
British Standard Specification for
**Safety requirements for mains-operated
electronic and related apparatus for
household and similar general use**

(Implementation of CENELEC HD 195.S6)

Règles de sécurité pour les appareils électroniques et appareils
associés à usage domestique ou à usage général analogue, reliés à un réseau

Sicherheitsanforderungen für netzbetriebene elektronische und
verwandte Geräte für den Gebrauch im Haushalt und ähnliche Zwecke

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Foreword

This revision of BS 415 has been prepared under the direction of the Electronic Equipment Standards Policy Committee. It implements Harmonization Document HD 195.S6 of the European Committee for Electrotechnical Standardization (CENELEC), which is based on IEC* Publication 65 (1985), fifth edition, 'Safety requirements for mains-operated electronic and related apparatus for household and similar general use'.

The CENELEC Harmonization Document was approved by the CENELEC Technical Board on 7 March 1989.

This edition of BS 415 is in agreement with IEC Publication 65 (fifth edition) except:

- (a) the CENELEC modifications that appear in HD 195.S6 have been included in the text in the appropriate position and are indicated by a single side line in the margin of the page;
- (b) it has been amended by declared UK deviations and Special National Conditions to the harmonization document; these have been included in the text and are indicated by a double side line in the margin of the page.

CENELEC harmonization documents recognize certain national deviations which cannot, for the moment, be removed. In the event of any conflict between the requirements in the Harmonization Document and the requirement in the United Kingdom deviation, the requirement in the United Kingdom deviation takes precedence and users of this British Standard should operate to the United Kingdom deviation.

Compliance with The Low Voltage Electrical Equipment (Safety) Regulations: 1989 will generally be assured if equipment complies with the requirements of BS 415.

Appendix A gives additional requirements for the safety of splashproof mains-operated electronic equipment.

NOTE. This standard calls for the use of substances and/or test procedures that may be injurious to health if adequate precautions are not taken. It refers only to technical suitability and does not absolve the user from legal obligations relating to health and safety at any stage. Particular care should be taken, for example, when performing tests in accordance with 11.2, item (b) of 14.4.1, 18.1, 20.1 and 20.2. Guidance regarding specific hazards is given in the text but this does not purport to be exhaustive.

In order to expedite publication and for ease of reproduction, the text of IEC Publication 65 (fifth edition) has been used as the basis of this British Standard. As a result some terminology and certain conventions are not identical with those used in British Standards. For the purposes of this British Standard any references to IEC page numbers in the text should be ignored.

In this British Standard the following print types are used to differentiate between requirements, test specifications and explanatory matter.

Requirements: in roman type.

Test specifications: in *italic type*.

Explanatory matter: in small roman type.

Additional information

The following typographical errors in the text of IEC Publication 65 (fifth edition) have been corrected in this British Standard.

- (a) In 9.1.1, line 3, 'be' has been inserted between 'not' and 'live'.
- (b) In 18.2.1, item (a), line 2, the spelling of 'humidity' has been corrected.
- (c) In table III a note that should have been deleted has been removed.

Cross-references

International standard	Corresponding British Standard
IEC 68-2-2 : 1974	BS 2011 Basic environmental testing procedures Part 2.1B : 1977 Tests B. Dry heat (Identical)
IEC 68-2-3 : 1969	Part 2.1Ca : 1977 Test Ca. Damp heat, steady state (Identical)
IEC 68-2-6 : 1982	Part 2.1Fc : 1983 Test Fc. Vibration (sinusoidal) (Identical)
IEC 127 : 1974	BS 4265 : 1977 Specification for cartridge fuse links for miniature fuses (Identical)
IEC 169-2 : 1965	BS 3041 Radio-frequency connectors Part 2 : 1977 Specification for coaxial unmatched connector (Identical)
IEC 249-1 : 1982	BS 4584 : Metal clad base materials for printed wiring boards Part 1 : 1983 Methods of test (Identical)
IEC 417 : 1973	BS 6217 : 1981 Guide to graphical symbols for use on electrical equipment (Identical)

*IEC = International Electrotechnical Commission.

