or gel **consumable** that can contain nicotine

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

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Note 1 to entry: 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 1 to entry: Parts of the circuit may also be used for functional purposes.

3.10 Definitions relating to battery charging and discharging

3.10.1
battery system
system that includes a **battery**, **charging system** and the **battery-operated appliance**

Note 1 to entry: The **battery system**, including interfaces, may contain more than one **battery** and **charging system.**

3.10.2
charging system
circuitry that charges and maintains the state of charge of the **battery**

Note 1 to entry: Parts of the **charging system** may perform other functions such as charge balancing and may be separately enclosed.

3.10.3
specified operating region for charging
region during charging in which a **cell** operates within its voltage and current range as specified by the **cell** manufacturer

Note 1 to entry: An example of a specified operating region of a lithium-ion **cell** during charging is shown in Figure 14.

3.10.4
upper limit charging voltage
highest charging voltage in the **specified operating region for charging**

3.10.5
venting
condition intended by design that occurs when a **cell** provides a controlled release of excessive internal pressure without expulsion of major components of the **cell**

3.10.6
fully charged
at the maximum state of charge

Note 1 to entry: For **cells** and **batteries** that are rechargeable, this is the maximum state of charge permitted by the **charging system**.

Note 2 to entry: The maximum state of charge for **non-rechargeable batteries** and **batteries** that are rechargeable is specified in the artificial source characteristics of Table B.1.

3.10.7
fully discharged
discharged at a steady rate of current to attain, at 5 h of steady discharge (C_5 rate), or the fastest discharge rate allowed by the **cell** manufacturer or **battery** manufacturer if it is slower than the C_5 rate, until

– discharge terminates due to operation of discharge termination circuitry; or

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– the **battery** (or **cell**) reaches a total voltage with an average voltage per **cell** equal to the end-of-discharge voltage for the **cell** chemistry being used, unless a different end of discharge voltage is specified by the **cell** manufacturer

Note 1 to entry: Examples of the end-of-discharge voltages for **fully discharged** common **cell** chemistries are typically

- 0,9 V/**cell** for nickel cadmium;
- 0,9 V/**cell** for nickel metal-hydride;
- 1,75 V/**cell** for lead-acid;
- 2,5 V/**cell** for lithium iron-phosphate;
- 3,0 V/**cell** for lithium cobalt-oxide.

3.11 Definitions relating to remote functionality

3.11.1
entity
person, device, appliance, product, or service that interacts with an appliance

3.11.2
message
data which is transmitted from a sender (data source) to one or more receivers (data sink)

3.11.3
public network
network carrying digital data or analogue signals or both where access to the data and signals is not restricted by the physical space within the household or similar use environment of the appliance

Note 1 to entry: Determination of confinement to the physical space includes consideration of the network's range of communication, configuration, or construction.

For the purposes of this standard, examples of **public networks** include but are not limited to:

- PAN (personal area network);
- LAN (local area network) connected devices which may or may not be connected to a gateway,
- PLC (power line communication);
- SRD (short range devices);
- WAN (wide area network);

For the purposes of this standard, examples of networks which are not considered as being **public networks** include but are not limited to:

- NFC (near field communication);
- optical communication with line of sight (infra-red rays or visual rays);
- hardwired configurations constructed of physical media;

without connection to a **public network**.

3.11.4
remote communication
transmission of data between the appliance and an **entity** that can be initiated out of sight of the appliance, using communication means such as radio wave modulation, sound wave modulation or bus systems

Note 1 to entry: Examples of transmission of data includes but are not limited to remote monitoring, software downloading or control parameter modifications.

Note 2 to entry: Transmission of data can be one-way (simplex) or two-way (duplex).

3.11.5
remote operation
control of an appliance by **remote communication**

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Note 1 to entry: **Remote communication** that results in a change of appliance operation, such as change of rotational speed, temperature, spatial movement, start/stop of the intended function, is considered **remote operation**. It is possible to have **remote communication** that does not lead to **remote operation.**

Note 2 to entry: A line of sight infra-red signal by itself is not considered one used for **remote operation**.

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 informative 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 12, 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.*

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

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

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

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

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

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

If an appliance has to be dismantled in order to carry out a test, care shall 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*

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Clause 14, 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.*

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

*For appliances fitted with a voltage selector switch, 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 °C ± 5 °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 °C ± 2 °C in case of doubt.

5.8 Test conditions relating to frequency and voltage

5.8.1 *Appliances for alternating current (AC) only are tested with AC at **rated frequency**, and those for AC and DC are tested at the more unfavourable supply.*

*Appliances for AC 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**.*

*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. For **motor-operated appliances**, **combined appliances** and appliances having more than one **rated voltage** or **rated voltage***

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***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.*

*A **class III construction** part of the appliance is tested connected to its **detachable power supply part** taking into account 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.*

*If **batteries** intended for use with the appliance use metal-ion chemistry, the manufacturer or responsible agent shall provide the following information for each type of **battery***

- *end-of-discharge voltage;*
- ***upper limit charging voltage**, for **batteries** comprising series connected **cells**;*
- *rated capacity of the **battery** (C_5 Ah).*

*If **cells** intended for use with the appliance use metal-ion chemistry, the manufacturer or responsible agent shall provide the **specified operating region for charging** for each type of **cell**.*

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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 informative Annex P for enhanced requirements that can 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 tropical 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 ***Battery-operated appliances** and remote controls containing **batteries** are tested in accordance with normative Annex B.*

***Battery-operated appliances** having a functional earth connection or a supply connection are tested in accordance with the relevant clauses of the main part of this standard and normative Annex B.*

NOTE A supply connection can include a mains connection.

***Battery-operated appliances** having a supply connection are considered dual supply appliances. Dual supply appliances are regarded as **battery-operated appliances** when deriving their energy from **batteries**.*

***Separable batteries** and **detachable batteries** for **battery-operated appliances** are tested in accordance with normative Annex B.*

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5.18 *To condition **batteries** that are rechargeable, the **batteries** shall be **fully discharged** and then **fully charged** in accordance with the appliance manufacturer's instructions. The sequence shall be repeated at least 2 h after the **battery** was charged.*

*For **batteries** where there is a series arrangement of parallel clusters of **cells**, the cluster shall be treated as a single **cell** for those tests that require altering the amount of charge on a single **cell** prior to conducting the test.*

5.19 *Measurements of **cell** voltages or **battery** voltages shall be made using a single pole resistive-capacitive low pass filter with a –3 dB roll off frequency of 5 kHz ± 0,5 kHz. To determine if the **upper limit charging voltage** has been exceeded, the peak value of the filtered voltage shall be measured with a tolerance of ±1 %.*

*When measuring **cell** voltages or **battery** voltages, the peak value of any superimposed ripple exceeding 10 % of the average value shall be included. Transient voltages are ignored, such as a temporary increase of voltage, for example, after the **battery** is removed from the **charging system**.*

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

5.21 *Probes are applied with a force not exceeding 1 N.*

5.22 *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 this standard, then appliances incorporating such a component or part shall be tested with the **non-self-resetting feature** rendered inoperative.*

5.101 *Appliances, other than those with heating elements, are tested as **motor-operated appliances**.*

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**.

If an appliance consists of a part of **class III construction** and a **detachable power supply part**, the complete appliance is classified as a **class I appliance** or **class II appliance** in accordance with the classification applicable to its **detachable power supply part**.

Appliances shall be at least IPX4. This does not apply to the battery charger or **detachable power supply part** for rechargeable **battery-operated appliances**.

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 60529:1989 including IEC 60529:1989/AMD1:1999 and IEC 60529:1989/AMD2:2013.

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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;
– deleted
– symbol IEC 60417-5180 (2003-02), for **class III appliances**. This marking is not necessary for appliances operated only by **batteries** (primary **batteries** or secondary **batteries** recharged outside of the appliance) or appliances powered by **rechargeable batteries** recharged in the appliance.

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

Appliance outlets accessible to the user and socket-outlets accessible to the user:

– that are incorporated in appliances connected to the supply mains; and
– that operate at **rated voltage**

shall be marked with their **outlet load** in watts or amperes.

Appliances intended to be supplied from a **detachable power supply part** for the purposes of recharging the **battery** shall be marked with symbol ISO 7000-0790 (2004-01). They shall also be marked with symbol IEC 60417-6181 (2016-01) and the model or type reference of the **detachable power supply part** or with the substance of the following:

Use only with <model or type reference> supply unit

Class II appliances and **class III appliances** incorporating a functional earth shall be marked with the symbol IEC 60417-5018 (2011-07).

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 V – 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).

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

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

NOTE 3 Example: 230 V ∼/400 V 3N∼: The appliance is only suitable for the voltage values indicated, 230 V∼ being for single-phase, AC operation and 400 V 3N∼ for three-phase, AC with neutral operation (an appliance with terminals for both supplies).

Compliance is checked by inspection.

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

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

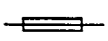
Compliance is checked by inspection.

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 current rating of the fuse link can 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

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	[symbol IEC 60417-5019 (2006-08)]	protective earth
	[symbol IEC 60417-5018 (2011-07)]	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 can be indicated in association with this symbol.

	[symbol ISO 7000-0434A (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**
	[symbol IEC 60417-6181 (2016-01)]	**detachable power supply part**

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.

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

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.

The correct mode of connection for multi-phase appliances is considered to be obvious if the terminals for the supply conductors are

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– indicated by arrows pointing towards the terminals; or
– marked in words.

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

Compliance is checked by inspection.

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);
– functional earthing terminals shall be indicated by symbol IEC 60417-5018 (2011-07).

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**. The 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 shall be provided in hard copy form with the appliance so that the appliance can be used safely.

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

NOTE If the instructions are marked on the appliance they are considered to be provided in hard copy form.

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

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The instructions shall state the substance of the following:

This appliance is not intended for use by persons 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 shall not handle the appliance.

The instructions for appliances having a part of **class III construction** supplied from a **detachable power supply part** 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.

For appliances intended for use at altitudes exceeding 2 000 m, the maximum altitude of use shall be stated.

The instructions for appliances incorporating a functional earth shall state the substance of the following:

This appliance incorporates an earth connection for functional purposes.

For appliances intended to be connected to a supply for the purposes of recharging the **battery**, the instructions shall state the substance of the following:

WARNING: Use only an external supply with the following specifications: <voltage and nature of supply> <power / current of supply>

For appliances intended to be supplied from a **detachable power supply part** for the purposes of recharging the **battery**, the type reference of the **detachable power supply part** shall be stated along with the substance of the following:

WARNING: Only use the supply unit provided with this appliance.

For appliances intended for use with **batteries** that use metal-ion chemistries, the instructions shall state the normal temperature range for charging the **battery**.

If the symbol for **detachable power supply part** is used, its meaning shall be explained.

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.

For appliances marked with different **rated voltages** or different **rated frequencies** (separated by a /), instructions shall be included to indicate to the user or installer what action must be taken to adjust the appliance for operation at the required **rated voltage** or **rated frequency**.

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

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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.

If a cord set is required to be provided with the appliance according to Subclause 22.58, the instructions shall contain the substance of the following:

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

Compliance is checked by inspection.

7.12.6 If a **non-self-resetting thermal cut-out** is required in order to comply with this standard, then the instructions for appliances incorporating a **non-self-resetting thermal cut-**

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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.

7.12.9 For each language, the instructions specified in 7.12 and from 7.12.1 to 7.12.8 shall be in hard copy form and shall appear together before any other instructions supplied with the appliance. Alternatively, these instructions may be supplied with the appliance separately from any functional use booklet. They may follow the description of the appliance that identifies parts, or follow the drawings/sketches common to the languages of the instructions.

In addition, instructions shall also be available in an alternative format such as on a website or on request from the user in a format such as a DVD.

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 this standard shall be clearly legible.

The signal words WARNING, CAUTION, DANGER if in the Latin alphabet shall be in uppercase having a height not less than:

– 3,5 mm for appliances normally used on the floor;

– 2,0 mm for **portable appliances** with a printable surface of less than 10 cm^2; and

– 3,0 mm for other appliances.

NOTE A height of 3,5 mm is similar to Arial 14 pt, 3,0 mm is similar to 12 pt Arial and 2,0 mm is similar to 8 pt Arial. Other typefaces might differ in the pt value.

Uppercase letter of the text explaining the signal word shall be no smaller than 1,6 mm, with other letters according to the font size of the uppercase letter.

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Countries that do not use the Latin alphabet need to specify the minimum size of the script to be used taking into account what is specified for the Latin alphabet.

Unless contrasting colours are used, moulded in, engraved, or stamped markings shall be either raised above or have a depth below the surface of at least 0,25 mm.

The markings required by this standard shall be durable. On containers that are likely to be cleaned frequently, the markings shall not be by means of paint or enamel, other than vitreous enamel.

Compliance is checked by inspection, by measurement 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.

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.

The symbol IEC 60417-5018 (2011-07) shall be placed next to the symbol IEC 60417-5172 (2003-02) or the symbol IEC 60417-5180 (2003-02) as appropriate.

The type reference of the **detachable power supply part** shall be placed next to symbol IEC 60417-6181 (2016-01).

The marking of the **outlet load** shall be on the appliance close to the appliance outlet or socket-outlet.

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.

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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**, unless otherwise specified.*

Test probe B and test probe 18 of IEC 61032 are 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 when probe B is used or 10 N when probe 18 is used. If the probe then enters the opening, the test is repeated with the probe in the angled position.

*During the tests with test probe B, all **detachable parts** are removed except 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.*

During the tests with test probe 18, the appliance shall be fully assembled as in normal use without any parts removed.

Test probe 18 is not applied to appliances for commercial use unless they are intended to be installed in an area open to the public.

*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, test probe 18 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**.*

*If a single switching action is obtained by a switching device, the switching device shall provide full disconnection and the **clearances** for full disconnection specified in 20.3.3 of*

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IEC 61058-1:2016 shall be obtained from Table 12 of IEC 61058-1:2016 using the next higher step for rated impulse withstand voltage.

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

Compliance is checked by inspection and by manual test.

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 AC, the peak value of the voltage does not exceed 42,4 V;
  - for DC, 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 DC, its peak value shall not exceed 0,7 mA for AC 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.

The quantity of electricity is calculated from the sum of all areas recorded on the voltage/time graph without taking voltage polarity into account. Details of a suitable circuit for measuring the current are given in Figure 4 of IEC 60990:2016.

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 applying test probe B of IEC 61032 as specified in 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 the test probes specified in 8.1.1 in accordance with the conditions specified in 8.1.1.

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8.3 For a **battery-operated appliance** where the **battery** circuit has a functional earth connection or a supply connection, it shall only be possible to touch parts within a **battery** compartment where:

– in **class I appliances**, **class 0I appliances** and **class II appliances**, they are separated from **live parts** by **double insulation** or **reinforced insulation**;

– in **class 0 appliances**, they are separated from **live parts** by **basic insulation**;

– the **battery** compartment is of **class III construction**. However, if the limits in 8.1.4 are exceeded, then **basic insulation** is required in addition to supply at **SELV**.

Compliance is checked by inspection and by applying the test probes specified in 8.1.1 in accordance with the conditions specified in 8.1.1.

9 Starting of motor-operated appliances

This clause of Part 1 is not applicable.

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.

In case of doubt, the power input of the 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 and its maximum value exceeds twice its arithmetic mean value occurring during a representative period, then the power input is the maximum value of the power input that is exceeded for more than 10 % of the representative

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period if this value is greater than the arithmetic mean value. Otherwise the power input is taken as the arithmetic mean value.

NOTE *Guidance on the measurement of power input concerning a representative period is given in informative Annex S.*

*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.*

Appliance outlets accessible to the user and socket-outlets accessible to the user that:

– *are incorporated in appliances connected to the supply mains; and*

– *operate at **rated voltage***

*are not loaded during the test; however, their contribution to the power input is considered to be the marked **outlet load** per appliance outlet or socket-outlet.*

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	≤0,2	+20 %
Heating appliances and **combined appliances**	>0,2 and ≤1,0	±10 %
	>1,0	+5 % or 0,10 A (whichever is the greater) –10 %
Motor-operated appliances	>0,2 and ≤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.

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 and its maximum value exceeds twice its arithmetic mean value occurring during a representative period, then the current is the maximum value of the current that is exceeded for more than 10 % of the representative period if this value is greater than the arithmetic mean value. Otherwise the current is taken as the arithmetic mean value.

NOTE *Guidance on the measurement of current concerning a representative period is given in informative Annex S.*

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*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.*

Appliance outlets accessible to the user and socket-outlets accessible to the user that:

– *are incorporated in appliances connected to the supply mains; and*

– *operate at **rated voltage***

*are not loaded during the test; however, their contribution to the current is considered to be the marked **outlet load** per appliance outlet or socket-outlet.*

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.*

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11.3 *Temperature rises, other than those of windings, are determined by means of thermocouples having a diameter not exceeding 0,3 mm positioned so that they have minimum effect on the temperature of the part under test.*

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.

If it is necessary to dismantle the appliance to position thermocouples, verify that the appliance has been correctly reassembled. In case of doubt, remeasure the power input or input current as appropriate.

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 1 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 **room temperature** at the beginning of the test;*

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

NOTE 2 The resistance of windings at the end of the test can 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.

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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 as specified in B.11.1.*

*Appliance outlets accessible to the user and socket-outlets accessible to the user are loaded with a resistive load that gives the marked **outlet load**.*

*For appliances incorporating **integral batteries** or **separable batteries** not disconnected from the appliance for charging purposes:*

– *the **battery** that has been **fully discharged** is charged for 1 h, while the appliance is operated continuously performing its intended function, if allowed by the construction of the appliance;*
– *the **battery** that has been **fully discharged** is charged, for a duration of 24 h or until it is **fully charged** whichever is shorter, without the **battery-operated appliance** performing its intended function.*

NOTE The duration of the test can 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.*

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 normative 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.*

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Table 3 – Maximum normal temperature rises

Part	Temperature rise K	
Windings[a], if the winding insulation according to IEC 60085 is:		
– class 105 (A)	*75*	*(65)*
– class 120 (E)	*90*	*(80)*
– class 130 (B)	*95*	*(85)*
– class 155 (F)	*115*	
– class 180 (H)	*140*	
– class 200 (N)	*160*	
– class 220 (R)	*180*	
– class 250	*210*	
Pins of appliance inlets:		
– for very hot conditions	*130*	
– for hot conditions	*95*	
– for cold conditions	*45*	

Part	Temperature rise K
Pins of appliances for insertion into socket-outlets, pins of plug connectors inserted into appliance outlets accessible to the user and plugs inserted into socket-outlets accessible to the user	*45*
*Terminals, including earthing terminals and functional earthing terminals, for external conductors of **stationary appliances**, unless they are provided with a **supply cord***	*60*
*Ambient of switches, **thermostats** and **temperature limiters**:* [b]	
– without T-marking	*30*
– with T-marking	*T-25*
*Rubber, polychloroprene or polyvinyl chloride insulation of internal and external wiring, including **supply cords**:*	
– without temperature rating or with a temperature rating not exceeding 75 °C	*50*
– with temperature rating (T) [j] *where T exceeds 75 °C*	*T-25*
*Cord sheaths used as **supplementary insulation***	*35*
Sliding contacts of cord reels	*65*
*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**.*	*50* [c]
Rubber, other than synthetic, used for gaskets or other parts, the deterioration of which could affect safety:	
*– when used as **supplementary insulation** or as **reinforced insulation***	*40*
– in other cases	*50*
Lampholders with T-marking [d]	
– B15 and B22 marked T1	*140*
– B15 and B22 marked T2	*185*
– other lampholders	*T-25*
Lampholders without T-marking [d]	
– E14 and B15	*110*
– B22, E26 and E27	*140*
– other lampholders and starter holders for fluorescent lamps	*55*

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Part	Temperature rise K	
Material used as insulation, other than that specified for wires and windings: [e]		
– impregnated or varnished textile, paper or press-board	*70*	
– laminates bonded with:		
• melamine-formaldehyde, phenol-formaldehyde or phenol-furfural resins	*85*	*(175)*
• urea-formaldehyde resin	*65*	*(150)*
– printed circuit boards bonded with epoxy resin	*120*	
– moulding of:		
• phenol-formaldehyde with cellulose fillers	*85*	*(175)*
• phenol-formaldehyde with mineral fillers	*100*	*(200)*
• melamine-formaldehyde	*75*	*(150)*
• urea-formaldehyde	*65*	*(150)*
– polyester with glass reinforcement	*110*	
– silicone rubber	*145*	
– polytetrafluoroethylene	*265*	
– pure mica and tightly sintered ceramic material when such materials are used as ***supplementary insulation*** *or* ***reinforced insulation***	*400*	
– thermoplastic material [f]	–	
Wood, in general [g]	*65*	
– Wooden supports, walls, ceiling and floor of the test corner and wooden cabinet:		
• ***stationary appliances*** *liable to be operated continuously for long periods*	*60*	
• other appliances	*65*	
Outer surface of capacitors: [h]		
– with marking of maximum operating temperature (T): [i]	*T-25*	
– without marking of maximum operating temperature:		
• small ceramic capacitors for radio and television interference suppression	*50*	
• capacitors complying with IEC 60384-14:2013 including IEC 60384-14:2013/AMD1:2016	*50*	
• other capacitors	*20*	
External enclosure of ***motor-operated appliances*** *except handles held in normal use:* [m]		
– of bare metal	*48*	
– of coated metal [n]	*59*	
– of glass and ceramic	*65*	
– of plastic having a thickness exceeding 0,4 mm [l]	*74*	
Surfaces of handles, knobs, grips and similar parts which are continuously held in normal use (e.g. soldering irons): [m]		
– of bare metal	*30*	
– of coated metal [n]	*34*	
– of porcelain or vitreous material	*40*	
– of rubber or of plastic having a thickness exceeding 0,4 mm [l]	*50*	
– of wood	*50*	

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Part	Temperature rise K
Surfaces of handles, knobs, grips and similar parts[k] which are held for short periods only in normal use (e.g. switches):[m]	
– of bare metal	*35*
– of coated metal[n]	*39*
– of porcelain or vitreous material	*45*
– of rubber or of plastic having a thickness exceeding 0,4 mm[l]	*60*
– of wood	*65*
Parts in contact with oil having a flash-point of t °C	*t-50*

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 normative 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 AC 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.

For hermetically sealed motors, the temperature rise limit may be increased by 8 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 60598-1:2014 including IEC 60598-1:2014/AMD1:2017.*

[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;*

*IEC 62821 Types 101 and 101f **supply cords** have a T rating of 70 °C;*

*IEC 62821 Types 102 and 102f **supply cords** have a T rating of 70 °C.*

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k	*The temperature rise limits of controls actuated by contact or proximity of a finger, with no movement of the contact surface also includes all surfaces within 5 mm of such controls, regardless of their shape.*
l	*The temperature rise limit of plastic also applies for plastic material having a metal finish of thickness less than 0,1 mm.*
m	*When the thickness of the plastic coating does not exceed 0,4 mm, the temperature rise limits of the coated metal or of glass and ceramic material apply.*
n	*Metal is considered coated when a coating having a minimum thickness of 90 μm made by enamel, powder or non-substantially plastic coating is used.*

12 Charging of metal-ion batteries

Charging a **battery** that uses metal-ion chemistry under **normal operation** shall not cause any **cell** to exceed its **specified operating region for charging**.

*Compliance is checked using a **battery** that has been **fully discharged**, by charging the **battery**, with the **charging system** indicated in the instructions, at an ambient temperature of 20 °C ± 5 °C, irrespective of the minimum and maximum ambient temperatures for charging the **battery** specified in the instructions.*

If the manufacturer's specified:

– *minimum ambient temperature for charging the battery is less than 10 °C, the test is repeated at the specified minimum ambient temperature $^{+0}_{-5}$ °C;*

– *maximum ambient temperature for charging the battery is greater than 40 °C, the test is repeated at the specified maximum ambient temperature $^{+5}_{-0}$ °C.*

*For all individual **cells**, the voltage, the temperature and the charging current are monitored.*

*In the case of parallel configurations, analysis may be used to avoid measuring the individual branch currents. The result shall not exceed the **specified operating region for charging** (e.g. limits of voltage and current dependent on the temperature).*

NOTE 1 The following are example results of such analysis:

The charging current for each branch of a parallel connection would not need to be monitored, if:

– the maximum deliverable current of the **charging system** did not exceed the maximum charging current of a single **cell**; or

– for **cells** with identical specifications, the maximum deliverable current of the **charging system** divided by the number of branches of parallel connections does not exceed the maximum charging current of a single **cell**. Currents measured during **battery** charging shall be the average current over a period of between 1 s and 5 s.