International standard	Corresponding British Standard
IEC 529 : 1976	BS 5490 : 1977 Specification for classification of degrees of protection provided by enclosures (Identical)
IEC 536 : 1976	BS 2754 : 1976 Memorandum. Construction of electrical equipment for protection against electric shock (Technically equivalent)
IEC 695-2-2 : 1980	BS 6458 Fire hazard testing for electrotechnical products Part 2 : Methods of test Section 2.2 : 1984 Needle-flame test (Identical)
ISO 306 : 1974	BS 2782 : Methods of testing plastics Part 1. Thermal properties. Methods 120A to 120E : 1976 Determination of the Vicat softening temperature of thermoplastics (Technically equivalent)
ISO 4046 : 1978	BS 3203 : 1979 Glossary of paper, board, pulp and related terms (Identical)
EN 60 950 : 1988 (IEC 950 (1986) modified)	BS 7002 : 1989 Specification for safety of information technology equipment including electrical business equipment (Identical)

The Technical Committee has reviewed the provisions of IEC 27, IEC 83, IEC 130-2, IEC 130-8, IEC 130-9, IEC 169-3, IEC 173, IEC 227-2 and IEC 326-2B, together with those listed below which are related to British Standards, and has decided that they are acceptable for use in conjunction with this standard.

International standard	Related British Standard
IEC 85	BS 2757 : 1986 Method for determining the thermal classification of electrical insulation
IEC 167 : 1974	BS 903 Methods of testing vulcanized rubber Part C5 : 1983 Determination of insulation resistance
IEC 227	BS 6500 : 1984 Specification for insulated flexible cords and cables
IEC 245	BS 6007 : 1983 Specification for rubber-insulated cables for electric power and lighting BS 6500 : 1984 Specification for insulated flexible cords and cables
IEC 249-2 : 1970	BS 4584 Metal clad base materials for printed wiring boards: Part 2 : 1972 : Epoxide woven glass fabric copper-clad laminated sheet, general purpose grade: EP-GC-Cu-2
IEC 260 : 1968	BS 3718 : 1964 Specification for laboratory humidity ovens (non-injection type)
IEC 317	BS 6811 Winding wires Part 3 : 1987 Specifications for particular types of round copper winding wires*

The reference to BS 3196 'Cotton cheese cloth : tubulars, flats and caps' in the note to 14.4.4 is given for information only. BS 3196 has been withdrawn but this does not affect the validity of this standard.

Product approval. Attention is drawn to the fact that products conforming to this British Standard may be approved by the British Electrotechnical Approvals Board for the purposes of participation in the CENELEC Certification Agreement and in the CB Scheme of the IECEE. (Details of the BEAB approval mark scheme are given on the inside back cover.)

Compliance with a British Standard does not of itself confer immunity from legal obligations.

*With reference to requirements relating to test 13.

British Standard Specification for

Safety requirements for mains-operated electronic and related apparatus for household and similar general use

1. Scope

1.1 This British Standard applies to the following apparatus that is to be connected to the supply mains, either directly or indirectly, intended for domestic and similar general indoor use and not subject to dripping or splashing:

- radio receiving apparatus for sound or vision;
- amplifiers;
- independent load transducers and source transducers;
- motor-driven apparatus which comprise one or more of the above-mentioned apparatus, or can be used only in combination with one or more of them, such as radio-gramophones and tape recorders;
- other apparatus obviously provided to be used in combination with the above-mentioned apparatus, such as antenna amplifiers, supply apparatus and cable-connected remote control devices;
- battery eliminators.

Equipment explicitly mentioned in the scope of EN 60 950 is not covered by this standard.

In the absence of an appropriate standard for professional apparatus likely to be operated by laymen, this standard will be used in so far as it is applicable.

Supplementary requirements for splash-proof electronic equipment are given in Appendix A, page 137.

1.2 This standard applies to apparatus for use at altitudes up to 2 000 m.

For apparatus to be used in tropical climates, different requirements, as mentioned in the relevant clauses, are applicable.

1.3 This standard does not apply to apparatus designed for a rated supply voltage exceeding:

- 433 V (r.m.s.) between phases in the case of apparatus for three-phase supply;
- 250 V (r.m.s.) in all other cases.

1.4 This standard is concerned with safety only and not with the other properties of the apparatus (see Clause 3).

1.5 (Sub-clause deleted)

2. Definitions

The following definitions apply for the purpose of this standard:

2.1 The *type test* of a product is the complete series of tests to be carried out on a number of specimens representative of the type, with the object of determining whether a particular manufacturer can be considered to be able to produce products meeting the standard.