*The location of thermocouples for each **cell** temperature measurement shall be on the outer surface, halfway along the longest dimension of the **cell**.*

NOTE 2 A specially prepared **battery** can be used for this test.

*For each **cell**, the **specified operating region for charging** specified by the **cell** manufacturer shall not be exceeded at the temperature of the **cell** (T_{cell}).*

When the test is carried out at an ambient temperature of 20 °C ± 5 °C

– $T_{cell} = T_{meas} + (T_{amb(max)} - T_{amb(test)})$, *for the maximum recommended ambient temperature for charging;*

– $T_{cell} = T_{meas} - (T_{amb(test)} - T_{amb(min)})$, *for the minimum recommended ambient temperature for charging.*

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When the test is carried out at the recommended ambient temperature for charging, T_{cell} = T_{meas}

where

T_{meas}	*is the **cell** surface temperature measured during the test;*
T_{cell}	*is the **cell** surface temperature specified by the **cell** manufacturer;*
$T_{amb(max)}$	*is the maximum ambient temperature for charging specified by the manufacturer;*
$T_{amb(min)}$	*is the minimum ambient temperature for charging specified by the manufacturer;*
$T_{amb(test)}$	*is the ambient temperature of the test room during the test.*

*For **batteries** where the **cells** are configured in series, the test is repeated with the charge in one **battery** deliberately imbalanced. The imbalance is introduced into a **battery** that is **fully discharged** by charging one **cell** to approximately 50 % of being **fully charged**.*

*If it can be demonstrated that an imbalance less than 50 % would actually occur in **normal operation**, then this lower imbalance may be used.*

*This may be demonstrated by operating the **battery** in cycles. Each cycle starts with the **battery fully discharged** then the **battery** is **fully charged**. The cycling is continued until the **battery** capacity has decreased to 80 % of its rated capacity. The imbalance at this decreased capacity is then used.*

*Use of a lower imbalance may also be demonstrated through evaluation of those designs that employ circuitry intended for maintaining balance between **cells** in the **battery**. **Batteries** with a small number of **cells** in series may be shown to exhibit limited imbalance in practice, if charging ceases with the **battery** prepared with a smaller initial imbalance.*

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 *The leakage current is measured by means of the circuit described in Figure 4 of IEC 60990:2016. For **class 0I appliances** and **class I appliances**, except parts of **class II***

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***construction**, C may be replaced by a low impedance ammeter responding to the **rated frequency** of the appliance.*

The leakage current is measured between any pole of the supply and:

- ***accessible metal parts** intended to be connected to protective earth, for **class I appliances** and **class 0I appliances**;*
- *metal foil having an area not exceeding 20 cm × 10 cm which is in contact with **accessible surfaces** of insulating materials and metal parts not intended to be connected to protective earth, for **class 0 appliances**, **class II appliances**, **class II constructions** and **class III appliances**.*

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 they are **class II appliances** or parts of **class II construction**, Figure 1;*
- *if they are neither **class II appliances** nor parts of **class II construction**, Figure 2.*

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

For three-phase with neutral (3N~) connected appliances, the measuring circuit is shown in the following figures:

- *if they are **class II appliances** or parts of **class II construction**, Figure 3;*
- *if they are neither **class II appliances** nor parts of **class II construction**, Figure 4.*

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 three-phase without neutral (3~) connected appliances, the measuring circuit in Figure 3 or Figure 4 shall be used as applicable, but the neutral is not connected to the appliance.

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** and for parts of **class II construction***	*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**.*

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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 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.

WARNING – In order to avoid an electric shock hazard, the appliance shall be supplied through an isolating transformer or it shall 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.*

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**.*

*During the test, care shall 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.

Glow discharges without a drop in voltage are neglected.

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Table 5 – Characteristics of high-voltage sources

Test voltage	***Minimum current***	
	mA	
V	I_s	I_r
≤ 4 000	*200*	*100*
> 4 000 and ≤ 10 000	*80*	*40*
> 10 000 and ≤ 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 µs standard impulse specified in IEC 61180. The impulse test voltage is applied three times for each polarity with intervals of at least 1 s.

*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	***Impulse test voltage***[a]
V	*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*

[a] *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 shall be used as noted in Subclause 6.1.2.2.1.3 of IEC 60664-1:2007.*

*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.*

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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. For appliances and parts of appliances with pins for insertion into socket-outlets an inspection shall show that no water has entered the enclosure.*

15.1.1 *Appliances other than those classified IPX0 are subjected to the tests of IEC 60529:1989 including IEC 60529:1989/AMD1:1999 and IEC 60529:1989/AMD2:2013.*

IPX3 appliances are tested as described in Subclause 14.2.3a). The test as described in subclause 14.2.3b) may be used for testing appliances that cannot be placed under the oscillating tube.

IPX4 appliances are tested as described in Subclause 14.2.4a). The test as described in subclause 14.2.4b) may be used for testing appliances that cannot be placed under the oscillating tube;

IPX7 appliances are tested as described in Subclause 14.2.7. For this test, the appliance is immersed in water containing approximately 1 % NaCl.

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.*

Appliances with an automatic cord reel are tested to 15.1.1 with the ***supply cord*** *unreeled and coiled in close proximity to the appliance under test so that the minimum diameter of the coil is 30 cm. The coil is concentric and in a single layer positioned in such a way that the appliance and the* ***supply cord*** *are subjected to water spray. After the test of 15.1.1 is completed, the* ***supply cord*** *shall be reeled into the appliance at free speed. The* ***supply cord*** *shall not be dried before reeling.*

If the appliance is a ***fixed appliance*** *mounted on the wall or ceiling, the cord will be allowed to drop to the floor from a height equal to the minimum height specified in the instructions before being coiled.*

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 are mounted as in normal use in the centre of a wooden board having dimensions which are 15 cm ± 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.

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Appliances and parts of appliances with integral pins for insertion into socket-outlets are held by the pins in the most unfavourable position during the test. They are not mounted in a socket-outlet for the tests. They may be held by the pins using a laboratory clamp or similar device.

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 using a spillage solution comprising water containing approximately 1 % NaCl and 0,6 % rinsing agent.

*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 the solution 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.

Any commercially available non-ionic rinsing agent may be used, but if there is any doubt with regards to the test results, the rinsing agent shall have the following properties:

- *viscosity,17 mPa s;*
- *pH,2,2 (1 % in water);*
- *and its composition shall comprise the following substances*

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- *Plurafac ® LF 221*[11] *15,0 % parts by mass*
- *Cumene sulfonate (40 % solution) 11,5 % parts by mass*
- *Citric acid (anhydrous) 3,0 % parts by mass*
- *Deionized water 70,5 % parts by mass*

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 ± 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^{+4}_{0} *°C.*

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 AC test voltage is applied between* ***live parts*** *and:*

– ***accessible metal parts*** *intended to be connected to protective earth, for* ***class I appliances*** *and* ***class 0I appliances****;*

11 Plurafac ® LF 221 is the trade name of a product supplied by BASF. This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of this product.

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– *metal foil having an area not exceeding 20 cm × 10 cm which is in contact with* ***accessible surfaces*** *of insulating material and metal parts not intended to be connected to protective earth, for* ***class 0 appliances****,* ***class II appliances****,* ***class II constructions*** *and* ***class III appliances****.*

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*** *and for parts of* ***class II construction***	*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 RMS 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. 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. Care is to be taken that the metal foil is placed so that no flashover occurs at the edges of the insulation.*

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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**.*

During the test care shall be taken to avoid overstressing

- *the components of **electronic circuits**;*
- *the **basic insulation** or the **supplementary insulation** when applying the voltage to **reinforced insulation** in **class II constructions** incorporating both **reinforced insulation** and **double insulation**.*

NOTE 1 The characteristics of the high-voltage source used for the test are described in Table 5.

NOTE 2 When testing insulating coatings, the metal foil can be pressed against the insulation by means of a sandbag so that the pressure is approximately 5 kPa. The test can be limited to places where the insulation is likely to be weak, for example where there are sharp metal edges under the insulation.

NOTE 3 If practicable, insulating linings can be tested separately.

No breakdown shall occur during the test.

Glow discharges without a drop in voltage are neglected.

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.*

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*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 61558-1:2017.

18 Endurance

This clause of Part 1 is not applicable.

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 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 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.

*Appliances having a mains connection and **batteries** that are replaceable are subjected to the test of 19.16.*

*Appliances incorporating **batteries** that are rechargeable and use metal-ion chemistries are subjected to the test of 19.17.*

*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. That same part on the second sample shall also become permanently open-circuited in the second test, unless a **non-self-resetting thermal cut-out** operates or steady conditions are established.*

NOTE Fuses, **thermal cut-outs**, overcurrent protection devices, or similar devices incorporated in the appliance, can 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**.*

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*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. If the control performs more than one function, only that aspect of the control under consideration is rendered inoperative. Other functions of the control may continue to operate normally.

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

Compliance is also checked by 19.101.

19.2 Not applicable.

19.3 Not applicable.

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.*

*A control that operates during this test and the test of Clause 11 and that incorporates an **electronic circuit** is not considered to be a **protective electronic circuit** if the appliance complies with 19.13 with the electronic control rendered inoperative.*

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;*
- *where an **all-pole disconnection** occurs during the test of 19.4; or*
- *used in a system with polarized plugs intended for connection to polarized socket outlets.*

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.*

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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 S2 or S3 of IEC 60252-1:2010 including IEC 60252-1:2010/AMD1:2013.

NOTE 1 This test is carried out with the rotor locked since some motors can 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. If the timer or programmer is an electronic type that operates to ensure compliance with the test before the maximum period under the conditions of Clause 11 is reached, it is considered to be a **protective electronic circuit** as well as a control that operates under the conditions of Clause 11.*

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

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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 can 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 can 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 can be made to informative Annex Q. It should be realized that in the Parts 2 there can be additional or alternative abnormal operation tests specified; these are not shown in the flow chart. For correct application of this standard, the normative text takes precedence over the guidance given in informative Annex Q.

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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 61558-1:2017. 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 normative 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.*

The measurements shall be made from only one pole of the supply source, preferably the one that gives the fewest low-power points. The power consumed by the variable resistor shall be measured by a wattmeter.

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

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;*

a) open circuit at the terminals of any component;

b) short circuit of capacitors, unless they comply with IEC 60384-14:2013 including IEC 60384-14:2013/AMD1:2016;

c) 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;*

d) failure of triacs in the diode mode;

e) 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.

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If it can be shown that a particular output signal is unlikely to occur, then the relevant fault is not considered;

f) failure of an electronic power switching device in a partial turn-on mode with loss of gate (base) control.

NOTE 1 This mode can 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.

Any cord provided between a ***battery-operated appliance*** *that consumes more than 15 W and the* ***detachable power supply part*** *shall be short-circuited at the point along its length likely to produce the most adverse effects.*

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*** *that operates to ensure compliance with Clause 19, the appliance is tested as follows:*

A fault as indicated in a) to g) of 19.11.2 shall be incorporated in the ***protective electronic circuit*** *either before the appliance is started or at any point in time after the appliance is started so that the most unfavourable conditions of the test are applied.*

If the appliance is able to operate after the fault in the ***protective electronic circuit*** *is incorporated, then the appliance is further tested as follows.*

For appliances for continuous operation the appliance is operated until steady conditions are reached. Then the relevant test of Clause 19 is repeated.

Other appliances are operated for one cycle of operation. Then the relevant test of Clause 19 is repeated.

Compliance is checked as specified in 19.13.

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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, the tests for electromagnetic phenomena are not applied to **protective electronic circuits** that operate during the test of 19.7 in appliances that are used while attended.*

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

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

NOTE 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.*

The frequency ranges tested shall be:

– *80 MHz to 1 000 MHz, test level 3;*
– *1,4 GHz to 2,0 GHz, test level 3;*
– *2,0 GHz to 2,7 GHz, test level 2.*

*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. An open circuit test voltage of 2 kV is applicable for the line-to-line coupling mode, a generator having a source impedance of 2 Ω being used. An open circuit test voltage of 4 kV 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 can be needed.

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

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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.*

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 61000-4-11:2020. The values specified in Table 1 and Table 2 of IEC 61000-4-11:2020 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 61000-4-34:2005 including IEC 61000-4-34:2005/AMD1:2009. The values specified in Table 1 and Table 2 of IEC 61000-4-34:2005 including IEC 61000-4-34:2005/AMD1:2009 are applied at zero crossing of the supply voltage.*

19.11.4.7 *The appliance is subjected to mains signals in accordance with IEC 61000-4-13:2002 including IEC 61000-4-13:2002/AMD1:2009 and IEC 61000-4-13:2002/AMD2:2015, 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 current rating 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 current rating of the fuse-link, the circuit is considered to be adequately protected;*
- *is between 2,1 times and 2,75 times the current rating 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.*

In case of doubt, the maximum resistance of the fuse-link shall be taken into account when determining the current.

NOTE 1 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 2 Other fuses are considered to be **intentionally weak parts** in accordance with 19.1.

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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.*

During and after the tests, the no-load output voltage of an ***accessible safety extra-low voltage*** *outlet or connector or Universal Serial Bus (USB) outlet shall not have increased by more than 3 V or 10 % of its no-load output voltage in normal use, whichever is higher, with a maximum of 42,4 V for DC and a peak value of 42,4 V for AC.*

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 could 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.

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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.

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.*

19.16 *Appliances having mains connection and **batteries** that are replaceable by the user are supplied at **rated voltage** and operated under **normal operation** but with the **batteries** removed or in any position allowed by the construction.*

NOTE The intent is to determine that safe operation does not depend upon the presence of a **battery** voltage.

19.17 ***Battery-operated appliances** incorporating a **battery** that uses metal-ion chemistry, the **charging system** and **battery** are checked by the following tests.*

*The **battery system** is operated as specified in the appliance manufacturer's instructions under the abnormal conditions listed below in a) to d). Each test is conducted until the test sample returns to **room temperature**, for at least 7 h or until twice the normal charge period has elapsed, whichever is longer.*

a) *the state of the **battery** is as follows:*

   – *a series configured **battery** shall have a deliberate imbalance. The imbalance is introduced into a **battery** that has been **fully discharged** by charging one **cell** to the percentage of being **fully charged** applied during the test of Clause 12;*

   – *a single **cell** or parallel only configuration **battery** shall be **fully discharged**.*

b) *If the test of Clause 12 is conducted with an imbalance of less than 50 % due to the function of circuitry intended for maintaining balance between **cells** in the **battery** and if a single fault of any component within that circuitry is shown to result in the loss of that function, then a series configured **battery** shall be **fully charged** with a deliberate imbalance. The imbalance is introduced into a **battery** that has been **fully discharged** by charging one **cell** to approximately 50 % of being **fully charged**.*

c) *For a **battery** with a series configuration, all **cells** are at approximately 50 % of being **fully charged**, except for one which is shorted. The **battery** is then **fully charged**.*

d) *With a **battery** that is **fully charged** connected to the **charging system**, a short circuit is introduced to the **charging system** across a component or between adjacent printed circuit tracks at a location expected to produce the most unfavourable results to evaluate the effect of back-feed from the **battery**. In addition, for a **charging system** with a cord that connects*

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*to the **battery**, the short circuit shall be introduced at the point likely to produce the most adverse effects. The resistance of the short circuit shall not exceed 10 mΩ.*

*No explosion or ignition of the **battery** shall occur during or after the test. However, **venting** of the **cells** is permitted provided that they have not vented by any means other than through their vents and the **venting** of appliance pressure is not directed towards the user's mouth.*

*The voltage on any **cell** shall not exceed the **upper limit charging voltage** by more than 150 mV unless the **charging system** is permanently disabled from recharging the **battery**.*

*To determine if recharging is permanently disabled, the **battery** shall be discharged to approximately 50 % of being **fully charged**, by using the **battery-operated appliance** tested (in the case of an **integral battery**) or by using a new sample of the **battery-operated appliance** (in the case of a **detachable battery** and **separable battery**). An attempt is then made to recharge the **battery** normally. There shall be no charging current after 10 min or after 25 % of the nominal capacity has been delivered, whichever occurs first.*

19.101 *Charge the appliance with 130 % of the **rated voltage** of the power source provided with the appliance or specified in the instruction or 7,5 V, whichever is higher. Maintain the voltage until the surface temperature of the appliance achieves steady conditions.*

*For the purpose of this standard, a steady condition is considered to be attained if the difference in peak temperature does not exceed 3 K in 30 min. No explosion or ignition of the **battery** shall occur during or after the test. However, **venting** of the **cells** is permitted provided that they have not vented by any means other than through their vents.*

19.102 Appliances, other than those complying with B.20.101, shall not generate fire hazards and hazardous events to users due to heating from an accidental operation.

Compliance is checked by the following test:

The appliance is operated according to B.3.1.1 until steady conditions are established. The appliance is then immediately wrapped by a layer of compressed wool felt sheet with a mass per unit area of 4 kg/m^2 ± 0,4 kg/m^2 and a total thickness of 25 mm and the surface temperature of the appliance is measured in the most unfavourable position by means of fine-wire thermocouples according to 11.3.

The surface temperature shall not exceed 150 °C.

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°.*

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.

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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 an appliance having parts that are necessarily exposed so that it can perform its working function.

Compliance is checked by:

– *inspection;*
– *the test of 21.1;*
– *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; and*
– *applying test probe 18 of IEC 61032 with a force not exceeding 2,5 N.*

Test probe 18 is not applied to appliances for commercial use unless they are intended to be installed in an area open to the public.

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 the test probes.

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.

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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 cm^2. Lamps within the appliance and their covers are only tested if they are likely to be damaged in normal use.

*When applying the release cone to the guard of a **visibly glowing heating element**, the hammer head passing through the guard shall not strike the heating element.*

For appliances and parts of appliances having pins for insertion into mains socket-outlets, 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 tests, 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

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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.

21.3 Appliances with pins for insertion into socket-outlets where the plug part is capable of rotation shall be provided with a mechanical stop to prevent rotation beyond which stress to electrical connections and internal wiring may occur. The mechanical stop shall have adequate mechanical strength and be constructed to withstand such rough handling that may be expected in normal use.

Compliance is checked by inspection and by the following test.

The part relying upon the mechanical stop shall be rotated as intended until the mechanical stop prevents further rotation. A torque of 2 Nm is then applied for 1 min in an attempt to override the mechanical stop. The part relying upon the mechanical stop shall not rotate.

The test shall be repeated in the opposite direction of rotation.

22 Construction

22.1 If the appliance is marked with the first numeral of the IP system or any of the additional letters of the IP system, the relevant requirements of IEC 60529:1989 including IEC 60529:1989/AMD1:1999 and IEC 60529:1989/AMD2:2013 shall be fulfilled.

Compliance is checked by the relevant tests.

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

– a **supply cord** fitted with a plug;
– a switch providing **all-pole disconnection** and 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 line 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. 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 apertures.

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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. 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 °C ± 2 °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 or pins for insertion into socket-outlets shall be constructed so that in normal use, when pins are touched, there is no risk of electric shock from charged capacitors that result in a capacitance equal to or greater than 0,1 µF across any two pins.

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 having an input impedance of not less than 100 MΩ in parallel with an input capacitance not exceeding 25 pF.*

The voltage shall not exceed 34 V.

*If compliance relies on the operation of an **electronic circuit**, the electromagnetic phenomena tests of 19.11.4.3 and 19.11.4.4 are applied one at a time to the appliance. The test for measuring the voltage between the pins of the plug is then repeated three times and for each test, 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.

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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 this 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 this 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;*

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– *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 parts providing a similar function shall be fixed in a reliable manner so that they will not work loose in normal use if loosening could result in a hazard, including a choking hazard. If these parts are used to indicate the position of switches or similar components, it shall not be possible to remove or fix them incorrectly if this could result in a hazard. The requirement concerning the choking hazard does not apply to appliances intended for commercial use.

Sealing compound and similar materials, other than self-hardening resins, shall not be used 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.

If the part is removed and can be contained within the small parts cylinder in Figure 13, its loosening is considered to result in a choking hazard.

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.

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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 The test can be interrupted 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.

The requirement is not applicable to parts made from stainless steel, plated steel and similar corrosion-resistant alloys.

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

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NOTE Compatibility of the materials of terminals and the effect of heating can influence corrosion.

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.

The requirement is not applicable to glass-wool thermal insulation.

NOTE 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;
– insulating material where 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 parts of **class III constructions** that do not contain **live parts**;
– where a core is provided that effectively prevents the heating conductor from sagging; or
– where **supplementary insulation** is provided to prevent the heating conductor from contacting **accessible metal parts**.

Compliance is checked by inspection.

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**.*

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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** can 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.

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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**. Ceramic and similar porous 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 ± 0,07 MPa and maintained at a temperature of 70 °C ± 1 °C.

WARNING – The use of the oxygen bomb presents some danger unless handled with care. Precautions shall 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** or unearthed metal parts that are separated from **live parts** by **basic insulation** only.

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.

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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 other than **class III constructions**, 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** and cordless 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.

NOTE A cordless appliance is an appliance that is connected to the supply only when placed on its associated stand.

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 **class III appliances**, 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.

Hand-held parts shall be **class III appliances** or **class III constructions** having a **working voltage** not exceeding 24 V.

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.

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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 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 14.2 a) in IEC 60065:2014 and capacitors are checked by the tests for class Y capacitors in IEC 60384-14:2013 including IEC 60384-14:2013/AMD1:2016 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 1 Examples of such enclosures are those representing animals, characters, persons or scale models.

The requirement is not applicable to appliances where there is a toy shaped like the appliance.

NOTE 2 An example of a toy shaped like an appliance is a toy refrigerator.

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.

Compliance is checked by inspection and by applying a force of 30 N to ***accessible surfaces****.*

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.

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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 normative 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****.*

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 back-siphonage 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 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.

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Compliance is checked by inspection.

22.53 **Class II appliances** and **class III appliances** that incorporate functionally earthed parts shall have at least **double insulation** or **reinforced insulation** between **live parts** and the functionally earthed parts.

Compliance is checked by inspection and test.

22.54 Button **cells** and **batteries** designated R1 shall not be accessible without the aid of a **tool** unless the cover of their compartment can only be opened after at least two independent movements have been applied simultaneously.

Compliance is checked by inspection and by manual test.

NOTE **Batteries** are specified in IEC 60086-2.

22.55 Devices that are operated by the user to stop the intended function of the appliance, if any, shall be distinguished from other manual devices by means of shape, or size, or surface texture, or position. This requirement concerning position does not preclude use of a push on push off switch.

An indication when the device has been operated shall be given by:

– tactile feedback from the actuator or tactile feedback from the appliance such as stopping of the vibration on the body of the appliance or of a part of it; or
– reduction in heat output; or
– audible and visible feedback.

The sound of the motor or sound of an actuator switching from on to off is considered as an audible feedback. A switch with a stable **off-position** different from the on-position is considered visual and tactile feedback. The force feedback from the actuator when operating it is considered to be tactile feedback.

Compliance is checked by inspection and by manual test.

22.56 **Detachable power supply part** shall be provided with the part of **class III construction** of the appliance.

Compliance is checked by inspection.

22.57 The properties of non-metallic materials shall not degrade from exposure to UV-C radiation generated from UV sources provided for microbiological control within the appliance such that they no longer comply with this standard. This requirement does not apply to glass, ceramics or similar materials.

Compliance is checked by the conditioning and tests of normative Annex T.

22.58 Appliances connected to the supply mains by an appliance inlet, shall be provided with a cord set or a connector for attachment to a suitable flexible cord.

The requirement is not applicable to:

– appliances connected to the supply mains by an appliance inlet complying with the standard sheets of IEC 60320-3;
– single phase appliances having a **rated current** exceeding 16 A and that are connected to the supply mains by an appliance inlet complying with the standard sheets of IEC 60309-2;

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– multi-phase appliances connected to the supply mains by an appliance inlet complying with the standard sheets of IEC 60309-2;

Compliance is checked by inspection.

22.59 Protective extra-low voltage circuits shall be separated by at least **supplementary insulation** from circuits operating at **safety extra-low voltage**.

NOTE **Supplementary insulation** is not required between **protective extra-low voltage circuits**.

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

22.60 Functional earthing terminals and functional earthing contacts shall not be connected to the neutral terminal.

Compliance is checked by inspection.

22.61 Appliance outlets complying with the standard sheets in IEC 60320-3 accessible to the user and socket-outlets accessible to the user:

– that are incorporated in appliances connected to the supply mains; and
– that operate at **rated voltage**

shall be single-phase with a current rating not exceeding 16 A.