- 2.2 *By hand* denotes that the operation does not require the use of an object such as a tool, coin, etc.
- 2.3 *Accessible part* denotes a part which can be touched by the standard test finger (see Sub-clause 9.1.1).
Any accessible area of a non-conducting part is considered as being covered with a conductive layer (see Sub-clause 4.3.1).
- 2.4 *Live part* denotes a part contact with which may cause a significant electric shock (see Sub-clause 9.1.1).
- 2.5 *Creepage distance* denotes the shortest distance along the surface of an insulating material between two conductive parts.
- 2.6 *Clearance* denotes the shortest distance in air between two conductive parts.
- 2.7 *Supply mains* denotes any power source with an operating voltage of more than 34 V (peak) which is not used solely to supply the equipment specified in Sub-clause 1.1.
- 2.8 *Rated supply voltage* denotes the supply mains voltage or mains voltage range (for three-phase supply, the line-to-line voltage) for which the manufacturer has designed the apparatus.
- 2.9 *Part directly connected to the supply mains* denotes a part of an apparatus which is in electrical connection with the supply mains in such a way that a connection between the part and either pole of the supply mains causes in that connection a current equal to or greater than 9 A.
A current of 9 A is chosen as the minimum rupturing current of a 6 A fuse.
In tests to determine which parts are directly connected to the supply mains, fuses in the apparatus are not short-circuited.
- 2.10 *Part conductively connected to the supply mains* denotes a part of an apparatus which is in electrical connection with the supply mains in such a way that a connection through a resistance of 2 000 Ω between the part and either pole of the supply mains causes in that resistance a current greater than 0.7 mA (peak), the apparatus not being connected to earth.
- 2.11 *Supply apparatus* denotes an apparatus which takes energy from the mains and from which one or more other apparatus are fed.
- 2.12 *Battery eliminator* denotes a supply apparatus which may be used instead of the battery supply of an electronic apparatus.
- 2.13 *Remote control device* denotes a device for controlling an apparatus from a distance, either mechanically, electrically or by means of radiation.
- 2.14 *Source transducer* denotes any apparatus intended to convert the energy of a non-electrical signal to electrical energy.
Examples: gramophone pick-up, microphone, magnetic reproducing head.
- 2.15 *Load transducer* denotes any apparatus intended to convert the energy of an electrical signal into another form of energy.
Examples: loudspeaker, record cutting head, picture tube.
- 2.16 *Portable apparatus* denotes an apparatus specifically designed to be carried easily by hand. However, such an apparatus is not considered portable if its mass exceeds 15 kg.
- 2.17 *Terminal device* denotes a part of an apparatus by which connection is made to external conductors or other apparatus; it may contain several terminal contacts.

- 2.18 *Protective earth terminal* denotes a terminal to which are connected parts that must be earthed for safety reasons.
- 2.19 *Functional earth terminal* denotes a terminal to which are connected parts which it may be necessary to connect to earth for reasons other than safety.
- 2.20 *Thermal release* denotes a device which prevents the maintenance of excessively high temperatures in certain parts of the apparatus by disconnecting those parts from their supply.
- 2.21 *Protective switch* denotes a device which interrupts the supply mains for safety reasons when a cover is opened.
- 2.22 *Audio amplifier* denotes either an independent audio amplifying apparatus or the audio amplifying part of an apparatus for which this standard applies.
- 2.23 *Rated load impedance of the output circuit of an audio amplifier* denotes the resistance, specified by the manufacturer, by which that output circuit should be terminated.
- 2.24 *Minimum input voltage for rated temperature-limited output power of an audio amplifier* denotes the voltage which must be supplied to a given set of input terminals at flat response curve, if adjustable, to obtain the rated temperature-limited output power, the apparatus being adjusted for maximum sensitivity and the frequency being 1 000 Hz unless otherwise specified by the manufacturer.
- 2.25 *Minimum input voltage for rated output power of an audio amplifier* denotes the voltage which must be supplied to a given set of input terminals at flat response curve, if adjustable, to obtain the rated output power, the apparatus being adjusted for maximum sensitivity and the frequency being 1 000 Hz unless otherwise specified by the manufacturer.
- 2.26 *Rated temperature-limited output power of an audio amplifier* denotes the power, specified by the manufacturer, which this apparatus is capable of supplying continuously to the rated load impedance without exceeding the maximum permissible temperature at any point, the frequency being within the range specified by the manufacturer.

It is possible that for certain frequency ranges, the apparatus can sustain continuously a higher output power than the rated temperature-limited output power.