Appliance outlets accessible to the user, other than those intended to supply accessories supplied with the appliance and socket-outlets accessible to the user shall be protected by one of the following **protective devices**, having a current rating not exceeding the current rating of the appliance outlet or socket-outlet:

– a circuit breaker for equipment complying with IEC 60934;
– a non-user replaceable fuse-link.

The **protective device** shall be placed behind a **non-detachable cover**. The actuating member of the circuit breaker may be accessible.

The current rating of appliance outlets and socket-outlets marked with the **outlet load** in watts, is obtained from the marked **outlet load** divided by the **rated voltage**.

Compliance is checked by inspection.

22.62 Remote communication through **public networks** shall not impair compliance with this standard.

The requirement is only applicable to:

a) **remote communication** that includes the download of software or the transmission of data that includes:
   – measures according to normative Annex R necessary for compliance with 22.46; or
   – means necessary for compliance with Clauses 8 to 32 of this standard.

NOTE 1 Examples of such means are constants, algorithms, timers or a downloaded software or parameter set which regulates or limits the maximum normal temperature rises in Clause 11.

NOTE 2 Examples of means which do not affect Clauses 8 to 32 of this standard are the change of speed setting of a range hood fan, operation of a drive to open or close a driven part or change of operational setting of an air conditioner, such as fan speed, heating and cooling temperatures and louver movement.

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b) **remote communication** that includes the download of software or the transmission of data, that only affects that part of the software that is not covered by the above case a), but where compliance with this standard may be impaired due to improper separation or partitioning from the software or data in the above case a).

The requirement is not applicable to appliances:

- where all measures to comply with this standard are independent of software;
- using **remote communication** through **public networks** for the send-only transmission of data; or
- that only provide event driven **messages** or push remote monitoring.

Compliance is checked by inspection of the product, inspection of the technical documentation, and by the requirements and tests in normative Annex U.

22.101 If the **consumable** is a solid item which can be removed from the appliance for replacement or disposal purpose, it shall not burn or ignite the surroundings after use.

*Compliance is checked by visual inspection and by operating with the **consumable** attached to or inserted into the appliance under normal conditions as specified in B.3.1.1. As soon as the **consumable** is consumed and needs to be replaced, it is removed from the appliance in accordance with the manufacturer's instructions and placed on a wooden table which is covered with a layer of wrapping tissue with mass per unit area between 12 g/m^2 and 30 g/m^2. The wrapping tissue shall not burn or ignite.*

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, such as the sheath of a flexible cord complying with IEC 60227, IEC 60245 or IEC 62821, in addition to the insulation of the conductors.

Compliance is checked by inspection and by the following test.

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*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 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 A single layer of internal wiring insulation shall not be used to provide **reinforced insulation**.

For **class II construction**, the sheath of a cord complying with IEC 60227 or IEC 60245 or IEC 62821 may provide **supplementary insulation**.

Insulation of single layer internal wiring that is subjected to the supply mains voltage shall withstand the electrical stress likely to occur in normal use.

Compliance is checked by inspection and as follows.

*The insulation of single layer internal wiring shall be electrically equivalent to the **basic insulation** of cords complying with IEC 60227 or IEC 60245 or IEC 62821 or shall comply with the following electric strength test. If the **basic insulation** of the conductor does not fulfil one of these conditions, the conductor is considered to be bare.*

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.

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.

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23.8 Aluminium wires shall not be used for internal wiring.

The requirement does not apply to windings.

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.

The requirement does not apply to the soldered tip of a stranded conductor.

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 and by the tests specified in Table 6 of IEC 60227-5:2011 reference numbers 1 and 2.

24 Components

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

Compliance with the IEC standard for the relevant component does not necessarily ensure compliance with the requirements of this standard.

Motors are not required to comply with IEC 60034-1. They are tested as part of the appliance according to this standard.

Relays shall be tested as part of the appliance according to this standard. They may be alternatively tested to IEC 60730-1:2013 including IEC 60730-1:2013/AMD1:2015, in which case they must also meet the additional requirements in IEC 60335-1.

Unless otherwise specified, the requirements of Clause 29 of this standard apply between **live parts** of components and **accessible parts** of the appliance. Unless otherwise specified, components may comply with the requirements for **clearances** and **creepage distances** for **functional insulation** as specified in the relevant component standard.

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 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.

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 pre-selection alternatives in 30.2 are used, the test report for the component states the values of t_E and t_i as required by IEC 60695-2-11:2014.

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If the above two conditions are not satisfied, the component is tested as part of the appliance.

NOTE 1 There are two levels of severity specified for appliances for which 30.2.3 is applicable.

Power electronic converter circuits are not required to comply with IEC 62477-1. They are tested as part of the appliance according to 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 2 For automatic controls, marking includes documentation and declaration as specified in Clause 7 of IEC 60730-1:2013/AMD1:2015.

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.

Unless they are specifically mentioned in the text of this standard, there are no additional tests specified for nationally standardized plugs such as those detailed in IEC TR 60083 or connectors or plug connectors complying with the standard sheets of IEC 60320-3 or connectors complying with the standard sheets of IEC 60309-2.

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 60384-14:2013 including IEC 60384-14:2013/AMD1:2016.*

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 normative Annex F.

24.1.2 *The relevant standard for transformers in associated switch mode power supplies is Annex BB of IEC 61558-2-16:2009 including IEC 61558-2-16:2009/AMD1:2013. Clause 26 of IEC 61558-1:2017 and Annex H of IEC 61558-1:2017 are not applicable.*

The relevant standard for ***safety isolating transformers*** *is IEC 61558-2-6:2009. If they have to be tested, they are tested in accordance with normative Annex G.*

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24.1.3 *The relevant standard for switches is IEC 61058-1:2016. The number of cycles of operation declared for 7.4 of IEC 61058-1:2016 shall be at least 10 000. If they have to be tested, they are tested in accordance with normative Annex H.*

The number of operating cycles for switches need not be declared for 7.4 if the appliance meets the requirements of this standard when they are rendered inoperative.

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 60730-1:2013 including IEC 60730-1:2013/AMD1:2015 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 60730-1:2013 including IEC 60730-1:2013/AMD1:2015 together with the relevant part 2.*

The number of cycles of operation declared for 6.10 and 6.11 of IEC 60730-1:2013 including IEC 60730-1:2013/AMD1:2015 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*
– *timers*	*3 000*
– *energy regulators*	*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 or rendered inoperative.

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 60730-1:2013 including IEC 60730-1:2013/AMD1:2015 as type 1 controls. The tests of Clauses 12, 13 and 14 of IEC 60730-1:2013 including IEC 60730-1:2013/AMD1:2015 are not carried out before carrying out the test of Clause 17.

The ambient temperature during the test of Clause 17 of IEC 60730-1:2013 including IEC 60730-1:2013/AMD1:2015 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 normative 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 60730-2-8:2018 shall be IPX7.*

Thermal cut-outs *of the capillary type shall comply with the requirements for type 2.K controls in IEC 60730-2-9:2015 including IEC 60730-2-9:2015/AMD1:2018.*

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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.*

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 60730-1:2013 including IEC 60730-1:2013/AMD1:2015 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.*

24.1.10 *Lamps and lamp systems that have not been previously tested and found to comply with the exempt group classification of IEC 62471:2006 general lighting systems (GLS) regarding actinic ultraviolet hazard (E_S) and near-UV hazard (E_{UVA}) are tested as a part of the appliance and shall comply with the requirements of Clause 32 under the conditions occurring in the appliance.*

Unless otherwise specified, the following components are considered to comply with the exempt group classification of IEC 62471:2006 regarding actinic ultraviolet hazard (E_S) and near-UV hazard (E_{UVA}):

- *visible light indicators;*
- *infrared sources used for signalling or communication;*
- *seven-segment indicators;*
- *liquid-crystal displays;*
- *organic LED displays (OLED);*
- *plasma displays.*

24.1.11 *For cord sets required to be provided with the appliance, the relevant standard is IEC 60799. Cord sets with cords complying to IEC 62821-3 are allowed.*

24.2 Appliances shall not be fitted with:

- switches, automatic controls, power supplies and the like 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 61058-1:2016, between the supply mains and those parts that are intended to be disconnected.

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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, appliance inlets, plug connectors and appliance outlets complying with the standard sheets of IEC 60320-3.

Compliance is checked by inspection.

24.5 Capacitors in auxiliary windings of motors shall be marked with their voltage rating 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 voltage rating.*

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 normative Annex I.

Compliance is checked by measurement and by the tests of normative 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 S2 or S3 according to IEC 60252-1:2010 including IEC 60252-1:2010/AMD1:2013;
– 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 can 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 normative 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.

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For capacitors complying with IEC 60252-1:2010 including IEC 60252-1:2010/AMD1:2013, the damp heat test severity parameters for 5.14 of IEC 60252-1:2010 including IEC 60252-1:2010/AMD1:2013 shall be:

– temperature 40 °C ± 2 °C at a relative humidity of 93 % ± 3 %;
– duration 21 days.

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, the current rating and voltage rating of the plug being not less than the corresponding ratings of its associated appliance;
– 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 can 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:

– cord anchorage and a set of terminals allowing the connection of a flexible cord;
– 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

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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.

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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).

These **supply cords** shall not be used on 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).

These **supply cords** may be connected to appliances intended to be used in low temperature applications.

– Polyvinyl chloride sheathed

These **supply 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 **supply 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.

– Halogen-free, low smoke, thermoplastic insulated and sheathed

Their properties should at least be those of:

- light duty halogen-free low smoke flexible cable (code designation 62821 IEC 101 for circular cable and code designation 62821 IEC 101f for flat cable);
- ordinary duty halogen-free, low smoke flexible cable (code designation 62821 IEC 102 for circular cable and code designation 62821 IEC 102f for flat cable).

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.

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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	≤2,5	0,5 a
>2,5	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 nominal length does not exceed 2 m between the point where the cord 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.

In multi-phase appliances, the colour of the neutral conductor of the **supply cord**, if any, shall be blue.

Where additional neutral conductors are provided in the **supply cord**:

– other colours may be used for these additional neutral conductors;
– all of the neutral conductors and line conductors shall be identified by marking using the alphanumeric notation specified in IEC 60445;
– the **supply cord** shall be fitted to the appliance.

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.

The requirement does not apply to the soldered tip of a stranded conductor.

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.

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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. If it is not evident from the construction of the appliance that the **supply cord** can be introduced without risk of damage, 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.

This requirement does not apply to appliances with automatic cord reels that comply with the requirement and test of 22.16.

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 mm^2;*
- *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. A flexing is one movement of 90°. The rate of flexing is 60 per minute.*

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 or functional 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.*

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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 at a distance of approximately 20 mm from the cord anchorage or other suitable point. The mark is made while the cord is subjected to a pull force of:

– *100 N, for **fixed appliances** regardless of the mass of the appliance;*
– *the value as shown in Table 12, for other appliances.*

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 *kg*	***Pull force*** *N*	***Torque*** *Nm*
≤ 1	*30*	*0,10*
>1 and ≤ 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. However, this does not apply 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, even if the clamping member can be removed from the studs;
  - 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;

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NOTE 1 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.

– 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 2 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 conductors of the **supply cord** for **type Y attachment** and **type Z attachment** shall be 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.

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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. The cord anchorage may be used to provide the clamping.*

*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 flexible cord of the cord set 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 10 and not by the **rated current** of the appliance. If the measured current in the **interconnection cord** is greater than the **rated current** but does not exceed the **rated current** by more than the current deviation in Table 2, the cross-sectional area of the conductors in the **interconnection cord** do not need to be greater than the cross-sectional area of the conductors in the **supply cord**;

– the thickness of the insulation of the conductor may be reduced if the voltage of the conductor is less than the **rated voltage**;

– for **class III construction**, **interconnection cords** of a **class I appliance or class II appliance**, the cross-sectional areas of the conductors need not comply with 25.8 if the temperature of the cord insulation specified in Table 3 and Table 9 are not exceeded during the tests of Clause 11 and Clause 19, respectively.

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.

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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, such as male tabs of flat quick-connect terminations in accordance with IEC 61210, 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 60999-1:1999, for the connection of external conductors. The terminals of a component such as a switch may also be used as terminals for external conductors as long as they comply with the requirements of this clause.

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 and functional 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.

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;

– 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 60999-1:1999, the torque applied being equal to two-thirds of the torque specified.

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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. Reshaping of the conductor before its introduction into the terminal or twisting a stranded conductor to consolidate the end is not considered special preparation.

The terminals 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.

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.

*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.

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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**, including metal parts behind a decorative cover that does not withstand the test of 21.1, of **class 0I appliances** and **class I appliances** that may become live in the event of a failure of **basic insulation**, shall be permanently and reliably connected to an earthing terminal within the appliance or to the earthing contact of the appliance inlet.

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 protective 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.

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Terminals for the connection of external equipotential bonding conductors shall allow the connection of conductors having nominal cross-sectional areas of 2,5 mm^2 to 6 mm^2 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 The terminal for the earthing conductor in a **supply cord** is not a terminal for external equipotential bonding conductors.

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 processed by cold forming, 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.

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

NOTE 1 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 2 Parts subjected to a treatment such as chromate conversion coating are in general not considered to be adequately protected against corrosion, but they can 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.

In case of doubt, the thickness of the coating is measured as described in ISO 2178 or in ISO 1463.

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.

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A current derived from a source having a no-load voltage not exceeding 12 V (AC or DC) 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 test is carried out until steady conditions have been established.*

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. The resistance of the* ***supply cord*** *is not included in the resistance calculation.*

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.

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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;*
- *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.

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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 shall 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 by means such as spring washers, lock washers and crown type locks as part of the screw head, if they also make electrical connections or connections providing earthing continuity. Sealing compound that softens on heating may also be used to provide security against loosening but only for screw connections not subject to torsion in normal use.

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

Rivets used for electrical connections or for connections providing earthing continuity shall be secured against loosening if these connections are subject to torsion in normal use. A rivet having a non-circular shank or an appropriate notch may be used to secure against loosening if these connections are subject to torsion in normal use.

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

Compliance is checked by inspection and by manual test.

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 that are carried out separately.

*If coatings are used on printed circuit boards to protect the microenvironment (type 1 protection) or to provide **basic insulation** (type 2 protection), normative 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 60664-3:2016. These values apply to **functional insulation**, **basic insulation**, **supplementary insulation** as well as **reinforced insulation**.*

NOTE The requirements and tests are based on IEC 60664-1:2007 from which further information can be obtained.

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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.

For appliances intended for use at altitudes exceeding 2 000 m, the **clearances** in Table 16 shall be increased according to the altitude correction factor in Table A.2 of IEC 60664-1:2007.

If the construction is such that the distances could be affected by any of the following:

– distortion;
– movement of parts;
– assembly of parts;
– wear of **basic insulation**;
– wear of **functional insulation**,

the impulse voltage test is not applicable and the **clearances** for **rated impulse voltages** of 1 500 V and above specified in Table 16 are increased by 0,5 mm.

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**; or
– to appliances intended for use at altitudes exceeding 2 000 m.

Appliances are in overvoltage category II.

NOTE 1 Informative Annex K gives information regarding overvoltage categories.

Table 15 – Rated impulse voltage

Rated voltage[a] 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 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.			
[a] For multi-phase appliances, the line to neutral or line to earth voltage is used for **rated voltage**.			

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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
NOTE If the **rated impulse voltage** is not specified in the table, **clearances** for intermediate values of Table 16 can be determined by interpolation.	
[a] The distances specified apply only to **clearances** in air. [b] The smaller **clearances** specified in IEC 60664-1:2007 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 2 The way in which **clearances** are measured is specified in IEC 60664-1:2007.

NOTE 3 The procedure for assessing **clearances** is given in informative Annex L.

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.

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 in Table 16.

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Compliance is checked by measurement.

29.1.3 **Clearances** of **reinforced insulation** shall be not less than those specified 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 60664-1:2007 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 60664-4:2005 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 60664-1:2007 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 60664-4:2005 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 **clearances** applied for **basic insulation** are selected from Table F.7a of IEC 60664-1:2007 or Clause 4 of IEC 60664-4:2005, 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 60664-1:2007, 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**.

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If the **clearances** applied for **basic insulation** are selected from Clause 4 of IEC 60664-4:2005, 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.

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 line 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 informative Annex M.

Compliance is checked by measurement.

NOTE 3 The way in which **creepage distances** are measured is specified in IEC 60664-1:2007.

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 60664-1:2007, 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 60112:2003 including IEC 60112:2003/AMD1:2009 using solution A. If the CTI value of the material is unknown, a proof tracking index (PTI) test in accordance with normative Annex N is carried out at the CTI values specified, in order to establish the material group.

NOTE 4 The procedure for assessing **creepage distances** is given in informative Annex L.

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*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 60664-4:2005. 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.

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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** for **basic insulation** in other than a **double insulation** construction 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** can be found by interpolation.

[a] Material group IIIb is allowed if the **working voltage** does not exceed 50 V.

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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, excluding its NOTE 1 and NOTE 2, or Table 2 of IEC 60664-4:2005, as applicable.

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, excluding its NOTE 1 and NOTE 2, or Table 2 of IEC 60664-4:2005, as applicable.

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 60664-4:2005. 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[a]						
			1	2			3		
				Material group			Material group		
				I	II	IIIa/IIIb	I	II	IIIa/IIIb [b]
		≤ 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 [c]			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 **working voltages** > 10 V and ≤ 630 V, if the voltage is not specified in the table, the values of **creepage distances** can be found by interpolation.

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[a]	For tracks on printed wiring boards under pollution degree 1 and pollution degree 2 conditions, the values specified in Table F.4 of IEC 60664-1:2007 apply. For voltages less than 100 V, the values shall not be less than those specified for 100 V.
[b]	Material group IIIb is allowed if the **working voltage** does not exceed 50 V.
[c]	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*
- *for insulation, other than single layer internal wiring insulation, 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*
- *by an assessment of the thermal quality of the material according to 29.3.3 combined with an electric strength test in accordance with 23.5, for each single layer internal wiring insulation touching each other, or*
- *as specified in Subclause 6.3 of IEC 60664-4:2005 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.*

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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 60664-1:2007 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;

– those parts of coil formers that do not support or retain terminals in position;

– parts of ceramic material.

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 °C ± 2 °C plus the maximum temperature rise determined during the test of Clause 11, but it shall be at least:

– *75 °C ± 2 °C, for external parts;*

– *125 °C ± 2 °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 °C ± 2 °C plus the maximum temperature rise determined during the tests of Clause 19, if this is higher. The temperature rises obtained during the tests of 19.4 and 19.5 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 The selection and sequence of tests for resistance to heat are shown in Figure O.1 of informative Annex O.

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.

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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 parts of the appliance that are connected to the supply mains during the charging period, 30.2.3 applies.

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 60695-2-11:2014, 4.3.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 Figure O.2 to Figure O.4 of informative Annex O.

30.2.1 *Parts of non-metallic material are subjected to the glow-wire test of IEC 60695-2-11:2014, 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 ± 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.

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, such as switch contacts and similar contacts in other components and parts of non-metallic material within a distance of 3 mm of such connections are subjected to the glow-wire test of IEC 60695-2-11:2014.*

The tip of the glow-wire should be applied to the part in the vicinity of the connection.

The test severity is:

– *750 °C, for connections that carry a current exceeding 0,5 A during **normal operation**,*
– *650 °C, for other connections.*

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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 60695-2-11:2014 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.

However, the glow-wire test of IEC 60695-2-11:2014 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 60695-2-11:2014 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 normative 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 ± 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.

The glow-wire test of IEC 60695-2-11:2014 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 Some applications of the term "within a distance of 3 mm" are shown in Figure O.5 of informative Annex O.

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 of informative Annex O.

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30.2.3.1 *Parts of non-metallic material supporting connections, such as switch contacts and similar contacts in other components, 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 60695-2-11:2014 with a test severity of 850 °C.*

The tip of the glow-wire should be applied to the part in the vicinity of the connection.

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 60695-2-11:2014 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.

However, the glow-wire test of IEC 60695-2-11:2014 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 ± 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.

30.2.3.2 *Parts of non-metallic material supporting connections, such as switch contacts and similar contacts in other components and parts of non-metallic material within a distance of 3 mm of such connections are subjected to the glow-wire test of IEC 60695-2-11:2014.*

The tip of the glow-wire should be applied to the part in the vicinity of the connection.

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 60695-2-11:2014 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.

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 ± 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.

If the glow-wire flammability index (GWFI) is not available for a sample with a thickness within ± 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.

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*The glow-wire test of IEC 60695-2-11:2014 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 normative 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 normative 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 60695-2-11:2014 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 normative Annex E was applied; or*

– ***small parts** for which a material classification of V-0 or V-1 was applied.*

NOTE 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*

– *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*

– *shielded by a flame barrier that meets the needle-flame test (NFT) of normative 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.*

*There shall be no **battery** in the area of the vertical cylinder used for the consequential needle flame test, unless the **battery** is shielded by a barrier that meets the needle flame test of normative 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 normative 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 can 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 normative Annex E is not carried out on:

– *printed circuit boards of low-power circuits described in 19.11.1;*

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– *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.*
– *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.

Unless otherwise specified in the relevant part 2, the appliance is deemed to comply with the requirement without testing.

32 Radiation, toxicity and similar hazards

32.1 Appliances shall not emit harmful radiation or present a toxic or similar hazard due to their operation in normal use.

Unless otherwise specified in the relevant part 2, the appliance is deemed to comply with the requirement without testing.

32.2 Appliances shall not present an optical radiation hazard due to their operation in normal use.

This requirement does not apply to lamps and lamp systems that comply with 24.1.10.

*Compliance is checked as follows with the appliance supplied at **rated voltage**.*

Radiation assessment is performed at or recalculated to 200 mm distance or at the fixed use distance indicated in the instructions for use, following the measurement procedure described in IEC 62471:2006.

If a lamp or lamp system is intended to illuminate objects, it shall be assessed at the GLS assessment distance which produces a luminance of 500 lux as described in IEC 62471:2006.

The appliance shall comply with the exempt group classification requirements of IEC 62471:2006 regarding actinic ultraviolet hazard (E_S) and near-UV hazard (E_{UVA}).

NOTE To avoid errors associated with low signal to noise ratio from spectroradiometers, handheld radiometers with specialized detectors sensitive to either the actinic UV or UV-A region can be used for these measurements.

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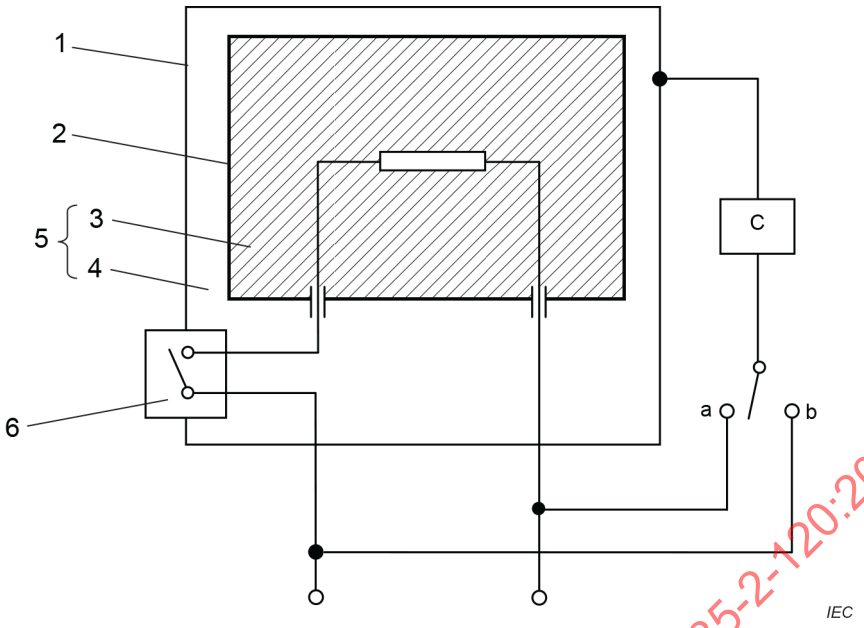

Key

C circuit of Figure 4 of IEC 60990:2016

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 and for parts of class II construction

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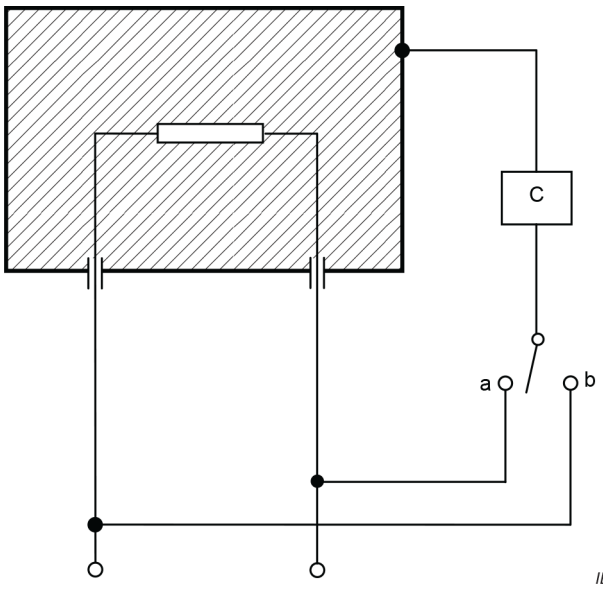

Key

C circuit of Figure 4 of IEC 60990:2016

NOTE For **class 0I appliances** and **class I appliances**, C can be replaced by a low impedance ammeter responding to the **rated frequency** of the appliance.

Figure 2 – Circuit diagram for leakage current measurement at operating temperature for single-phase connection of other than class II appliances or parts of class II construction

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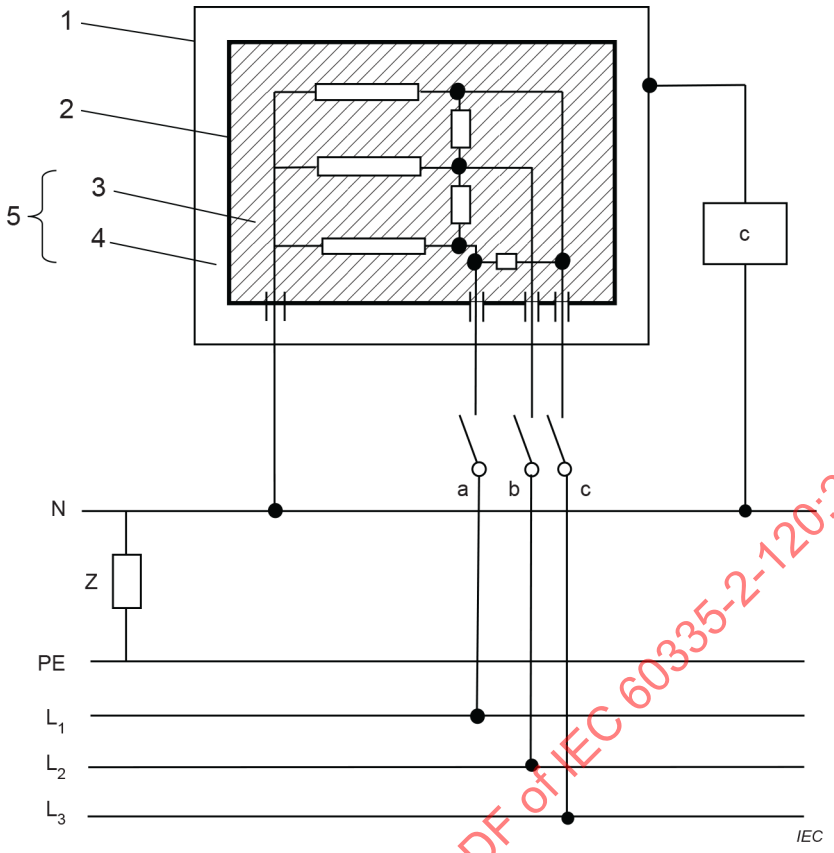

Key

C circuit of Figure 4 of IEC 60990:2016

1 **accessible part**

2 inaccessible metal part

3 **basic insulation**

4 **supplementary insulation**

5 **double insulation**

Connections and supplies

L_1, L_2, L_3, N supply voltage with neutral

PE protective earth conductor

Z IT system neutral to earth high impedance

NOTE If the test laboratory is supplied from a TN or TT distribution system, then Z will be zero. Consequently, always connecting "C" to the neutral conductor will ensure reproducibility of the test result regardless of the type of distribution system (TN, TT or IT) used by the test laboratory and will cover the most onerous condition likely to be encountered during normal use of the appliance.

Figure 3 – Circuit diagram for leakage current measurement at operating temperature for three-phase with neutral class II appliances and for parts of class II construction

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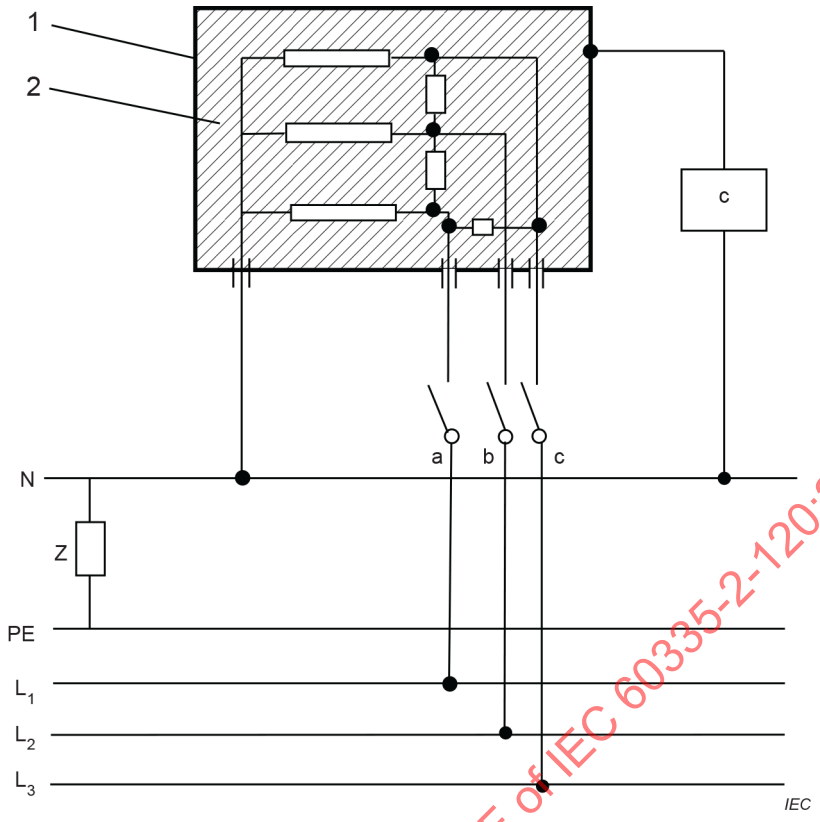

Key		Connections and supplies	
C	circuit of Figure 4 of IEC 60990:2016	L_1, L_2, L_3, N	Supply voltage with neutral
1	**accessible part**	PE	protective earth conductor
2	**basic insulation**	Z	IT system neutral to earth high impedance

NOTE 1 For **class 0I appliances** and **class I appliances**, C can be replaced by a low impedance ammeter responding to the **rated frequency** of the appliance.

NOTE 2 If the test laboratory is supplied from a TN or TT distribution system,< then Z will be zero. Consequently, always connecting "C" to the neutral conductor will ensure reproducibility of the test result regardless of the type of distribution system (TN, TT or IT) used by the test laboratory and will cover the most onerous condition likely to be encountered during normal use of the appliance.

Figure 4 – Circuit diagram for leakage current measurement at operating temperature for three-phase with neutral appliances other than those of class II or parts of class II construction

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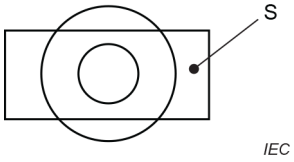
a) Example of a **small part**

b) Example of a **small part**



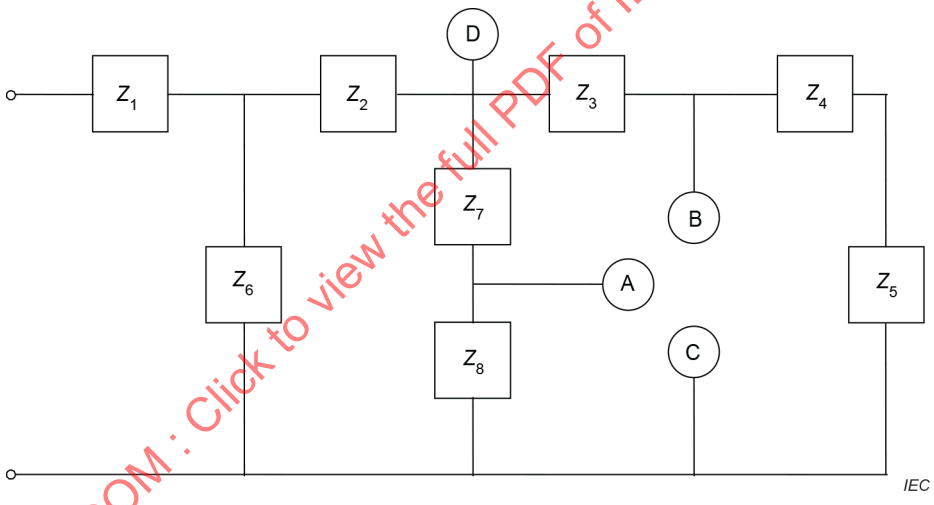
c) Example of a part that is not a **small part**

Key

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 Z_1, Z_2, Z_3, Z_6 and Z_7, where applicable.

Figure 6 – Example of an electronic circuit with low-power points

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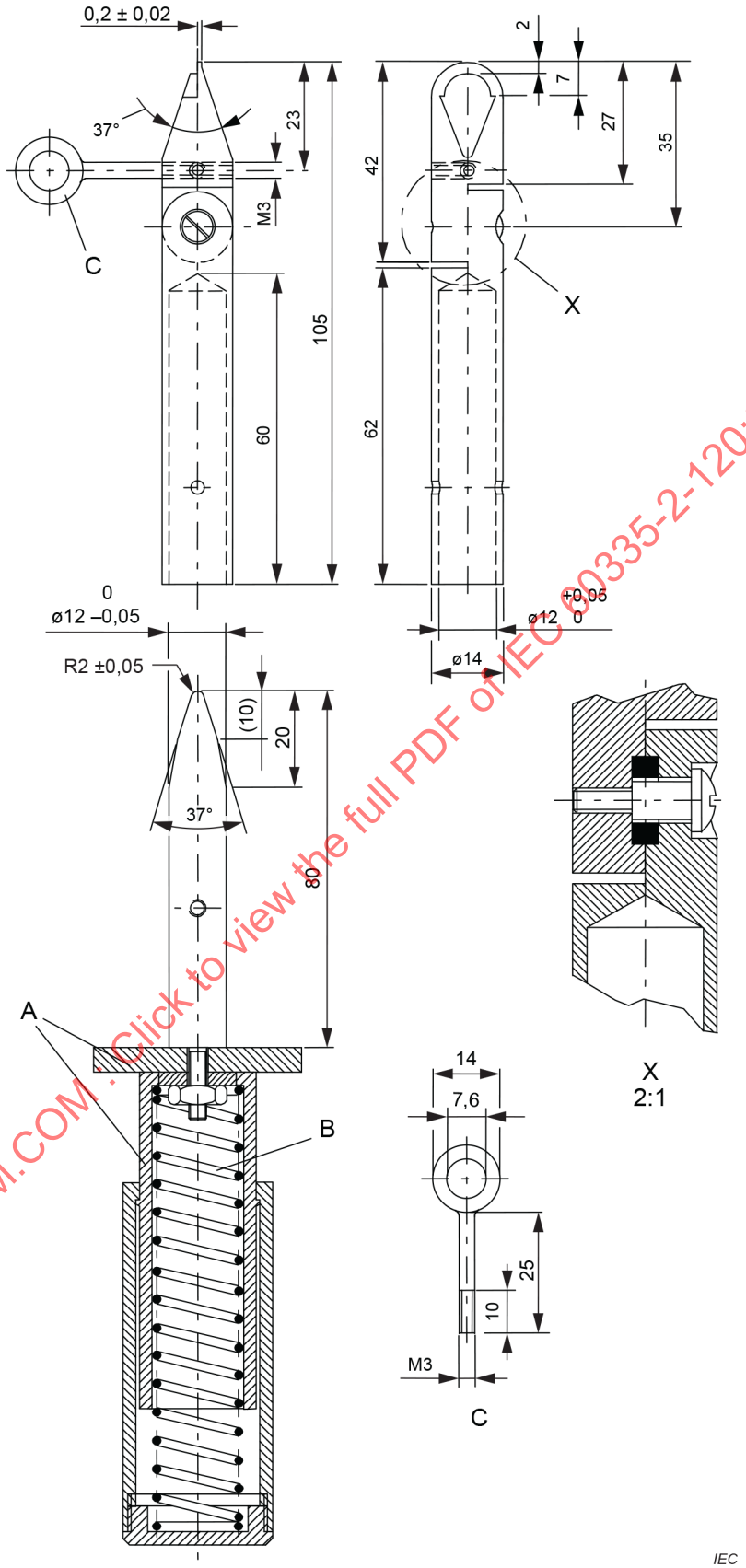
Dimensions in millimetres



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

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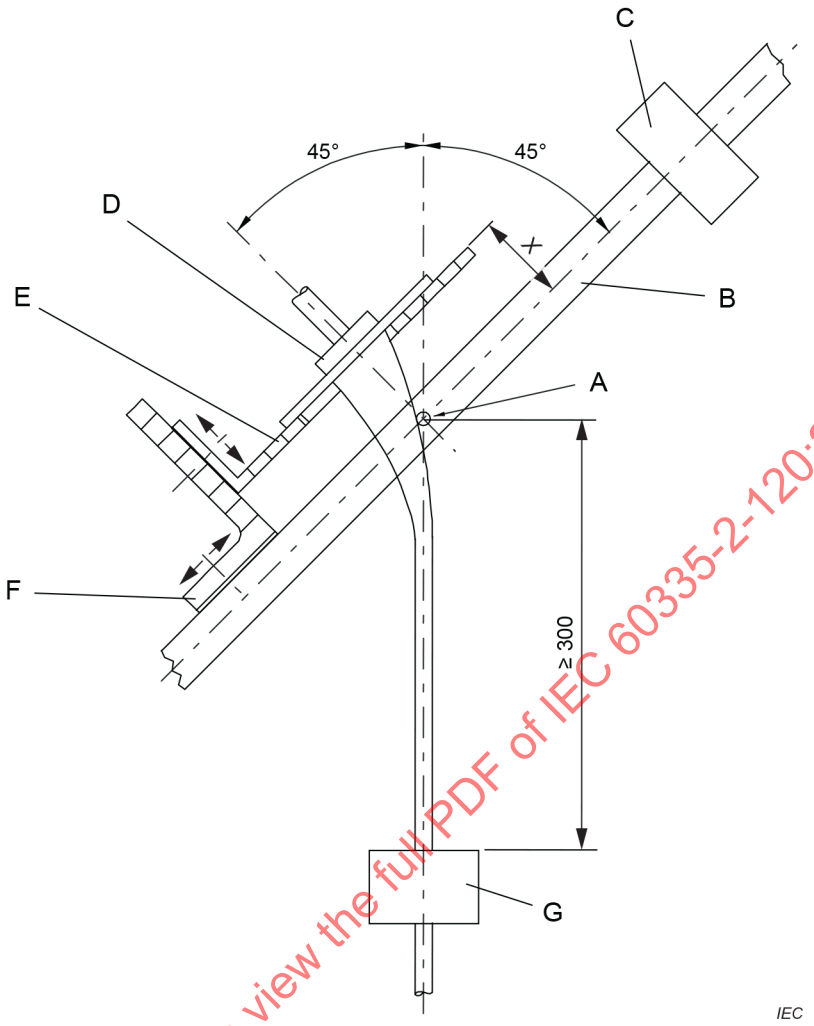
Dimensions in millimetres



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

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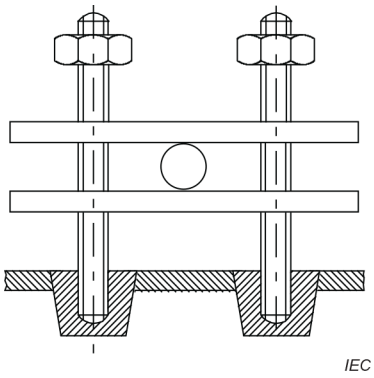
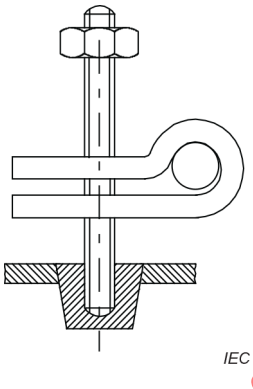
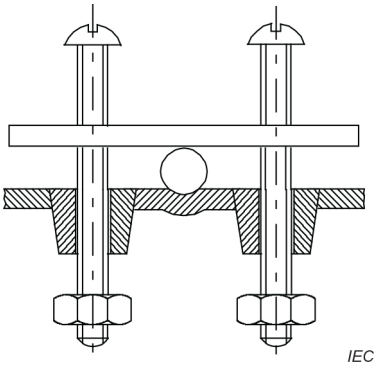
ACCEPTABLE CONSTRUCTIONS

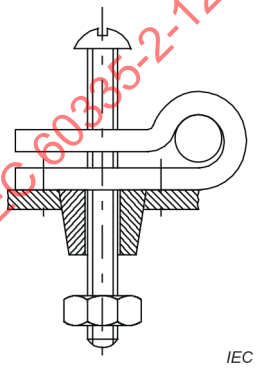




Construction showing studs securely attached to the appliance



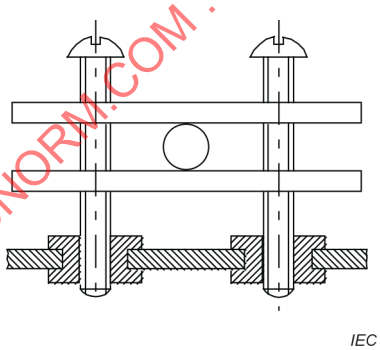
Construction showing part of appliance of insulating material and so shaped that it obviously forms part of a cord clamp.

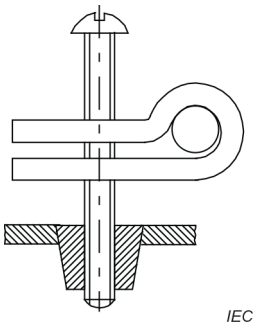


Construction showing one of the clamping members is fixed to the appliance

NOTE 1 Clamping screws can 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 2 Clamping screws can screw into threaded holes in the appliance or pass through holes where they are secured by nuts.

Figure 9 – Constructions of cord anchorages

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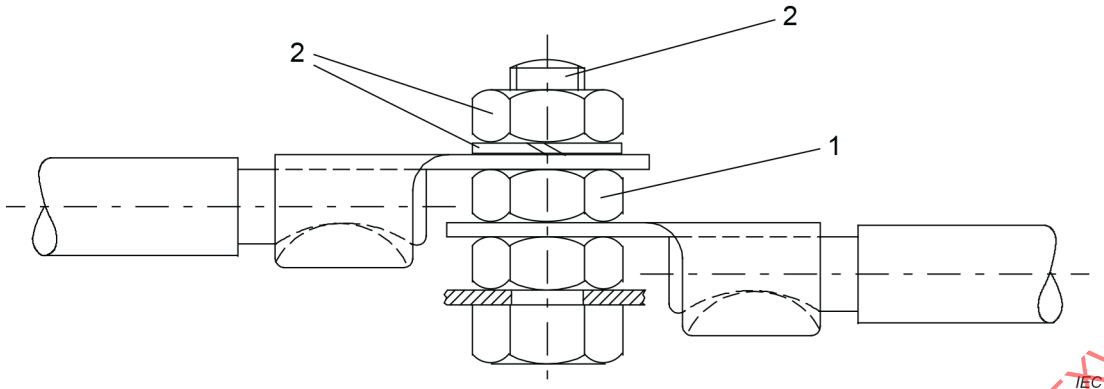

Key

1 part providing earthing continuity

2 part providing or transmitting contact pressure

Figure 10 – An example of parts of an earthing terminal

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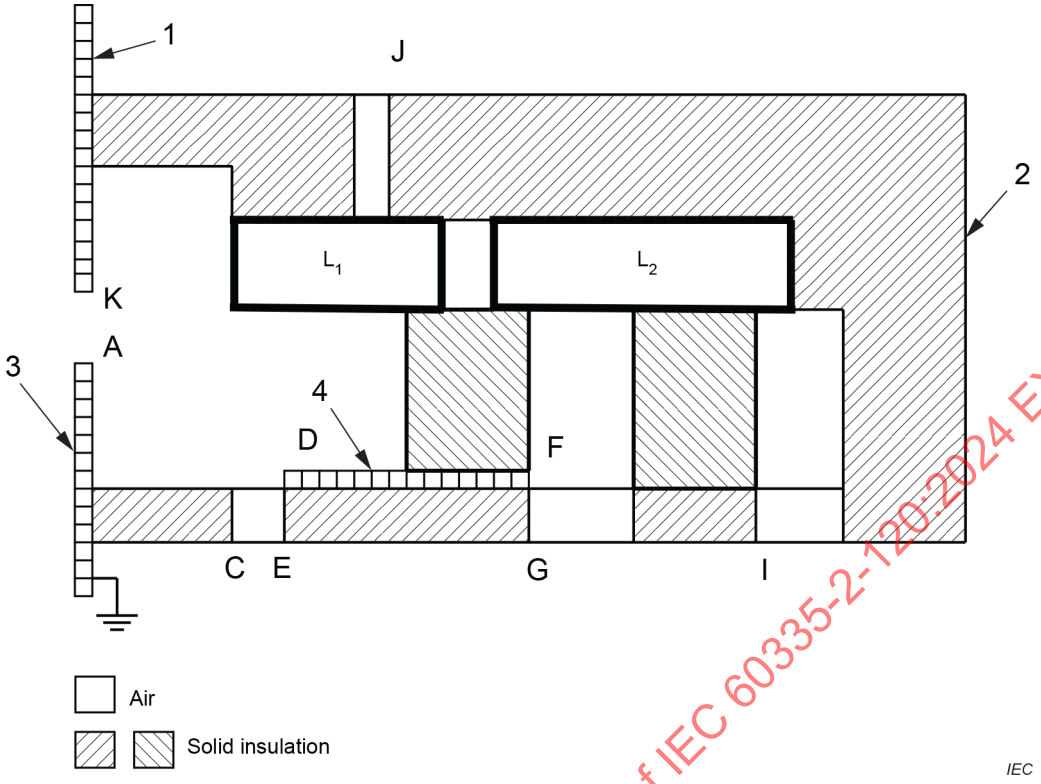

Key

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

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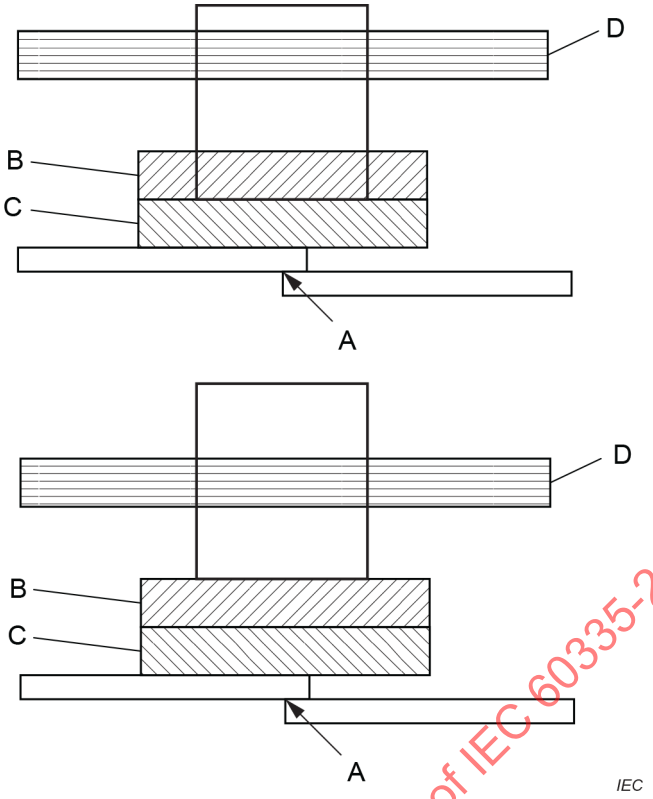

Key

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

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Dimensions in millimetres

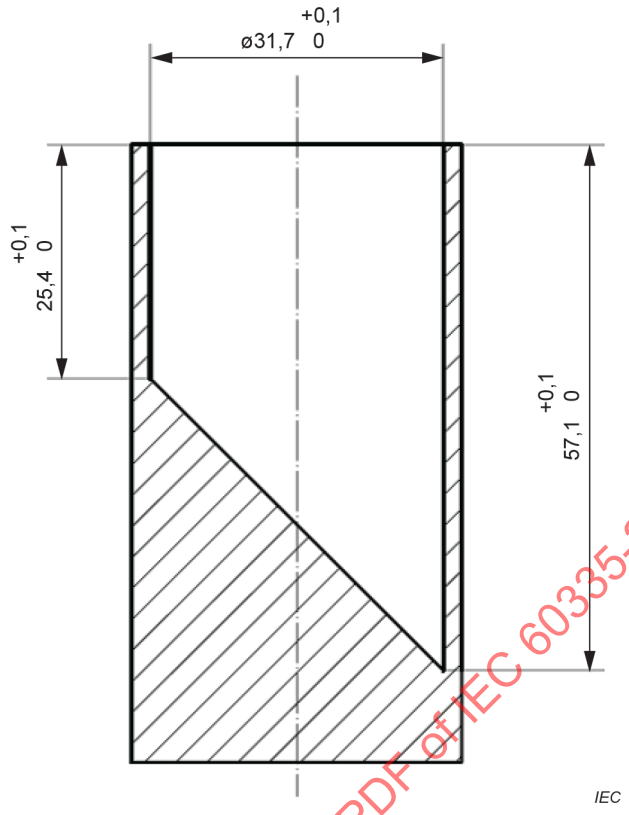

Figure 13 – Small parts cylinder

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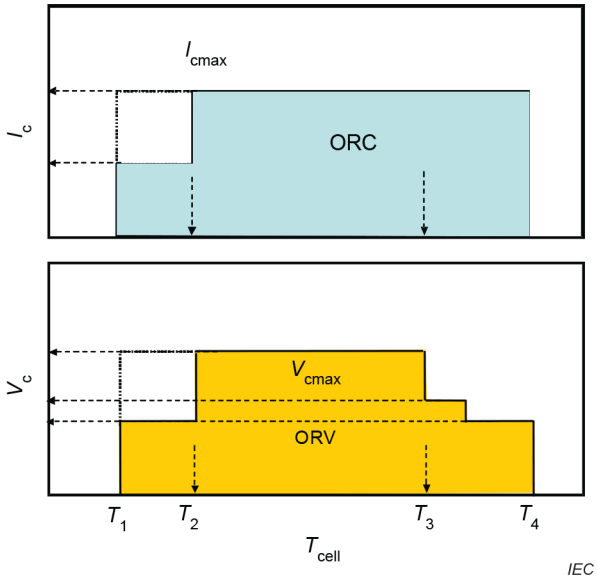

Key

T_1 to T_2	low temperature range
T_2 to T_3	standard temperature range
T_3 to T_4	high temperature range
ORC	operating region (current)
I_{cmax}	maximum charging current
I_c	charging current
ORV	operating region (voltage)
V_{cmax}	**upper limit charging voltage**
V_c	charging voltage
T_{cell}	cell surface temperature

Figure 14 – Example of a specified operating region of a lithium-ion cell during charging

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Annex A
(informative)

Routine tests

A.1 Overview

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.