- 2.27 *Rated output voltage of an audio amplifier* denotes the voltage at a given set of output terminals which corresponds to the rated output power.
- 2.28 *Rated output power of an audio amplifier* denotes the sine wave power dissipated in the rated load impedance, this power and the corresponding distortion being specified by the manufacturer, the frequency being 1 000 Hz, unless otherwise specified by the manufacturer.

In general, an audio amplifier cannot supply the rated output power for an unlimited period. This power appears only for short durations, for example, at peaks of modulation.

- 2.29 *Rated input voltage of a loudspeaker* denotes the maximum voltage, specified by the manufacturer, which can be supplied to the sound circuit of the loudspeaker, the frequency being 1 000 Hz unless otherwise specified by the manufacturer.
- 2.30 *Rated input impedance of a loudspeaker* denotes the impedance, specified by the manufacturer, of the sound circuit of the loudspeaker, the frequency being 1 000 Hz unless otherwise specified by the manufacturer.
- 2.31 *Rated input power of a loudspeaker* denotes the maximum power, specified by the manufacturer which can be supplied to the sound circuit of the loudspeaker, the frequency being 1 000 Hz unless otherwise specified by the manufacturer.

In general, the rated input power cannot be supplied continuously to the loudspeaker. This power appears only for short durations, e.g. at peaks of modulation.

- 2.32 *Printed board* denotes a base material cut to size, containing all holes and bearing at least one conductive pattern.
- 2.33 *Conductive pattern* denotes a configuration formed by electrically conductive material of a printed board.
- 2.34 *Basic insulation* denotes an insulation applied to live parts to provide basic protection against electric shock.
- 2.35 *Supplementary insulation* denotes an independent insulation applied in addition to basic insulation in order to provide protection against electric shock in the event of a failure of the basic insulation.
- 2.36 *Double insulation* denotes an insulation comprising both basic insulation and supplementary insulation.
- 2.37 *Reinforced insulation* denotes a single insulation system applied to live parts which provides a degree of protection against electric shock equivalent to double insulation under the conditions specified in this standard.

The term "insulation system" does not imply that the insulation must be one homogeneous piece. It may comprise several layers which cannot be tested singly as supplementary or basic insulation.

- 2.38 *Class I apparatus* denotes an equipment in which protection against electric shock does not rely on basic insulation only, but which includes an additional safety precaution in such a way that means are provided for the connection of accessible conductive parts to the protective (earthing) conductor in the fixed wiring of the installation in such a way that accessible conductive parts cannot become live in the event of a failure of the basic insulation.

Such apparatus may have parts consisting of Class II construction.

- 2.39 *Class II apparatus* denotes an equipment in which protection against electric shock does not rely on basic insulation only, but in which additional safety precautions, such as double insulation or reinforced insulation, are provided, there being no provision for protective earthing or reliance upon installation conditions.

Definitions 2.34 to 2.39 are according to IEC Publication 536: Classification of Electrical and Electronic Equipment with Regard to Protection Against Electric Shock.

- 2.40 *All-pole mains switch* denotes a switch or switching system which is intended to disconnect all parts of the apparatus, except those indicated in Sub-clause 14.6.1, from all poles of the supply mains.

One example of a switching system is a combination of a relay and a switch controlling the relay.

- 2.41 *Single-pole mains switch* denotes a switch or switching system which is intended to disconnect all parts of the apparatus, except those indicated in Sub-clause 14.6.1, from one pole only of the supply mains.

One example of a switching system is a combination of a relay and a switch controlling the relay.

- 2.42 *Functional switch* denotes a switch or switching system, other than an all-pole mains switch or a single-pole mains switch, situated anywhere in the circuit of the apparatus and which can interrupt the intended function, such as sound or vision.

One example of a switching system is a combination of a relay and a switch controlling the relay.

- 2.43 *Non clipped output power* of an audio amplifier denotes the maximum attainable sinewave power dissipated in the rated load impedance, measured at 1000 Hz at the onset of clipping. In cases where the amplifier is not intended for operation at 1000 Hz, a test frequency at the nominal peak response of the amplifier shall be used.

3. General requirements

The apparatus shall be so designed and constructed as to present no danger, either in normal use or under fault conditions, providing particularly:

- personal protection against electric shock;
- personal protection against the effects of excessive temperature;
- personal protection against the effects of ionizing radiation;
- personal protection against the effects of implosion;
- personal protection against the effects of mechanical instability and of moving parts;
- protection against fire.

The apparatus shall be constructed so as to ensure adequate protection against electric shock by the provision of either earthing (Class I construction) or special insulation methods (Class II construction).