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.2 Earth continuity test

A current of at least 10 A, derived from a source having a no-load voltage not exceeding 12 V (AC or DC), 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;*

– *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****;*

– *other appliances, 0,1 Ω.*

The duration of the current flow is that required to enable the voltage drop to be measured.

A.3 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.

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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*	*800*	*1 000*	*400*
• ***double** or **reinforced insulation*** [a, b]	*2 000*	*2 500*	–

[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.*

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.

Instead of being subjected to an AC voltage, the insulation may be subjected to a DC voltage of 1,5 times the value shown in the table. An AC voltage having a frequency up to 5 Hz is considered to be a DC voltage.

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.

The circuit used for the test should incorporate a current sensing device that trips when the current exceeds the limit. The high voltage transformer should be capable of maintaining the specified voltage at the limiting current.

A.4 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**.

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Annex B
(normative)

Battery-operated appliances, separable batteries and detachable batteries for battery-operated appliances

The following modifications to this standard are applicable to:

– **battery-operated appliances** and remote controls employing **non-rechargeable batteries** (primary **batteries**);

– **battery-operated appliances** and remote controls employing **batteries** that are rechargeable (secondary **batteries**);

– **detachable batteries** and **separable batteries** for **battery-operated appliances**.

The clause numbers in this Annex refer to the clause numbers in the main part of this standard that are modified or not applicable. Clauses that are additional to the clauses in the main part of this standard are identified by adding the Annex letter with the numbering starting at 1.

NOTE 1 This annex does not apply to battery chargers (IEC 60335-2-29) (See Figure B.1 e). When used in conjunction with the word charger, battery is not a defined term so is not bolded.

NOTE 2 When supplied in parts, the complete appliance is the **detachable power supply part**:

– plus the part of the appliance containing the **battery** and the **battery** charging circuitry (Figure B.1 b);

– with the **battery** charging circuitry plus the part of the appliance containing the **battery** (see Figure B.1 c and d); or

– with the **battery** charging circuitry plus the **separable battery** and the part of the appliance performing the intended function (see Figure B.1 f).

An overview on the different configurations is given in Figure B.1.

NOTE 3 As the requirements in this annex are based on **battery systems** that use lithium-ion chemistry, other metal-ion and newer chemistries can have characteristics and performance not fully contemplated by these requirements or those of the referenced **battery** standard.

3 Terms and definitions

B.3.1 Definitions relating to physical characteristics

B.3.1.1
normal operation
battery-operated appliances are operated under the following conditions:

– for appliances operated with **detachable batteries** or **separable batteries** that are disconnected from the appliance for charging purposes, the appliance is operated to perform its intended function with a **battery** that is **fully charged**. The **battery** being the model or type reference of the **battery** provided or indicated in the instructions;

– for appliances operated with **integral batteries** or **separable batteries** not disconnected from the appliance for charging purposes, and that cannot perform their intended function while the **batteries** are being charged, the appliance is operated to perform its intended function with a **battery** that is **fully charged**;

– for appliances operated with **batteries** that are replaceable, including **integral batteries** that are replaceable, or **non-rechargeable batteries**, the appliance is operated to perform its intended function with the artificial source described in B.5.3 with the specified upper limit short circuit current capacity I_{sc} (high) as indicated in Table B.1.

Note 1 to entry: Operation of the appliance to perform its intended function is specified in the relevant part 2.

*Before the test, the appliance is assembled or filled with the **consumable** and activated according to the manufacturer's procedures.*

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B.3.6 Definitions relating to parts of an appliance

B.3.6.1
non-rechargeable battery
battery that is supplied in a **fully charged** state and cannot be recharged thereafter

5 General conditions for the tests

5.2 *The tests of subclauses B.19.1 to B.19.6 may be carried out on separate samples.*

5.8.1 This subclause is not applicable.

5.8.2 This subclause is not applicable.

5.8.3 This subclause is not applicable.

5.8.4 This subclause is not applicable.

B.5.1 *Before starting a test requiring a **battery** that is **fully charged**, the **battery** shall be **fully charged** and then shall be disconnected from the charging source and allowed to rest for at least 2 h but no more than 6 h.*

B.5.2 *Whenever a **rated voltage** is specified, a **battery** that is **fully charged** shall be used.*

*For **battery-operated appliances**, where the supply terminals for the connection of the **battery** have no indication of polarity, the more unfavourable polarity shall be applied unless such a connection is unlikely to occur due to the construction of the appliance.*

B.5.3 *Where it is specified in the requirements that the **battery** provided with or intended for the appliance may be replaced with an artificial source, that source shall consist of a DC power supply or a specially constructed **battery**, the output of each having the characteristics described in Table B.1 for the relevant **battery** type.*

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Table B.1 – Artificial source characteristics

Battery type	***Initial open circuit voltage*** *V* ***± 10 %***	***I_{sc} [a] (low)*** *A* ***+0 %*** ***−25 %***	***I_{sc} [a] (high)*** *A* ***+25 %*** ***−0 %***	***Minimum capacity*** *Ah* [c]	***(Informative) IEC References*** [b]
Rechargeable	***Fully-charged battery*** *voltage*	*0,5 × I_{sc} of* ***battery*** *provided*	*2,0 × I_{sc} of* ***battery*** *provided*	*300 % of capacity of* ***battery*** *provided measured at 1 A and 0,9 V/**cell** cut-off*	
Non-rechargeable AAA[d]	*1,5*	*3*	*10*	*0,5*	*LR03*
Non-rechargeable AA[d]	*1,5*	*5*	*15*	*1,0*	*LR6*
Non-rechargeable C[d]	*1,5*	*5*	*15*	*3,0*	*LR14*
Non-rechargeable D[d]	*1,5*	*6*	*20*	*10*	*LR20*
Non-rechargeable PP3[d] *(9 V)*	*9,0*	*0,6*	*6*	*0,5*	*6LR61*
Non-rechargeable (other)	*Nominal* ***battery*** *voltage*	*0,5 × I_{sc} of* ***battery*** *provided*	*2,0 × I_{sc} of* ***battery*** *provided*	*200 % of capacity of* ***battery*** *provided measured at 1 A and 0,9 V/**cell** cut-off*	-

NOTE 1 *I_{sc} limits are specified for those **batteries** likely to be replaced with others of the same type but of differing performance.*

NOTE 2 *The specified Ah values are based upon nominal 1 A discharge current with a 0,9 V/**cell** end-of-discharge voltage except for PP3 (9 V), which is based upon 0,1 A discharge current with a 0,9 V/**cell** end-of-discharge voltage.*

NOTE 3 As used in this table, "provided" means either the **battery** that is provided with the appliance or, if not provided, the **battery** that is intended or specified to be used with the appliance.

[a] *The short circuit current is measured after 1 s ± 0,2 s into a resistance of 10 mΩ ± 2 mΩ. Care shall be taken to ensure that self-heating of the resistance is managed to minimize the variability on the current during the tests.*

[b] *References are taken from IEC 60086-1.*

[c] *If the measured capacity is less than 50 % of the capacity specified by the **battery** manufacturer, calculation of minimum capacity shall be based on the capacity specified by the **battery** manufacturer instead of measurement.*

[d] *The non-rechargeable types specified are for alkaline types only.*

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6 Classification

6.1 Battery-operated appliances without a supply connection or a functional earth connection are not classified with respect to protection against electric shock.

NOTE Potential for electric shock hazard is considered to exist only between parts of opposite polarity with no reference to earth.

Compliance is checked by inspection and the relevant tests.

7 Marking and instructions

7.1 Battery-operated appliances and remote controls containing **batteries** shall be marked with the:

– name, trade mark or identification mark of the manufacturer or responsible vendor;
– model or type reference;
– IP number according to degree of protection against ingress of water, other than IPX0;
– type reference of the **battery** if the **battery** is either not recharged in the appliance or is non-rechargeable.

Appliances incorporating **batteries** that are replaceable shall be marked with the **battery** type reference, **battery** voltage and the polarity of the terminals. Polarity marking is not required if incorrect insertion of the **battery** by the user is unlikely to occur due to the construction of the appliance.

If more than one **battery** type can be used with the appliance, the appliance shall be marked with the type reference of at least one of the **battery** types that can be used together with either the symbol ISO 7000-0790 (2004-01) or with the substance of the following:

See instruction manual for additional battery types.

If appliances use more than one **battery**, appliances shall be marked to indicate correct polarity connection of the **batteries**.

If relevant, the positive terminal shall be indicated by symbol IEC 60417-5005 (2002-10) and the negative terminal by symbol IEC 60417-5006 (2002-10).

Examples of acceptable marking of an appliance using three **batteries** are shown in Figure B.2.

Detachable batteries and **separable batteries** shall be marked with the:

– name, trade mark or identification mark of the manufacturer or responsible vendor;
– model or type reference;
– IP number according to degree of protection against ingress of water, other than IPX0.

Detachable batteries and **separable batteries** that are disconnected from the appliance for charging the **battery** shall be marked with symbol ISO 7000-0790 (2004-01). They shall also be marked with symbol IEC 60417-6413 (2019-05) and the model or type reference of the battery charger or with the substance of the following:

Use only with <model or type reference> battery charger.

If more than one battery charger can be used to charge a **detachable battery** and **separable battery** that is disconnected from the appliance for charging, the **battery** shall be marked with the type reference of at least one of the battery chargers that can be used together with either the symbol ISO 7000-0790 (2004-01) or with the substance of the following:

See instruction manual for additional battery chargers.

Batteries that are user replaceable, other than general purpose **batteries**, shall be marked with the:

– name, trade mark or identification mark of the manufacturer or responsible vendor;
– model or type reference;
– nominal voltage.

NOTE Examples of general purpose **batteries** are AAA, AA, C and D alkaline **batteries** and some lead-acid **batteries**.

Compliance is checked by inspection.

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7.6

+	[symbol IEC 60417-5005 (2002-10)]	plus; positive polarity
—	[symbol IEC 60417-5006 (2002-10)]	minus; negative polarity
	[symbol IEC 60417-6413 (2019-05)]	battery charger

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

For appliances intended for use at altitudes exceeding 2 000 m, the maximum altitude of use shall be stated.

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 incorporating **batteries** that are intended to be removed for charging or are intended to be replaced by the user and that can be contained in the small parts cylinder in Figure 13 shall state the substance of the following:

> WARNING: Keep out of reach of children. Swallowing can lead to chemical burns, perforation of soft tissue, and death. Severe burns can occur within 2 h of ingestion. Seek medical attention immediately.

For appliances intended for use with **batteries** that use metal-ion chemistries, the instructions shall state the normal temperature range for charging the **battery**.

The instructions for **battery-operated appliances** shall contain the following information, as applicable:

– the **battery** type;
– details regarding safe disposal of used **batteries**;
– how to deal with leaking **batteries**.

The instructions for **battery-operated appliances** shall contain the substance of the following:

– do not expose the appliance or battery to excessive temperatures;
– be aware of the risk of terminals of the battery-operated appliance or battery being short-circuited by metal objects.

Instructions for **battery-operated appliances** containing **non-rechargeable batteries** shall state the substance of the following:

> This appliance contains non-rechargeable batteries, these batteries are not to be recharged.

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Instructions for **battery-operated appliances** containing **batteries** that are non-user-replaceable shall state the substance of the following:

This appliance contains batteries that are only replaceable by skilled persons.

Instructions for **battery-operated appliances** containing **batteries** that are non-replaceable shall state the substance of the following:

This appliance contains batteries that are non-replaceable. When the battery is at end of life, the appliance shall be properly disposed of.

The instructions for **battery-operated appliances** incorporating **batteries** intended to be removed for charging or replaced by the user shall include, as applicable, the substance of the following:

– rechargeable batteries are to be removed from the appliance before being charged;
– different types of batteries or new and used batteries are not to be mixed;
– exhausted batteries are to be removed from the appliance and safely disposed of;
– if the appliance is to be stored unused for a long period, the batteries should be removed;
– do not use non-rechargeable batteries in place of rechargeable batteries;
– do not use modified or damaged batteries.

The instructions for **battery-operated appliances** incorporating **batteries** intended to be removed for charging or replaced by the user shall include, as applicable, the following information:

– the **battery** type reference;
– the orientation of the **battery** with regard to polarity;
– the method of replacing **batteries** including maintaining correct polarity.

The instructions for **battery-operated appliances** incorporating **batteries** that are intended to be removed prior to disposal of the appliance shall include details regarding their safe removal and disposal.

The instructions for **battery-operated appliances** that use **detachable batteries** and **separable batteries** that are disconnected from the appliance for charging the battery shall include the model or type reference of the battery charger to be used along with the substance of the following:

WARNING: Use only with <model or type reference> battery charger.

If the symbol for battery charger is used, its meaning shall be explained.

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

7.15 The marking specified for **batteries** intended to be replaced by the user shall be in or adjacent to the **battery** compartment.

The marking to indicate correct polarity connection of the **batteries** specified for appliances using more than one general purpose **battery** (**battery** not designed or sold for a specific purpose) shall be in or adjacent to the **battery** compartment.

The type reference of the battery charger shall be placed next to symbol IEC 60417-6413 (2019-05).

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8 Protection against access to live parts

This clause is not applicable to the appliance functional part of a **battery-operated appliance** and its **batteries**, providing the **battery** circuits do not have an earth connection or mains connection.

NOTE 1 The requirements for parts requiring protection against simultaneous contact are specified in B.22.3 and B.22.4.

NOTE 2 The term appliance functional part is illustrated in Figure B.1.

10 Power input and current

10.1 This subclause is not applicable.

10.2 This subclause is not applicable.

11 Heating

11.1 **Battery-operated appliances**, their surroundings, and **batteries** 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 B.11.1, 11.2, 11.3, 11.7, and 11.8.

11.4 This subclause is not applicable.

11.5 This subclause is not applicable.

11.6 This subclause is not applicable.

B.11.1 ***Battery-operated appliances*** *are tested under the conditions of* ***normal operation****.*

For appliances operated with ***detachable batteries*** *or* ***separable batteries*** *that are disconnected from the appliance for charging purposes, the appliance is operated until it no longer operates due to depletion of the* ***battery****. On the completion of the test, the depleted* ***battery*** *is immediately replaced with another* ***battery*** *that is* ***fully charged****, the* ***battery*** *being the model or type reference of the* ***battery*** *provided or indicated in the instructions. The test is repeated until the appliance no longer operates due to depletion of the* ***battery*** *or until the temperature rises have stabilized to values not more than 5 K higher than the temperature rises measured at the same locations during the first test, whichever occurs first.*

For appliances incorporating ***integral batteries*** *or* ***separable batteries*** *not disconnected from the appliance for charging purposes, and that cannot perform their intended function while the* ***batteries*** *are being charged, the appliance is operated continuously until it cannot perform its intended function due to the depletion of the* ***batteries****.*

For appliances operated with ***batteries*** *that are replaceable or* ***non-rechargeable batteries****, the appliance is operated until the minimum capacity of the* ***battery*** *as specified in Table B.1 has been delivered or until steady conditions are established, whichever occurs first.*

The appliance is operated for a puff session consisting of 15 individual puffs or until the appliance automatically deactivates, whichever occurs first, followed by (10 ± 0,5) minutes between sessions or until device indicates usage is possible, whichever is shorter, and then repeated continuously until one of the following events occurs:

– *the* ***battery*** *is* ***fully discharged****, or*

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– ***e-liquid*** *is depleted, or*

– *the appliance ceases functioning due to low levels of the* ***consumable****, or*

– *temperature of the appliance achieves steady conditions.*

For the purpose of this standard, a steady condition is considered to be attained if the difference in peak temperature does not exceed 3 K in 30 min. In the case of the graph of temperature against time, cycling on and off, only peaks (maximum) are taken into account for the difference in temperatures.

An individual puff is defined as:

– *puff volume: 55 ml ± 5 %;*

– *puff duration: 3 s ± 0,1 s for appliances using* ***e-liquid****, 2 s ± 0,1 s for the others;*

– *puff period: 10 s ± 0,5 s for appliances using* ***e-liquid****, 30 s ± 0,5 s for the others.*

A vaping machine is used to drawn air through the appliance. The puff volume is the volume of air drawn at the mouth end of the appliance. The puff duration is the interval of time, measured in seconds, during which the suction is applied to the appliance. The puff period is the time between the start of one puff and the start of the subsequent puff.

NOTE 101 The vaping machine specified in ISO 20768 is an example of a vaping machine that can be used for this purpose.

If the standard operating regime above is incompatible with the appliance or compromises the intended function, it may be adjusted accordingly, taking into account the manufacturer's instructions.

15 Moisture resistance

15.1 *Addition:*

Inspection shall show that no water has entered the ***battery*** *compartment and that there is no wetting of* ***electronic circuits*** *or electrical components relied upon for compliance with this standard.*

15.1.1 *Addition:*

Battery-operated appliances *shall be tested with the* ***battery*** *compartment closed and with any* ***detachable battery*** *or* ***separable battery*** *in place.*

19 Abnormal operation

19.1 *For* ***battery-operated appliances****, instead of the tests specified, compliance is checked by the tests of 19.2, 19.4, 19.7, 19.9, 19.11, 19.12, 19.14, 19.15, B.19.1 to B.19.5.*

Detachable batteries *and* ***separable batteries*** *are also subjected to the test of B.19.6.*

For ***battery-operated appliances****, the tests are carried out under* ***normal operation****.*

19.2 *Appliances with heating elements are tested under the conditions specified in Clause 11 but with restricted heat dissipation.*

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

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19.7 *The **battery-operated appliance** is switched on and 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.

The test is conducted at both I_{sc} (high) and I_{sc} (low), if testing with the artificial source described in B.5.3.

The test is conducted:

– *until the test sample achieves a steady condition, including returning to **room temperature**; or*

– *until at a time period of at least 3 h has elapsed.*

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 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 is made to informative Annex Q. It is noted 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 this standard, the normative text takes precedence over the guidance given in informative 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. The appliance shall comply with the conditions specified in 19.13.

If a conductor of a printed circuit board becomes open-circuited, the appliance is considered to have withstood the particular test, provided that the base material of the printed circuit board withstands the test of normative Annex E.

19.11.2 *When any of the fault conditions are simulated, the duration of the test is until steady conditions are established.*

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 and 19.11.4.2. The tests are carried out with the appliance supplied by a **battery** that is **fully charged**, 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 and 19.11.4.2. The tests are carried out after the **protective electronic circuit** has operated during the relevant tests of Clause 19 except 19.2 and 19.11.3.*

19.11.4.8 ***Battery operated appliances** are supplied with a **battery** that is **fully charged** and operated under **normal operation** for approximately 60 s, and then subjected to a 60 s interruption of the **battery** current. When the **battery** current is restored, the appliance shall:*

– *continue to operate normally from the same operating cycle point reached before the **battery** supply was interrupted; or*

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– *not continue operating without requiring manual intervention to restart from the same operating cycle point reached before the **battery** supply was interrupted; or*

– *not continue operating without requiring manual intervention to restart from the part of the cycle selected by the user.*

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. No explosion or ignition of the **battery** shall occur during or after the test.*

***Venting** of the **cells** is permitted provided that they have not vented by any means other than through their vents and the **venting** of appliance pressure is not directed towards the user's mouth.*

NOTE 1 Gas vented from **cells** is not considered to be poisonous or ignitable in hazardous amounts.

*After the tests, and when the appliance has cooled to approximately **room temperature**, compliance with B.22.3 and B.22.5 shall not be impaired and the appliance shall comply with 20.2 and Clause 29, 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
[a] For **motor-operated appliances**, these temperature rises are not determined.	

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 test of B.22.5 is carried out.

*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 2 Unintended operation that can 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.*

During and after the tests, the mouthpiece shall remain intact and not become dislodged.

19.15 *For **battery-operated appliances** incorporating a manual voltage selector switch intended to select **battery** voltage, this switch is set to the lowest voltage position and the highest voltage is applied.*

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B.19.1 *The supply terminals of a **battery-operated appliance** having an indication of polarity are connected to the **battery** terminals of the opposite polarity, unless such a connection by the user is unlikely to occur due to the construction of the appliance.*

B.19.2 *For **battery-operated appliances** with provision for multiple **batteries**, one or more of the **batteries** shall be reversed and the appliance shall be operated, if reversal by the user of **battery** polarity is allowed by the construction.*

B.19.3 *For **battery-operated appliances** with motor(s), the terminals of each motor are short circuited one at a time, where the resistance of the short-circuit does not exceed 10 mΩ and with the appliance operating under the conditions of Clause 11. The test is conducted until steady conditions are achieved, including returning to **room temperature** or until a time period of at least 3 h has elapsed.*

B.19.4 *Appliances incorporating **batteries** that use metal-ion chemistries are tested as follows.*

*The test is conducted with all the **cells** of the **battery fully charged** and, for **batteries** consisting of more than one **cell**, one **cell fully discharged** on a **detachable battery** or **separable battery** connected to the appliance or on an appliance containing an **integral battery**.*

*The main discharge connections of the **battery** are shorted with a resistance not to exceed 10 mΩ. The test is conducted until a **non-self-resetting protection device** operates or an **intentionally weak part** becomes permanently open-circuited or until the test sample returns to **room temperature**.*

NOTE The main discharge connections for **separable batteries** or **detachable batteries** are the **battery** terminals. For an **integral battery**, this is the output connection closest to the **cells** including their control circuitry.

B.19.5 *The **battery-operated appliance** and any cords except supply cords, as appropriate, are tested with the **battery** connected, under the following fault conditions applied one at a time:*

- *any cord provided between the **battery-operated appliance** and a **separable battery** shall be short-circuited at the point along its length likely to produce the most adverse effects;*
- *for appliances having **batteries** that are replaceable and 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;*
- *charging terminals of the **battery-operated appliance** that are simultaneously accessible with the test probe 13 of IEC 61032 are short circuited so as to produce the most unfavourable result.*

*The **battery-operated appliance** is switched on and no additional mechanical load is applied. The tests are conducted until the test sample achieves a steady condition, including returning to **room temperature** or, until a time period of at least 3 h has elapsed. The resistance of the short circuit shall not exceed 10 mΩ.*

B.19.6 ***Detachable batteries** and **separable batteries** are tested under the following fault condition.*

*Combinations of **detachable battery** terminals and **separable battery** terminals simultaneously accessible by applying the test probe 13 of IEC 61032 are short circuited so as to produce the most unfavourable result. The resistance of the short circuit shall not exceed 10 mΩ.*

20 Stability and mechanical hazards

B.20.1 The enclosure of a **battery-operated appliance** incorporating an **integral battery** that uses metal-ion chemistry shall withstand the pressure generated when a **cell** vents during failure.

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*Compliance is checked by inspection after the tests of Clause 19 for **batteries** with a capacity less than 0,2 Ah, and measurement in the case of a) or by the test of b).*

a) The total area of the unobstructed openings in the enclosure allowing gasses to pass shall be not less than the value specified in Table B.2; or

b) a volume of air of the amount specified in Table B.3 shall be injected through a (2,85 ± 0,05) mm diameter orifice into the enclosure at an initial overpressure of 2 070 kPa ± 10 %. Test fittings used for the test shall not increase the enclosure volume by more than 3 ml. The overpressure within the enclosure shall drop below 70 kPa within 30 s without any unintended rupturing damage to the enclosure

Table B.2 – Total area of openings for metal-ion cells

Capacity of the single metal-ion cell with the highest capacity *Ah*	*Min. total area of openings* *mm^2*
0,2 ≤ Ah < 1	*6*
1 ≤ Ah < 3	*10*
3 ≤ Ah < 5	*20*
5 ≤ Ah < 25	*30*
25 ≤ Ah < 100	*50*
Ah ≥ 100	*100*

Table B.3 – Volume of air injected at 2 070 kPa

Capacity of the single metal-ion cell with the highest capacity *Ah*	*Volume of air (±10 %)* *ml*
0,2 ≤ Ah < 1	*6*
1 ≤ Ah < 3	*10*
3 ≤ Ah < 5	*20*
5 ≤ Ah < 25	*30*
25 ≤ Ah < 100	*50*
Ah ≥ 100	*100*

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B.20.2 The enclosure of **detachable batteries** and **separable batteries** that use metal-ion chemistries shall withstand the pressure generated when a **cell** vents during failure.

*Compliance is checked by inspection after the tests of Clause 19 for **batteries** with a capacity less than 0,2 Ah, and measurement in the case of a) or by the test of b).*

a) The total area of the unobstructed openings in the enclosure allowing gasses to pass shall be not less than the value specified in Table B.2; or

b) a volume of air of the amount specified in Table B.3 shall be injected through a (2,85 ± 0,05) mm diameter orifice into the enclosure at an initial overpressure of 2 070 kPa ± 10 %. Test fittings used for the test shall not increase the enclosure volume by more than 3 ml. The overpressure within the enclosure shall drop below 70 kPa within 30 s without any unintended rupturing damage to the enclosure.

B.20.101 Appliances, other than those complying with 19.102, shall be constructed so that accidental operation is prevented. Appliances that are activated by a pressure difference are considered as constructed preventing accidental operation.

If a switch is used, the force necessary to activate shall be at least 2 N and the actuating member shall be recessed unless the appliance automatically shuts off after each operation and the actuation requires:

– *the application of a minimum of two independent and simultaneous movements, or*

– *particular action to be repeated a minimum of three times in succession within 2 s. If a touch control is used, it shall require at least two manual operations to switch on the appliance but only one operation to switch it off. Touching the contact surface at the same point twice is not considered to be two manual operations.*

Compliance is checked by inspection and manual test and, for switches with a recessed actuating member, applying a rigid cylindrical rod, having a diameter of 40 mm and a hemispherical end, to the actuating member of the switch. The test rod is applied with a force not exceeding 5 N. The appliance shall not operate.

21 Mechanical strength

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

Compliance is checked as follows.

*The appliance fitted with **fully charged batteries** and rigidly supported is subject to test Ehb of IEC 60068-2-75. Three blows, each having an impact energy of 0,5 J, are applied to every point of the appliance 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.

*When applying the release cone to the guard of a **visibly glowing heating element**, the hammer head passing through the guard shall not strike the heating element.*

If there is doubt as to whether a defect has occurred by the application of test Ehb of IEC 60068-2-75, 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.

***Hand-held battery-operated appliances** shall also be subjected to test free-fall – procedure 1, of IEC 60068-2-31. They shall be dropped three times from a height of 1 m onto a concrete surface. The sample shall be positioned to vary the point of impact. **Batteries** shall be **fully charged** prior to the test. **Hand-held battery-operated appliances** employing **detachable batteries** are tested with and without the **detachable battery**.*

Modification:

For the test free-fall − procedure 1 of IEC 60068-2-31, the height of the drop shall be 1,5 m instead of 1 m.

*Following the above tests, the appliance shall not catch fire, leak fluid that is visible from the outside of the appliance enclosure or explode and shall meet the requirements of Clause 20, Clause 29, B.22.3 and B.22.5 where short circuit of **functional insulation** will impair compliance with this standard.*

*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*

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access to parts requiring protection against simultaneous contact according to B.22.3 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.

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

B.21.1 Separable batteries and **detachable batteries**, when not connected to the appliance, shall have adequate mechanical strength and shall be constructed to withstand such rough handling that may be expected in normal use.

Compliance is checked as follows.

*The **fully charged battery**, rigidly supported is subject to test Ehb of IEC 60068-2-75. Three blows, each having an impact energy of 0,5 J, are applied to every point of the **battery** enclosure that is likely to be weak.*

If there is doubt as to whether a defect has occurred by the application of test Ehb of IEC 60068-2-75, 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.

***Detachable batteries** and **separable batteries** shall also be subjected to the test free-fall – procedure 1, of IEC 60068-2-31. They shall be dropped three times from a height of 1 m onto a concrete surface. The **battery** shall be positioned to vary the point of impact. **Batteries** shall be **fully charged** prior to the test.*

Modification:

For the test free-fall − procedure 1 of IEC 60068-2-31, the height of the drop shall be 1,5 m instead of 1 m.

*After the tests, visual inspection shall show there is no damage to the **battery** and the **battery** shall not catch fire, leak fluid that is visible from the outside of the **battery** enclosure or explode and shall meet the requirements of Clause 20, Clause 29, B.22.4 and B.22.5 where short circuit of **functional insulation** will impair compliance with this standard.*

*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 parts requiring protection against simultaneous contact according to B.22.4 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.

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

*For **batteries** that use metal-ion chemistry:*

- *the open circuit voltage of the **battery** 24 h after the tests shall not be less than 90 % of the voltage measured immediately prior to the tests;*
- ***cells** shall not have vented by any means other than through their vents.*

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22 Construction

22.11 **Non-detachable parts** that protect against electric shock, 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.

22.20 Direct contact between current carrying parts and thermal insulation that would impair compliance with this standard shall be effectively prevented unless such material is non-corrosive, non-hygroscopic and non-combustible.

The requirement is not applicable to glass-wool thermal insulation.

NOTE Non-impregnated slag-wool is an example of corrosive thermal insulation.

22.24 This requirement does not apply to **battery-operated appliances** that do not contain parts requiring protection against simultaneous contact according to B.22.3.

22.25 This requirement does not apply to **battery-operated appliances** that do not contain parts requiring protection against simultaneous contact according to B.22.3.

22.26 This subclause is not applicable.

22.27 This subclause is not applicable.

22.28 This subclause is not applicable.

22.29 This subclause is not applicable.

22.30 This subclause is not applicable.

22.31 This subclause is not applicable.

22.32 This subclause is not applicable.

22.33 Conductive liquids that are or may become accessible in normal use and conductive liquids that are in contact with **accessible metal parts** shall not be in direct contact with current carrying parts or unearthed metal parts that are separated from current carrying parts by **basic insulation** only or with other current carrying parts such that compliance with B.22.3 and B.22.4 would be impaired.

22.34 This subclause is not applicable.

22.35 This subclause is not applicable.

22.36 This subclause is not applicable.

22.37 This subclause is not applicable.

B.22.1 User accessible interfaces between elements of a **battery system** (not mains connections) shall not employ appliance couplers according to IEC 60320 (all parts) or IEC 60309-2.

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User accessible interfaces between elements of a **battery system** (not mains connections) shall not employ connectors of the following types unless the **battery system** is adequately protected against the use of an incorrect supply:

– barrel connectors with outside diameters of 6,5 mm or less;

– concentric connectors with a diameter of 3,5 mm or less according to IEC 60603-11.

Compliance is checked by inspection, measurement and for determining adequacy of protection against use of an incorrect supply, by the following test.

The mating connector shall be supplied by a:

– *5 V AC voltage that is increased in 5 V increments to 30 V for 5 min at each increment; and then;*

– *10 V DC voltage with less than 10 % ripple in 10 V increments to 60 V for 5 min at each increment.*

*The source shall be selected such that its current capability does not limit the charging of the **battery**.*

*During the application of incremental voltages, the appliance shall either be capable of operating normally or, if not, 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. No explosion or ignition of the **battery** shall occur during or after the test. **Venting** of the **cells** is permitted provided that they have not vented by any means other than through their vents.*

B.22.2 The external surfaces of **detachable batteries** and **separable batteries** shall be protected against excessive heat from heat sources (directly or via heated discharge air) that would be present during operation of the appliance.

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

B.22.3 Battery-operated appliances shall be so constructed and enclosed that there is adequate protection against simultaneous contact with two or more conductive parts where the:

– voltage between them exceeds 42,4 V; and

– current between the conductive parts exceeds 2 mA for DC or 0,7 mA peak for when ripple exceeds 10 %.

Compliance is checked by inspection and the following test.

Test probe B and test probe 18 of IEC 61032 are 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. The test probe is applied through openings 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 when probe B is used or 10 N when probe 18 is used. If the probe then enters the opening, the test is repeated with the probe in the angled position.

*During the tests with test probe B, all **detachable parts** are removed except lamps located behind a **detachable cover** are not removed. However, during insertion or removal of lamps which are located behind a **detachable cover**, protection against simultaneous contact with parts having a voltage between them exceeding 42,4 V shall be ensured.*

During the tests with test probe 18, the appliance shall be fully assembled as in normal use without any parts removed.

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However, test probe 18 is not applied to appliances for commercial use unless they are intended to be installed in an area open to the public.

It shall not be possible to touch two or more conductive parts of opposite polarity with the probes if the voltage between them exceeds 42,4 V and the current between them exceeds 2 mA for DC or 0,7 mA peak for when ripple exceeds 10 %.

The current is measured using the circuit in Figure 4 of IEC 60990:2016.

B.22.4 **Separable batteries** and **detachable batteries** shall be so constructed and enclosed that there is adequate protection against simultaneous contact with two or more conductive parts where the:

– voltage between them exceeds 42,4 V; and
– current between the conductive parts exceeds 2 mA.

Compliance is checked by inspection and the following test.

*Test probe B and test probe 18 of IEC 61032 are applied with a force not exceeding 1 N, the **battery** being in every possible position except that **batteries** having a mass exceeding 40 kg are not tilted. The test probe is applied through openings 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.*

During the tests with:

– *test probe B, all **detachable parts** are removed;*
– *test probe 18, no parts are removed.*

*However, test probe 18 is not applied to **batteries** for appliances for commercial use unless they are intended to be installed in an area open to the public.*

It shall not be possible to touch two or more conductive parts of opposite polarity with the probes if the voltage between them exceeds 42,4 V and the current between them exceeds 2 mA.

The current is measured using the circuit in Figure 4 of IEC 60990:2016.

B.22.5 Insulating materials providing protection against simultaneous contact with two or more conductive parts shall be adequate when:

– they are within 1,0 mm of the conductive parts;
– the voltage between the conductive parts exceeds 42,4 V peak; and
– the current between the conductive parts exceeds 2 mA for DC or 0,7 mA peak for when ripple exceeds 10 %.

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

*The insulating material is subjected for 60 s to 750 V or 1,2 times the **working voltage** plus 700 V, whichever is greater, in accordance with IEC 61180. The test voltage is applied on opposing sides of the insulating material.*

NOTE This does not exclude the testing of the material as situated within the appliance.

During the test care shall be taken to avoid overstressing parts not needed to provide protection against simultaneous contact with two or more conductive parts.

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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 200 mA and 100 mA, respectively.

No breakdown shall occur during the test.

Glow discharges without a drop in voltage are neglected.

The current is measured using the circuit in Figure 4 of IEC 60990:2016.

B.22.6 Vents of **cells** shall not be obstructed in such a way as to defeat their operation if **venting** is relied upon for compliance with this standard.

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

B.22.101 Appliances shall not be constructed with provision for user-replaceable sealed secondary lithium **cells** containing non-acid electrolyte.

Cells that can be removed from appliances only for disposal or recycling are not considered as user-replaceable **cells**.

NOTE This requirement only applies to sealed secondary lithium **cells** but does not apply to **batteries**.

Compliance is checked by inspection.

23 Internal wiring

23.3 *Instead of the electric strength test of 16.3, **battery-operated appliances** shall comply with B.22.3.*

23.5 *For **battery-operated appliances** compliance is checked by the test of B.22.5.*

24 Components

24.1 **Batteries** are not required to comply with IEC 62133-1:2017 or IEC 62133-2:2017. They are tested as part of the appliance according to this standard.

24.1.1 This subclause is not applicable.

24.1.3 Switches in **battery-operated appliances** shall have adequate breaking capacity and shall withstand, without excessive wear or other harmful effect, the mechanical, electrical, and thermal stresses occurring in the **battery-operated appliance**.

The relevant standard for switches is IEC 61058-1-1:2016 for mechanical switches and IEC 61058-1-2:2016 for electronic switches. The number of cycles declared for 7.4 of IEC 61058-1:2016 shall be at least 10 000 under the load conditions encountered in the appliance, this being the declared specific load according to 7.2.5 of IEC 61058-1:2016. If the switch makes and breaks a locked rotor current, the number of cycles declared for 7.4.9 of IEC 61058-1:2016 shall be at least 50 under the load conditions encountered in the appliance, this being the declared specific load according to 7.2.5 of IEC 61058-1:2016.

The declared number of operating cycles is only applicable for switches required for compliance with this standard.

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Unless switches have been previously tested to and found to comply with IEC 61058-1-1:2016 or IEC 61058-1-2:2016 for the number of cycles declared, compliance is checked by the following tests conducted on separate samples:

– *50 cycles of making and breaking the locked motor current, if any, encountered in the **battery-operated appliance** incorporating a **battery** that is **fully charged**. Each "on" period having a duration of not more than 0,5 s and each "off" period having a duration of at least 10 s;*

– *10 000 cycles of making and breaking the current encountered in a **battery-operated appliance** incorporating a **battery** that is **fully charged** with no additional mechanical load. The switch is actuated at a uniform rate of 30 cycles per minute.*

The switch shall complete the required cycles of operation and shall have no electrical or mechanical failure. At the end of the tests:

– *the switch contacts shall operate properly in the "on" and "off" positions;*

– *the temperature rise of the switch terminals shall not have increased by more than 30 K above the temperature rise measured in Clause 11.*

B.24.1 *The relevant standards for non-acid based electrolyte **cells** employed in **batteries** are IEC 62133-1:2017 for nickel systems and IEC 62133-2:2017 for lithium systems.*

NOTE The requirement for **cells** does not extend to the **battery** itself.

*A **battery** that uses metal-ion chemistry shall additionally be subjected to the tests of Subclauses 7.3.8.1 (vibration) and 7.3.8.2 (mechanical shock) of IEC 62133-2:2017.*

25 Supply connection and external flexible cords

25.9 The requirement also applies to i**nterconnection cords** of **battery-operated appliances**.

25.14 The requirement also applies to i**nterconnection cords** of **battery-operated appliances**.

25.15 The requirement also applies to i**nterconnection cords** of **battery-operated appliances**.

B.25.1 Insulated conductors of **interconnection cords** of **battery-operated appliances** shall comply with the requirements for internal wiring and shall be provided with at least 0,5 mm thick outer sheath made of insulating material equivalent to that of **supply cords** described in 25.7.

Compliance is checked by inspection and by test.

26 Terminals for external conductors

B.26.1 Terminal devices in an appliance for the connection of the flexible leads or flexible cord connecting a **separable battery** shall be so located or shielded that there is no risk of incorrect connection.

Compliance is checked by inspection.

27 Provision for earthing

27.1 The **battery-operated appliance** shall have no provision for a protective earth but may incorporate a functional earth.

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29 Clearances, creepage distances and solid insulation

29.1 **Clearances** shall not be less than the values specified in Table 16, taking into account the **rated impulse voltage**. For **battery-operated appliances**, the **rated impulse voltage** shall be 500 V for **working voltages** less than 50 V and 1 500 V for all other **working voltages**. However, if the construction, including between parts of opposite polarity for connecting the **battery**, 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 are increased by 0,5 mm and the impulse voltage test is not applicable.

NOTE The procedure for assessing **clearances** is given in informative Annex L.

B.29.1.1 For parts requiring protection against simultaneous contact according to B.22.3 and B.22.4, the sum total of the **clearances** between each of these parts and their nearest accessible surface shall not be less than two times the Table 16 **clearance** taking into account the **rated impulse voltage**. For the purpose of this determination, at least one of the **clearances** shall be not less than 1,0 mm.

Compliance is checked by measurement.

NOTE The procedure for assessing **clearances** is given in Clause L.3.

B.29.2.1 For parts requiring protection against simultaneous contact according to B.22.3 and B.22.4, the sum total of the **creepage distances** between each of these parts and their nearest accessible surface shall not be less than two times the Table 17 **creepage distances**. For the purpose of this determination, at least one of the **creepage distances** shall be not less than 1,0 mm.

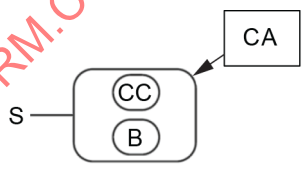
Compliance is checked by measurement.

NOTE The procedure for assessing **creepage distances** is given in Clause L.2.

30 Resistance to heat and fire

30.1 External parts of non-metallic material, the deterioration of which might cause the **battery-operated appliance**, **separable battery** or **detachable battery** to fail to comply with this annex, shall be sufficiently resistant to heat.

a)

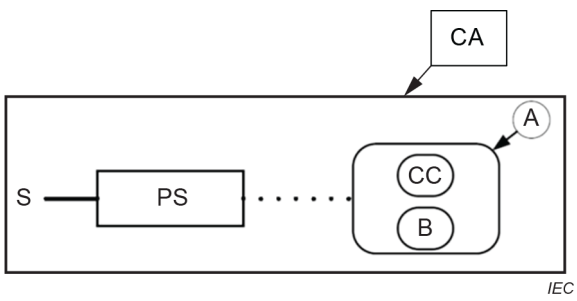


Complete appliance:

Tested to main part of standard while operated or charged by mains or renewable energy source (otherwise not applicable)

Tested to normative Annex B when operated on **battery** power

b)



Detachable power supply part:

Tested to main part of standard with and without the appliance connected

Complete appliance:

Tested to main part of standard while operated by or charged by mains or renewable energy source

Appliance functional part:

Tested to normative Annex B when operated on **battery** power

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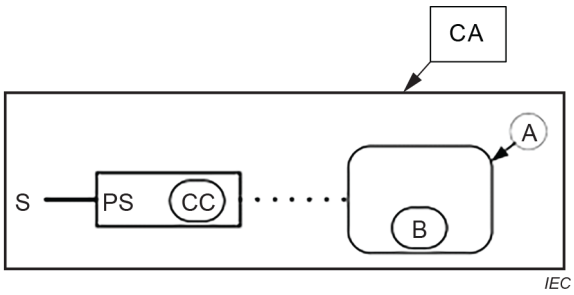
c)



Detachable power supply part:

Tested to main part of standard with and without the appliance connected

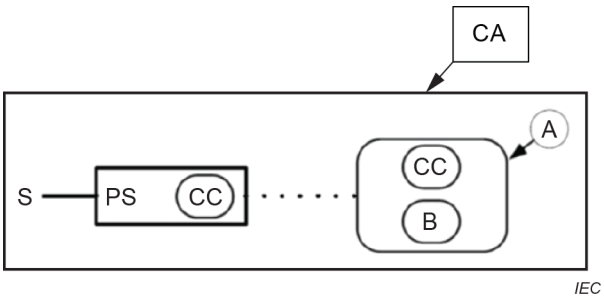
Complete appliance:

Tested to main part of standard while operated by or charged by mains or renewable energy source

Appliance functional part:

Tested to normative Annex B when operated on **battery** power

d)



Detachable power supply part:

Tested to main part of standard with and without the appliance connected

Complete appliance:

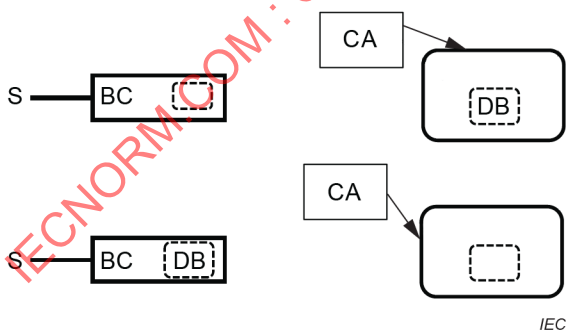
Tested to main part of standard while operated by or charged by mains or renewable energy source

Appliance functional part:

Tested to normative Annex B when operated on **battery** power

Figure B.1 – Examples of battery-operated appliance constructions and application of normative Annex B *(1 of 2)*

e)



Battery charger:

Tested to IEC 60335-2-29

Detachable battery:

Tested to normative Annex B

Complete appliance:

Tested to normative Annex B when operated on **battery** power with **detachable battery** attached

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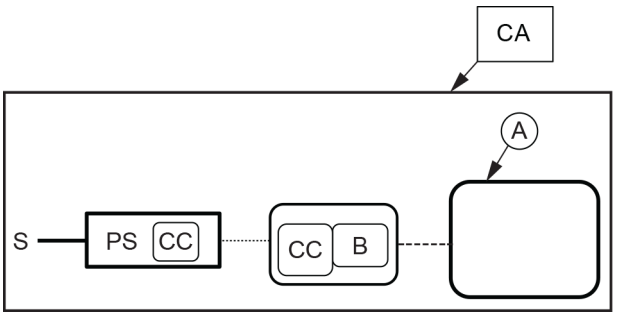
f)



Detachable power supply part:

Tested to main part of standard with and without the **battery** connected

Separable battery:

Tested to normative Annex B

Complete appliance:

Tested to main part of standard while operated by mains or renewable energy source while the **battery** is being charged:

Appliance functional part:

Tested to normative Annex B when operated on **battery** power with **separable battery** attached but detached from **detachable power supply part**:

Key

CA	complete appliance	CC	charge circuitry
A	appliance functional part	PS	**detachable power supply part**
B	**battery**	BC	battery charger
S	supply	.....	detachable connection
DB	**detachable battery**	----	non-detachable connection

Figure B.1 *(2 of 2)*

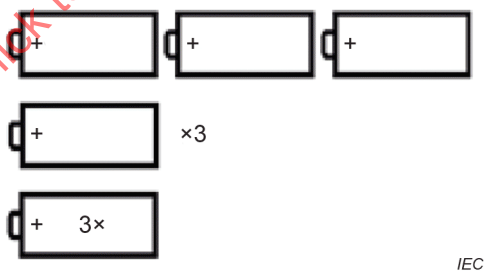


Figure B.2 – Examples of correct polarity connection marking representing three batteries

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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.

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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 this 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.

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Annex E
(normative)

Needle-flame test

The needle-flame test is carried out in accordance with IEC 60695-11-5:2016 with some of the clauses of IEC 60695-11-5:2016 being modified as follows.

7 Flame application times

Replacement:

The duration of application of the test flame is 30 s ± 1 s.

9 Test procedure

9.2 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 2.

9.3 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.

9.4 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.

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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 60384-14:2013 including IEC 60384-14:2013/AMD1:2016, being modified as follows.

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.

Class Y capacitors are tested according to subclass Y2.

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.

Only insulation resistance and voltage proof are checked (see Table 15).

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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 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.

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Annex G
(normative)

Safety isolating transformers

The following modifications to this standard are applicable for **safety isolating transformers**.

The clause numbers in this Annex refer to the clause numbers in the main part of this standard that are modified.

7 Marking and instructions

7.1 Transformers for specific use shall be marked with the:

– 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 61558-1:2017.

17 Overload protection of transformers and associated circuits

Fail-safe transformers shall comply with Subclause 15.5 of IEC 61558-1:2017.

NOTE This test is carried out on three transformers.

22 Construction

Subclauses 19.1 and 19.1.2 of IEC 61558-2-6:2009 are applicable.

29 Clearances, creepage distances and solid insulation

29.1, 29.2 and 29.3 The distances specified in Table 20, Table 21 and Table 22 of IEC 61558-1:2017 apply.

For insulated winding wires complying with Subclause 19.12.3 of IEC 61558-1:2017 there are no requirements for **clearances** or **creepage distances**. In addition, for windings providing **reinforced insulation**, the distances specified in Table 20 and Table 21 of IEC 61558-1:2017 are 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 60664-4:2005 are applicable, if these values are greater than the values specified in Table 20, Table 21 and Table 22 of IEC 61558-1:2017.

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Annex H
(normative)

Switches

Switches shall comply with the following clauses of IEC 61058-1:2016 and IEC 61058-1-1:2016, as appropriate, being modified as follows.

The tests 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 can 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. 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 17.5.4 of IEC 61058-1-1:2016, the number of cycles of actuation declared according to 7.4 is 10 000 unless otherwise specified in Subclause 24.1.3 of IEC 60335-1.

*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 17.5.4 of IEC 61058-1-1:2016 for 100 cycles of operation.*

Subclauses 17.3 and 17.6.2 of IEC 61058-1-1:2016 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.

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20 Clearances, creepage distances, solid insulation and coatings of rigid printed board assemblies

Clause 20 of IEC 61058-1:2016 is applicable to **clearances** across full disconnection and micro-disconnection. It is also applicable to **creepage distances** for **functional insulation**, across full disconnection and micro-disconnection, as stated in Table 14.

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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.

The clause numbers in this Annex refer to the clause numbers in the main part of this standard that are modified. Clauses that are additional to the clauses in the main part of this standard are identified by adding the Annex letter with the numbering starting at 1.

8 Protection against access to live parts

8.1 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 I.19.1.

I.19.1 *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. The faults are simulated as shown in Figure I.1.

22 Construction

I.22.1 For **class I appliances** incorporating a motor supplied by a rectifier circuit, the DC circuit shall be insulated from **accessible parts** of the appliance by **double insulation** or **reinforced insulation**.

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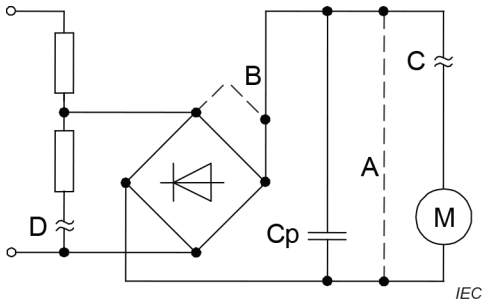
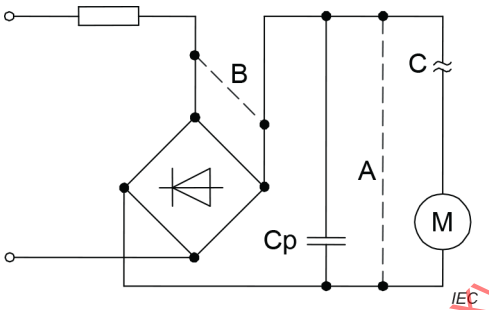
*Compliance is checked by the tests specified for **double insulation** and **reinforced insulation**.*



a) Parallel circuit



b) Series circuit

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

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Annex J
(normative)

Coated printed circuit boards

Protective coatings of printed circuit boards shall comply with IEC 60664-3:2016 with some of the clauses of IEC 60664-3:2016 being modified as follows.

5 Tests

5.1 General

When production samples are used, three samples of the printed circuit board are tested.

5.7 Conditioning of the test specimens

5.7.2 Cold conditioning

The test is carried out at –25 °C.

5.7.4 Rapid change of temperature

Severity 1 is specified, the number of cycles is 5.

5.7.5.2 Additional conditioning with respect to electromigration

The test duration is 10 days.

5.9 Additional tests

This subclause is not applicable.

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Annex K
(informative)

Overvoltage categories

The following information on overvoltage categories is extracted from IEC 60664-1:2007.

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.

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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 informative 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 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 60664-1:2007 or if the frequency exceeds 30 kHz, Clause 4 in IEC 60664-4:2005. The larger of the values so obtained is applied if they exceed the values specified in Table 16.

Clearances of **supplementary insulation** and **reinforced insulation** are measured and compared with the 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.

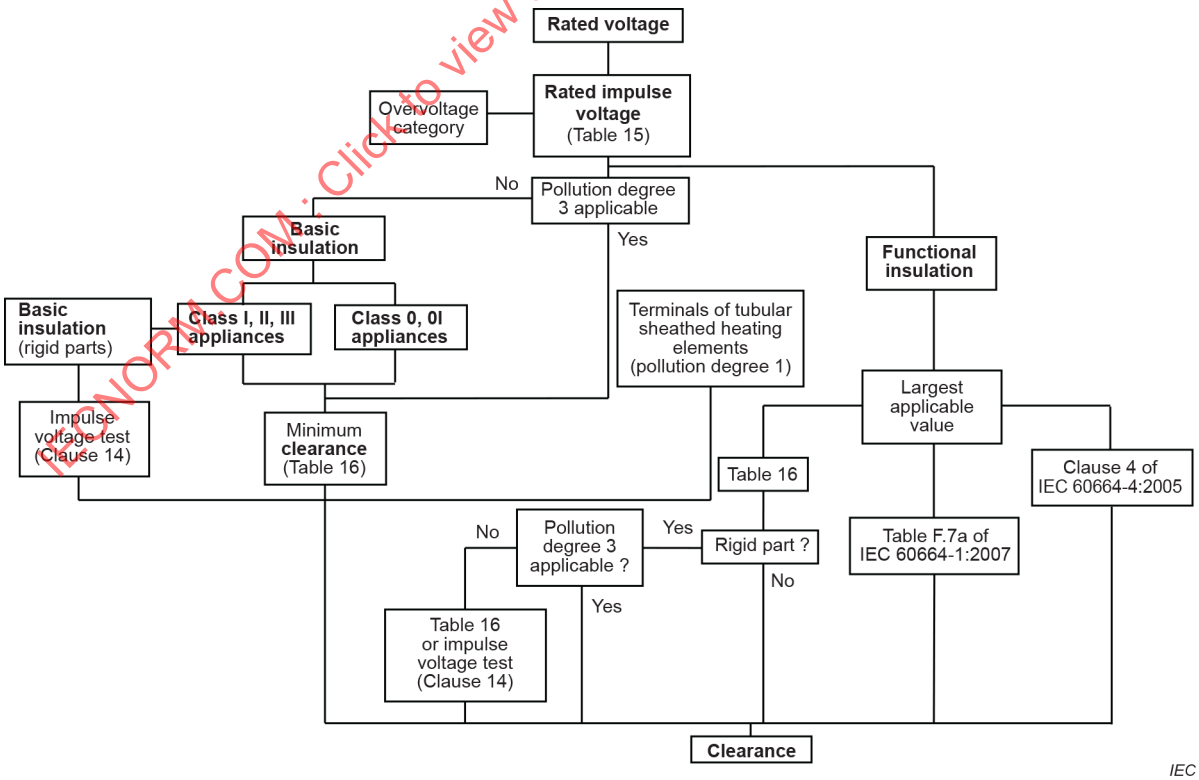

Figure L.1 – Sequence for the determination of clearances

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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 values specified in Table 17 or Table 2 in IEC 60664-4:2005 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** cannot be less than the values of Table 17.

The **creepage distances** of **functional insulation** are measured and compared with the values specified in Table 18 or, for periodic **working voltages** exceeding 30 kHz, Table 2 of IEC 60664-4:2005.

The **creepage distances** of **reinforced insulation** are measured and compared with twice the values specified in Table 17.

NOTE The sequence for determining **creepage distances** is shown in Figure L.2

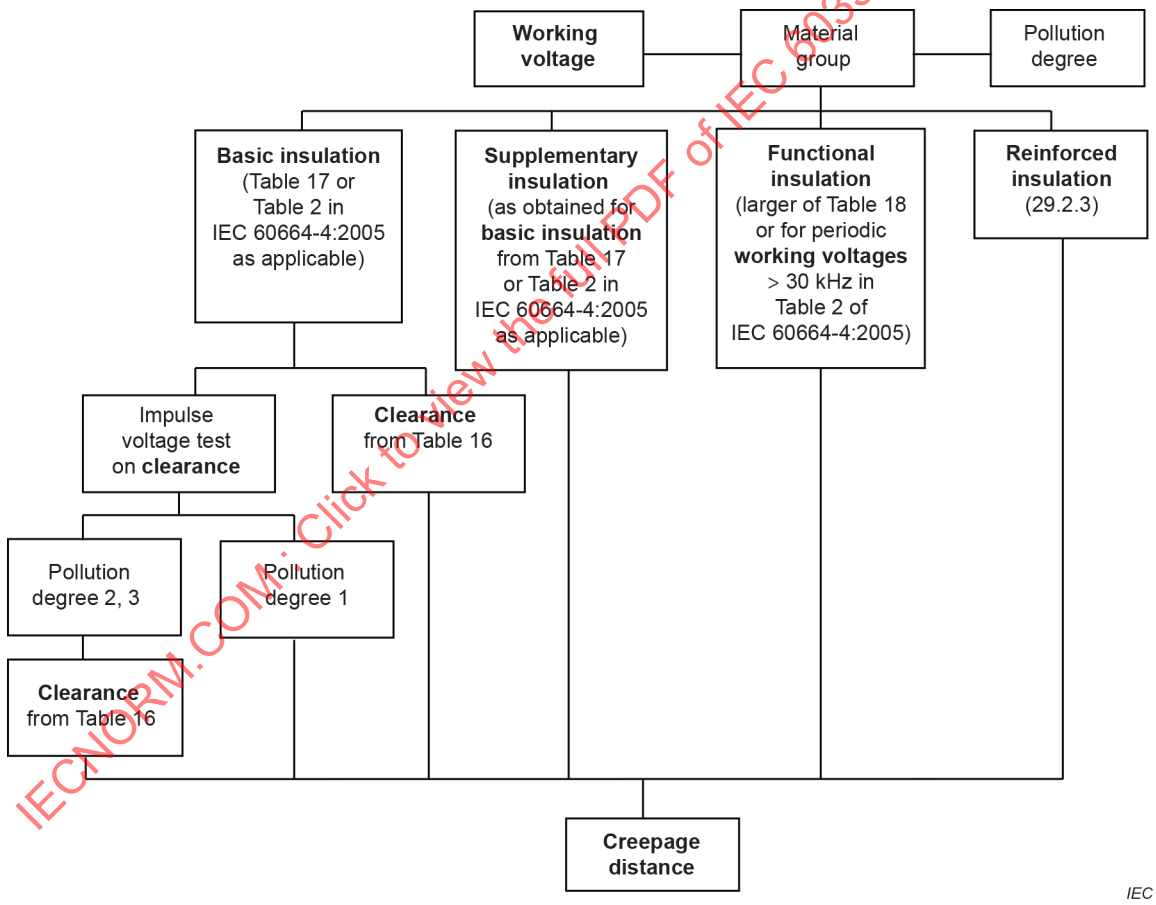

Figure L.2 – Sequence for the determination of creepage distances

L.3 When measuring the sum total of distances between parts requiring protection against simultaneous contact according to B.29.1.1 and **accessible surfaces**, the distance from each part to the **accessible surface** shall be added together to determine the sum total. See Figure L.3.

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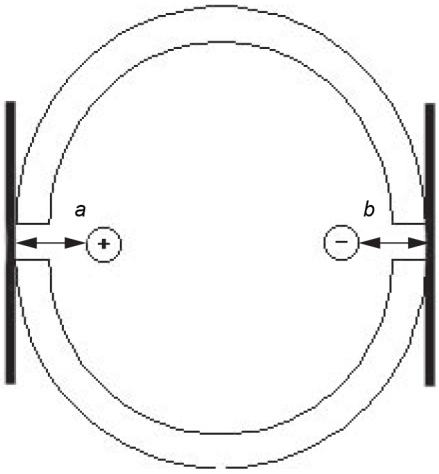

Key

Dimension *a*	positive bare part distance to the external surface represented by foil stretched across the openings
Dimension *b*	negative bare part distance to the external surface represented by foil stretched across the openings
a + *b*	sum total as specified in B.29.1.1.

Figure L.3 – Measurement of clearances

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Annex M
(informative)

Pollution degree

The following information on pollution degrees is extracted from IEC 60664-1:2007.

- 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 60664-1:2007.

- 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.

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Annex N
(normative)

Proof tracking test

The proof tracking test is carried out in accordance with IEC 60112:2003 including IEC 60112:2003/AMD1:2009 with some of the clauses of IEC 60112:2003 including IEC 60112:2003/AMD1:2009 being modified as follows.

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, 250 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.

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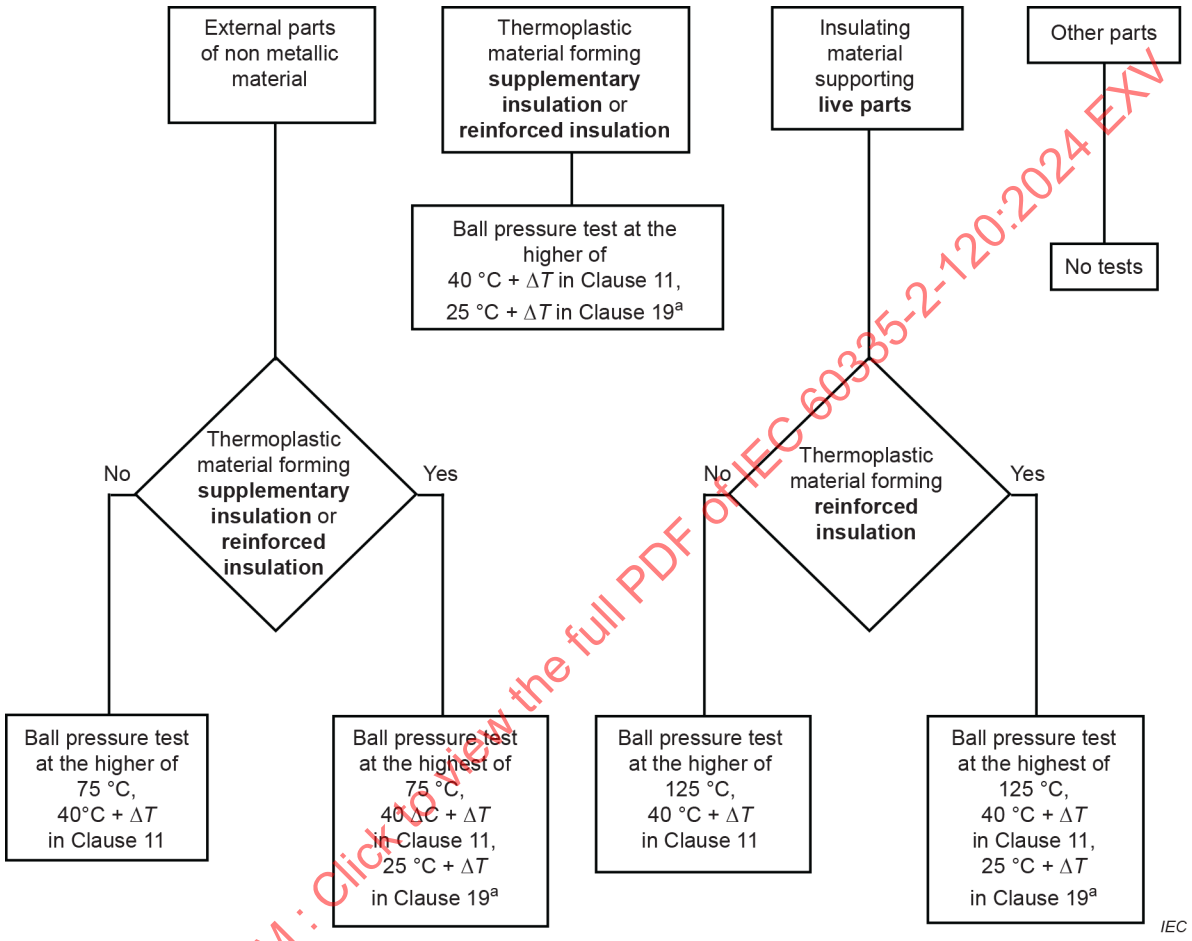
Annex O
(informative)

Selection and sequence of the tests of Clause 30

For correct application of this standard, the normative text takes precedence over the guidance given in this annex and reliance should not to be placed on these figures.



[a] ΔT is not taken into account if the tests of 19.4 and 19.5 are 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

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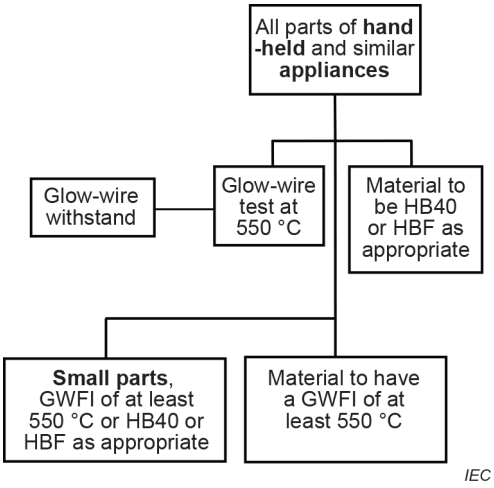

Figure O.2 – Selection and sequence of tests for resistance to fire in hand-held appliances

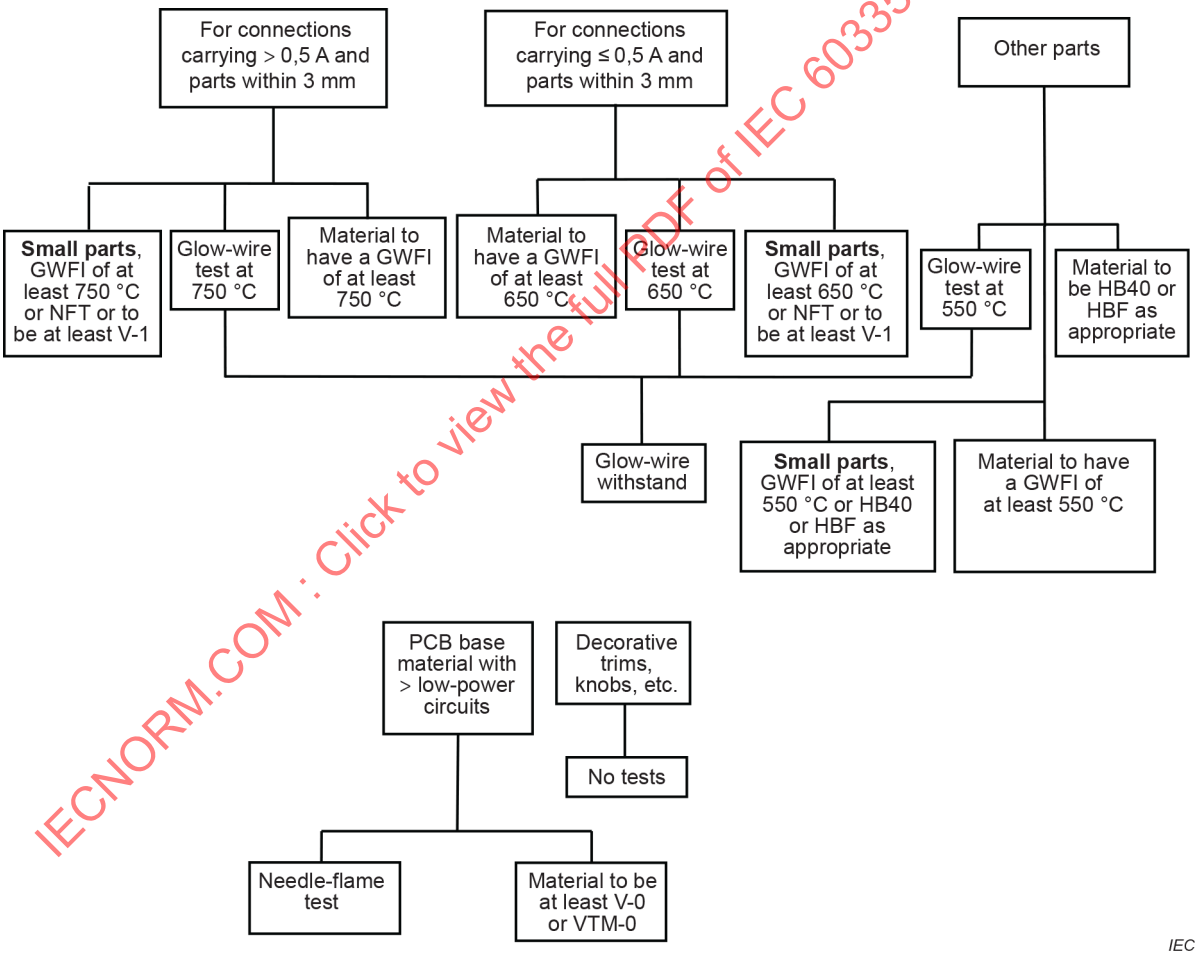

Figure O.3 – Selection and sequence of tests for resistance to fire in attended appliances

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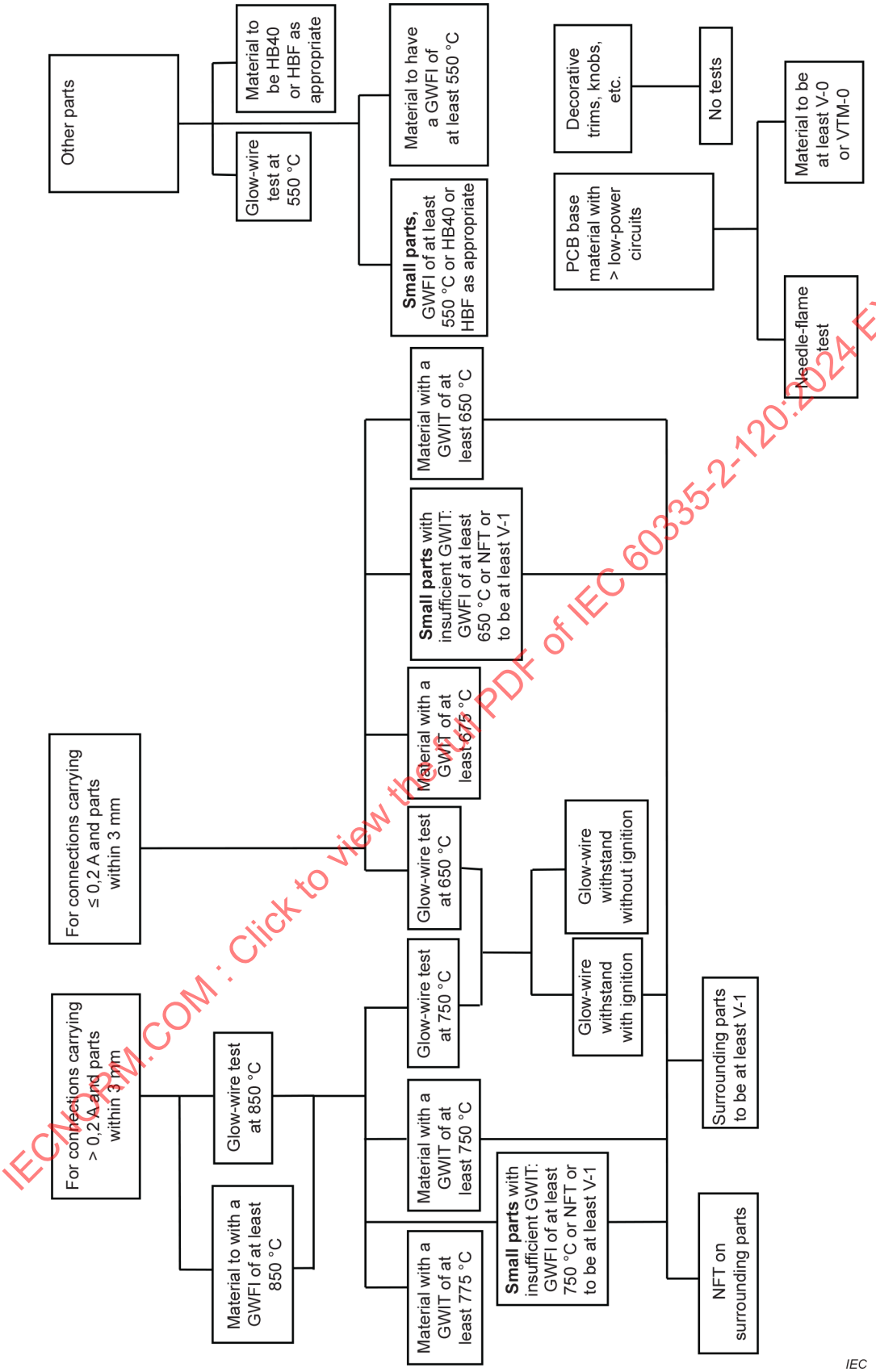

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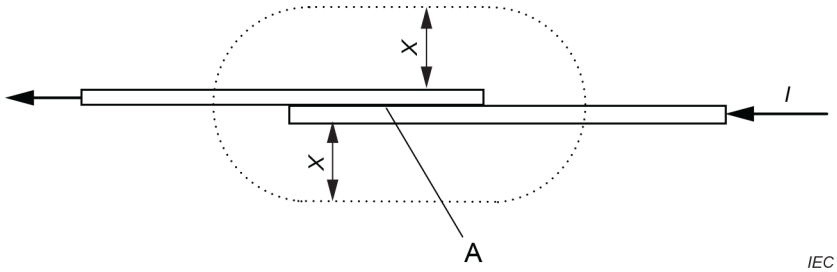
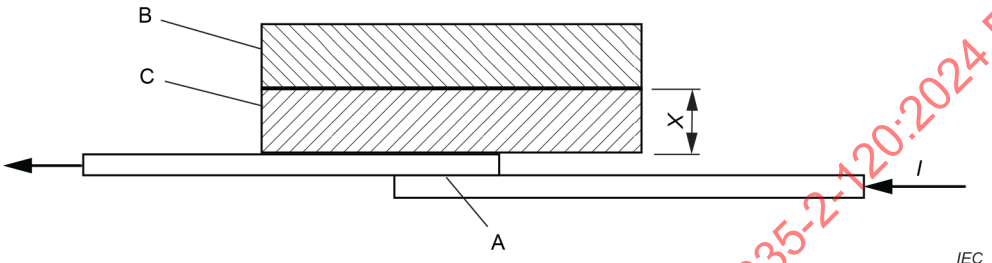
Figure O.4 – Selection and sequence of tests for resistance to fire in unattended appliances

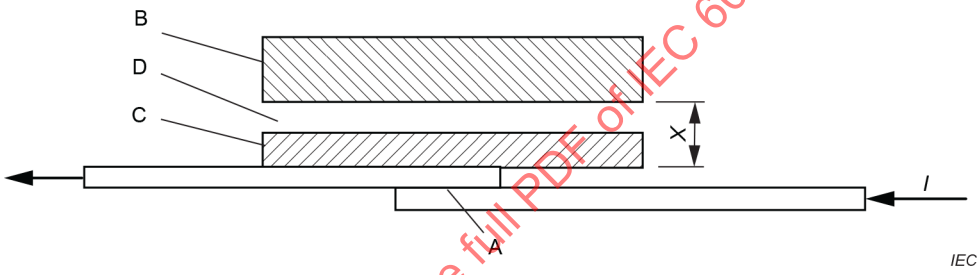


"Within a distance of 3 mm" means falling within the dotted boundary formed by the cylinder with hemispherical ends, as shown in the above drawing.

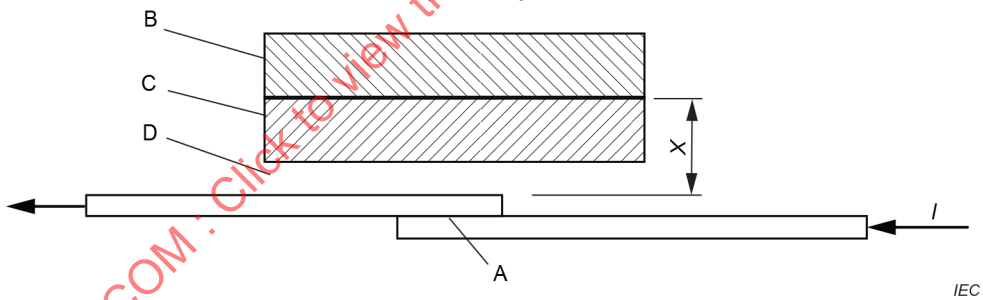
Some examples:



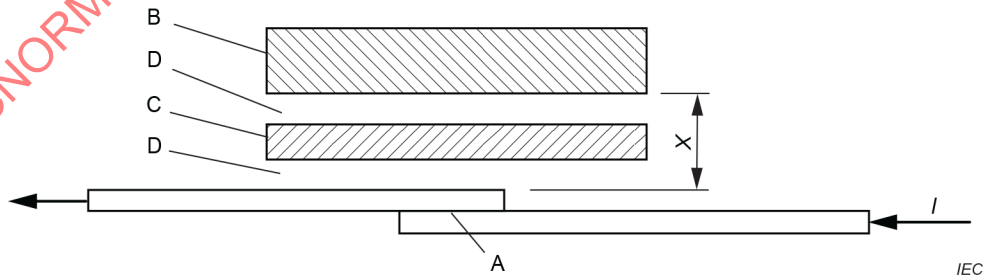
a) Example 1



b) Example 2



c) Example 3



d) Example 4

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

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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*** **≤ 3 mm**		***X*** **> 3 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"

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Annex P
(informative)

Guidance for the application of this standard to appliances used in tropical climates

The following modifications to this standard are applicable for **class 0 appliances** and **class 0I appliances** having a **rated voltage** exceeding 150 V, that are intended to be used in countries having a tropical climate and that are marked with symbol IEC 60417-6332 (2015-06).

NOTE Tropical 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 tropical climate and that are marked with symbol IEC 60417-6332 (2015-06), 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.

The clause numbers in this Annex refer to the clause numbers in the main part of this standard that are modified.

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 symbol IEC 60417-6332 (2015-06).

7.6

[symbol IEC 60417-6332 (2015-06)] tropical climate

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 tropical climate. It may also be used in other countries.

If symbol IEC 60417-6332 (2015-06) is used, its meaning shall be explained.

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.*

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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.*

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Annex Q
(informative)

Sequence of tests for the evaluation of electronic circuits

For correct application of this standard, the normative text takes precedence over the guidance given in this annex and reliance should not be placed on the flow chart of Figure Q.1.

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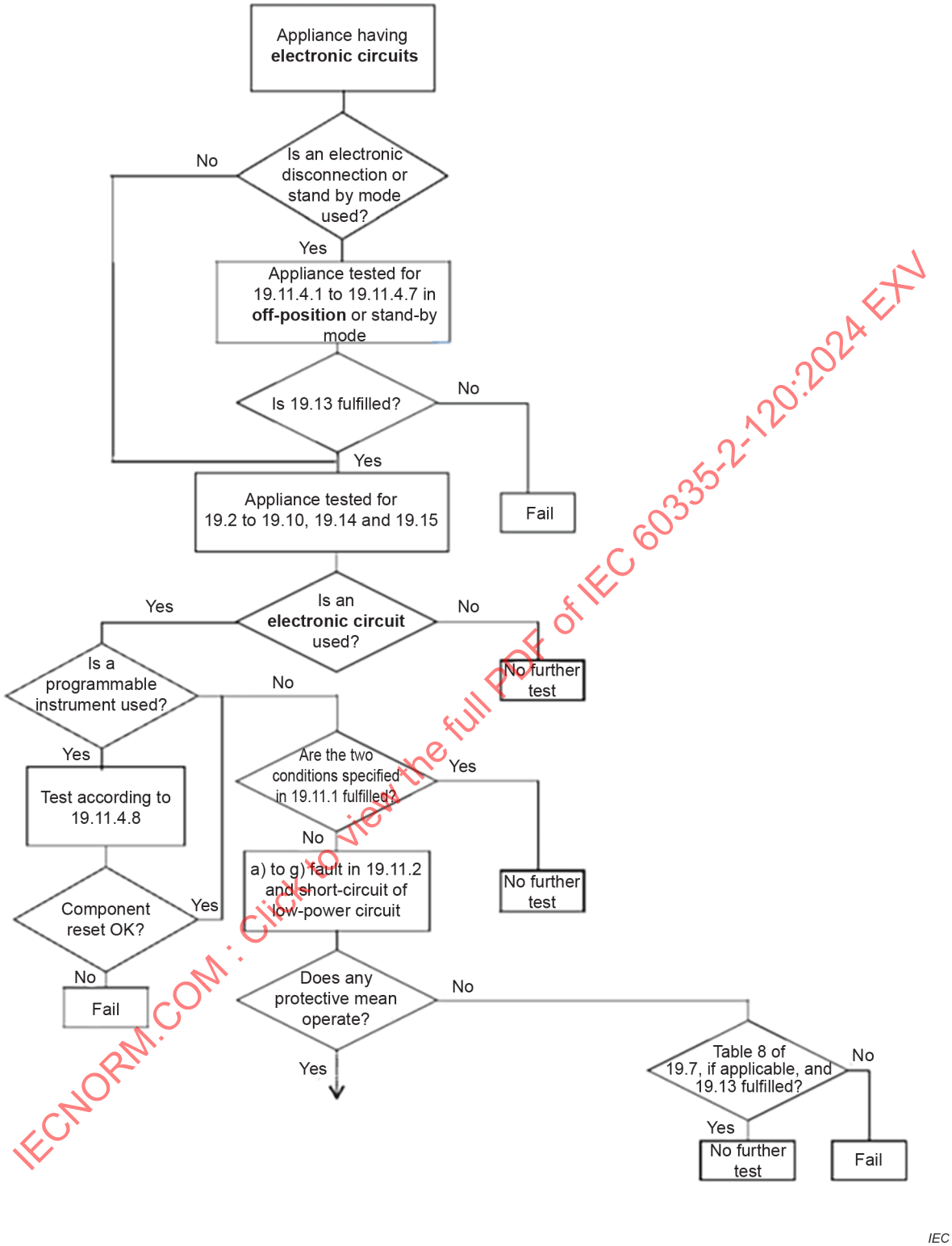

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Figure Q.1 – Flowchart outlining the sequence of tests for the evaluation of electronic circuits *(1 of 2)*

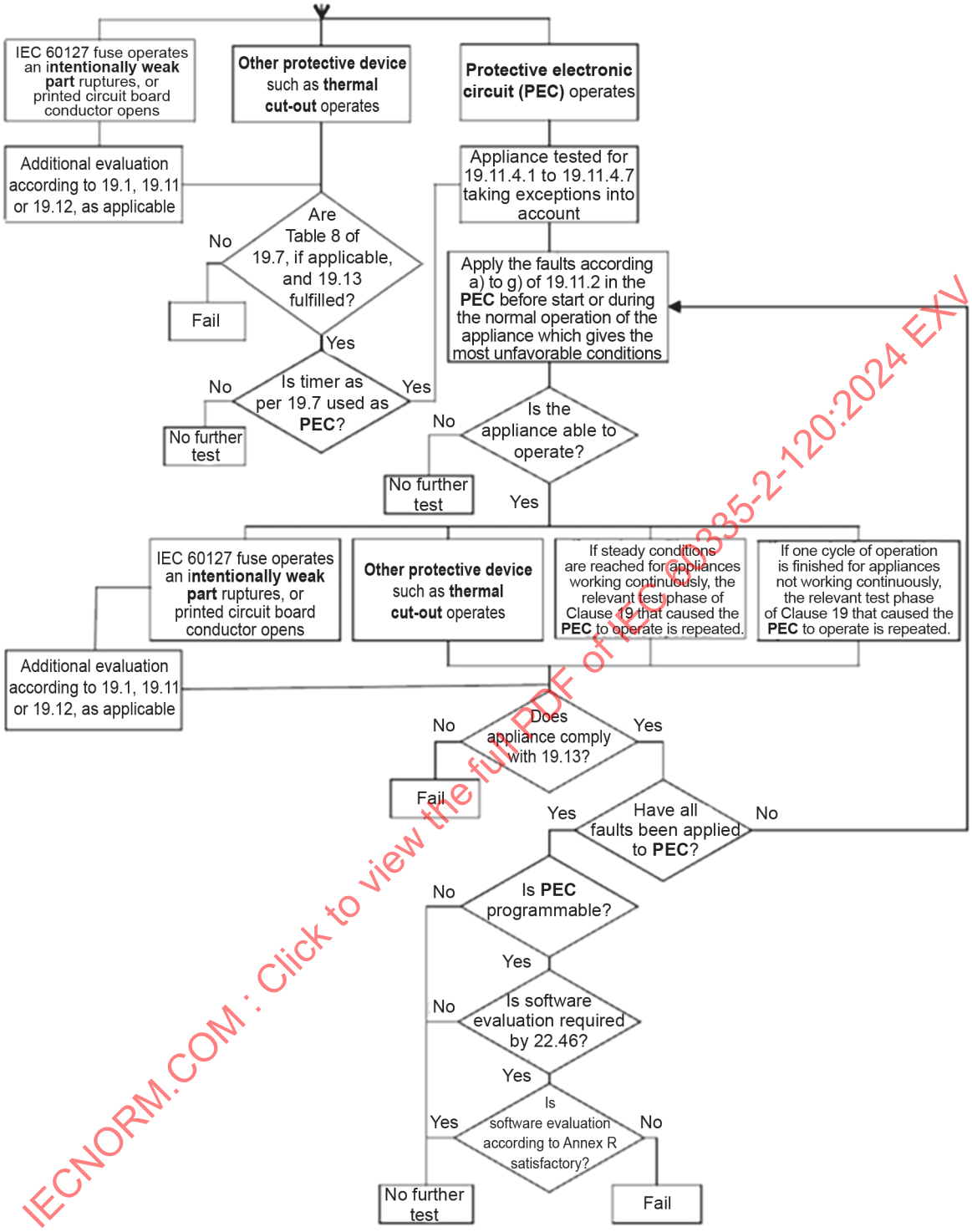

Figure Q.1 *(2 of 2)*

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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.1 of IEC 60730-1:2013 including IEC 60730-1:2013/AMD1:2015 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

R.2.1.1 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.3.4 inclusive.

R.2.1.2 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 60730-1:2013 including IEC 60730-1:2013/AMD1:2015, H.2.16.7);

– dual channel (homogenous) with comparison (see IEC 60730-1:2013 including IEC 60730-1:2013/AMD1:2015, H.2.16.3);

– dual channel (diverse) with comparison (see IEC 60730-1:2013 including IEC 60730-1:2013/AMD1:2015, H.2.16.2).

NOTE 1 Comparison between dual channel structures can be performed by:

- use of a comparator (see IEC 60730-1:2013 including IEC 60730-1:2013/AMD1:2015 H.2.18.3), or
- reciprocal comparison (see IEC 60730-1:2013 including IEC 60730-1:2013/AMD1:2015 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 60730-1:2013 including IEC 60730-1:2013/AMD1:2015 H.2.16.5);

– single channel with periodic self-test (see IEC 60730-1:2013 including IEC 60730-1:2013/AMD1:2015, H.2.16.6);

– dual channel without comparison (see IEC 60730-1:2013 including IEC 60730-1:2013/AMD1:2015, H.2.16.1).

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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 60730-1:2013 including IEC 60730-1:2013/AMD1:2015, 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.

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Table R.1 – General fault/error conditions

Component [a]	Fault/error	Acceptable measures [b, c]	Definitions See IEC 60730-1:2013 including IEC 60730-1:2013/ AMD1:2015
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
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

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Component [a]	Fault/error	Acceptable measures [b, c]	Definitions See IEC 60730-1:2013 including IEC 60730-1:2013/ AMD1:2015
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			
6.1 Data	Data corruption of up to 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
6.2 Addressing	Wrong address	Word protection with multi-bit redundancy including the address or CRC – single word including the addresses, 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
6.3 Timing	Wrong point in time Wrong sequence	Time-slot monitoring, or scheduled transmission Logical monitoring, or time-slot monitoring, or scheduled transmission	H.2.18.10.4 H.2.18.18 H.2.18.10.2 H.2.18.10.4 H.2.18.18
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

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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.

Table R.2 – Specific fault/error conditions

Component [a]	Fault/error	Acceptable measures [b, c]	Definitions See IEC 60730-1:2013 including IEC 60730-1:2013/AMD1:2015
1 **Central Processing Unit (CPU)**			
1.1 **Registers**	DC fault	Comparison of redundant CPUs by either:	
		– reciprocal comparison	H.2.18.15
		– independent hardware comparator, or	H.2.18.3
		internal error detection, or	H.2.18.9
		redundant memory with comparison, or	H.2.19.5
		periodic self-tests using either	
		– walkpat memory test	H.2.19.7
		– Abraham test	H.2.19.1
		– transparent GALPAT test; or	H.2.19.2.1
		word protection with multi-bit redundancy, or	H.2.19.8.1
		static memory test and	H.2.19.6
		word protection with single bit redundancy	H.2.19.8.2
1.2 **Instruction decoding and execution**	Wrong decoding and execution	Comparison of redundant CPUs by either:	
		– reciprocal comparison	H.2.18.15
		– independent hardware comparator, or	H.2.18.3
		internal error detection, or	H.2.18.9
		periodic self-test using equivalence class test	H.2.18.5
1.3 **Programme counter**	DC fault	Periodic self-test and monitoring using either:	H.2.16.7
		– independent time-slot and logical monitoring	H.2.18.10.3
		– internal error detection, or	H.2.18.9
		comparison of redundant functional channels by either:	
		– reciprocal comparison	H.2.18.15
		– independent hardware comparator	H.2.18.3

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Component [a]	Fault/error	Acceptable measures [b, c]	Definitions See IEC 60730-1:2013 including IEC 60730-1:2013/AMD1:2015
1.4 **Addressing**	DC fault	Comparison of redundant CPUs by either: – reciprocal comparison – independent hardware comparator; or internal error detection; or periodic self-test using – 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
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

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Component [a]	Fault/error	Acceptable measures [b, c]	Definitions See IEC 60730-1:2013 including IEC 60730-1:2013/AMD1:2015
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
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

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Component [a]	Fault/error	Acceptable measures [b, c]	Definitions See IEC 60730-1:2013 including IEC 60730-1:2013/AMD1:2015
6 **External communication**			
6.1 **Data**	Data corruption of up to Hamming distance 4	CRC – double word, or data redundancy or comparison of redundant functional channels by either – reciprocal comparison; or – independent hardware comparator	H.2.19.4.2 H.2.18.2.1 H.2.18.15 H.2.18.3
6.2 **Addressing**	Wrong address and multiple addressing	CRC – double word, including the address, or full bus redundancy of data and address, or comparison of redundant communication channels by either: – reciprocal comparison; or – independent hardware comparator	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 and logical monitoring, or comparison of redundant communication channels by either: – reciprocal comparison; or – independent hardware comparator	H.2.18.10.3 H.2.18.15 H.2.18.3
	Wrong sequence	Time-slot and logical monitoring, or comparison of redundant communication channels by either: – reciprocal comparison; or – independent hardware comparator	H.2.18.10.3 H.2.18.15 H.2.18.3
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

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Component [a]	Fault/error	Acceptable measures [b, c]	Definitions See IEC 60730-1:2013 including IEC 60730-1:2013/AMD1:2015
7.2 **Analog I/O**			
7.2.1 **A/D- and D/A-convertor**	Fault conditions 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
7.2.2 **Analog multiplexer**	Wrong addressing	Comparison of redundant CPUs by either: – 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, 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.			

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.

For appliances intended for **remote communication** through **public networks**, where normative Annex U is applicable as determined by 22.62, detection of a fault/error shall occur before compliance with normative Annex U 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.

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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. In addition, for appliances intended for **remote communication** through **public networks** where normative Annex U is applicable as determined by 22.62, the software and safety-related hardware under its control shall be initialized and shall terminate before compliance with normative Annex U 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 61508-3:2010 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.

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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*
Semi-formal methods	
Logical/functional block diagrams	
Sequence diagrams	
Finite state machines/state transition diagrams	*IEC 61508-7:2010, B.2.3.2*
Decision/truth tables	*IEC 61508-7:2010, C.6.1*

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*
Fault detection and diagnosis	*IEC 61508-7:2010, C.3.1*
Semi-formal methods:	
• *Logic/function block diagrams*	
• *Sequence diagrams*	
• *Finite state machines / state transition diagrams*	*IEC 61508-7:2010, B.2.3.2*
• *Data flow diagrams*	*IEC 61508-7:2010, C.2.2*

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 61508-7:2010, C.5.9);
- data flow analysis; (IEC 61508-7:2010, C.5.10);
- walk-through (software) (IEC 61508-7:2010, C.5.15);
- design review (IEC 61508-7:2010, C.5.16).

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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.

The module design shall specify:

– function(s);
– interfaces to other modules;
– data.

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 61508-7:2010, Subclause C.2.5) is recommended (e.g. range checks, check for division by 0, plausibility checks).

NOTE 3 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*
Limited size of software modules	*IEC 61508-7:2010, C.2.9*
Information hiding / encapsulation	*IEC 61508-7:2010, C.2.8*
One entry / one exit point in subroutines and functions	*IEC 61508-7:2010, C.2.9*
Fully defined interface	*IEC 61508-7:2010, C.2.9*
Semi-formal methods: • *Logic/function block diagrams* • *Sequence diagrams* • *Finite state machines / state transition diagrams* • *Data flow diagrams*	*IEC 61508-7:2010, B.2.3.2* *IEC 61508-7:2010, C.2.2*

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.

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Table R.6 – Design and coding standards

Technique / Measure	*Informative references*
Use of coding standard (see NOTE)	*IEC 61508-7:2010, C.2.6.2*
No use of dynamic objects and variables (see NOTE)	*IEC 61508-7:2010, C.2.6.3*
Limited use of interrupts	*IEC 61508-7:2010, C.2.6.5*
Limited use of pointers	*IEC 61508-7:2010, C.2.6.6*
Limited use of recursion	*IEC 61508-7:2010, C.2.6.7*
No unconditional jumps in programs in higher level languages	*IEC 61508-7:2010, C.2.6.2*
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 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*
Functional and black-box testing:	*IEC 61508-7:2010, B.5.1, B.5.2*
• *Boundary value analysis*	*IEC 61508-7:2010, C.5.4*
• *Process simulation*	*IEC 61508-7:2010, C.5.18*
Simulation, modelling:	
• *Finite state machines*	*IEC 61508-7:2010, B.2.3.2*
• *Performance modelling*	*IEC 61508-7:2010, C.5.20*

R.3.4 Management items

R.3.4.1 Management of software versions

A software version management system at the module level shall be put in place. All versions shall be uniquely identified for traceability.

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NOTE The use of a version ID number, if unique, is one possible solution.

Compliance is checked by inspection of the documentation.

R.3.4.2 Software modification

R.3.4.2.1 Software modifications shall be based on a modification request which details the following:

– the hazards which may be affected;
– the proposed change;
– the reasons for change.

R.3.4.2.2 An analysis shall be carried out to determine the impact of the proposed modification on functional safety.

R.3.4.2.3 A detailed specification for the modification shall be generated including the necessary activities for verification and validation, such as a definition of suitable test cases.

R.3.4.2.4 The modification shall be carried out as planned.

R.3.4.2.5 The assessment of the modification shall be carried out based on the specified verification and validation activities. This may include:

– a reverification of changed software modules;
– a reverification of affected software modules;
– a revalidation of the complete system.

R.3.4.2.6 All details of modification activities shall be documented.

Compliance of the requirements in R.3.4.2.1 to R.3.4.2.6 is checked by inspection of the documentation.

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