In general, compliance is checked under normal operating conditions and under fault conditions, as specified in Sub-clauses 4.2 and 4.3, by carrying out all the tests indicated.

4. General conditions for tests

4.1 Conduct of tests

4.1.1 *Tests according to this standard are type tests.*

4.1.2 *All tests are carried out on one and the same apparatus in the order of the clauses, as far as this is possible.*

4.1.3 *Unless otherwise specified, tests are made under normal operating conditions at an ambient temperature within the range of 15 °C to 35 °C, a relative humidity of 45% to 75% and an air pressure of 860 mbar to 1 060 mbar.*

For referee tests only, the three standard atmospheres in Table I are recognized and it is recommended that only one of these be used for any particular application.

TABLE I

	a	b	c
Temperature	20 ± 2 °C	23 ± 2 °C	27 ± 2 °C
Relative humidity	60% to 70%	45% to 55%	60% to 70%
Air pressure	860 mbar to 1 060 mbar		

4.1.4 *Unless otherwise specified:*

- *the currents and voltages are substantially sinusoidal;*
- *measurements of voltages and currents are carried out with instruments which do not appreciably affect the values to be measured.*

4.1.5 *In the case of an audio amplifier, the rated output power is supplied to the rated load impedance by applying a standard signal taken from a white-noise signal generator. The signal is supplied to the apparatus via a double RC low-pass filter with a time constant $\tau = 250 \mu\text{s}$ and a double RC high-pass filter with a time constant $\tau = 5 \text{ ms}$ (see Figures 2a and 2b, pages 119 and 120).*

The output measuring equipment shall be frequency and waveform independent.

If appropriate, the standard signal may be used to modulate a carrier wave.

4.2 *Normal operating conditions*

Normal operating conditions are considered to consist of the most unfavourable combination of the following conditions:

4.2.1 *Any position of normal use of the apparatus, normal ventilation not being impeded.*

This will be obtained by positioning the apparatus on a horizontal support having dimensions not smaller than that of the apparatus base, leaving a free space of not less than 5 cm depth behind the apparatus.

When determining the accessible parts with the test finger in accordance with Sub-clause 9.1.1, this condition does not apply.

Tests on apparatus intended to be part of an assembly not provided by the apparatus manufacturer, shall be carried out according to the instructions for use provided by the manufacturer, specifically those dealing with the proper ventilation of the apparatus.

4.2.2 *A supply voltage of 0.9 times or 1.1 times any rated supply voltage for which the apparatus is set.*

For apparatus having a rated supply voltage range not requiring the adjustment of a voltage setting device, a supply voltage of 0.9 times the lower limit or 1.1 times the upper limit of any rated supply voltage range; if necessary, a supply voltage of 0.9 times or 1.1 times any nominal supply voltage within the range marked on the apparatus.

Any rated frequency of the supply voltage.

For a.c./d.c. apparatus, a.c. or d.c. supply.

4.2.3 *Any position of controls which are accessible to the user for adjustment by hand, except voltage setting devices complying with Sub-clause 14.8 and taking into account the conditions specified in Sub-clause 4.2.6.*

Any remote control device connected or not.

4.2.4 *Any earth terminal being connected to earth or not, and either pole of the isolated supply source, used during the test, being earthed.*4.2.5 *The apparatus being used for reception or reproduction or not.*4.2.6 *In addition, for an audio amplifier*

a) the terminals of each input circuit short-circuited or not;

b) the apparatus operated in such a way as to deliver one-eighth of the rated output power to the rated load impedance, using the standard signal described in Sub-clause 4.1.5 or

the apparatus is operated in such a way as to deliver one-eighth of the non clipped output power to the rated load impedance using the standard signal described in Sub-clause 4.1.5.

Where clipping is not possible, one-eighth of the maximum attainable power is taken.

c) if the rated temperature-limited output power is marked on the apparatus, the apparatus operated in such a way as to provide the rated temperature-limited output power to the rated load impedance, using the standard signal described in Sub-clause 4.1.5;

d) the rated load impedance of any output circuit being connected or not.

The above test conditions should be maintained for as short a time as is necessary to make the relevant measurements.

4.2.7 *For motor-driven apparatus, load conditions in accordance with the instructions for use given by the manufacturer or the conditions of load which may reasonably be assumed if these are less favourable.*

When testing motor-driven apparatus, other parts of the apparatus are not disconnected during the test.

- 4.2.8 *Apparatus supplying power to other apparatus for example battery eliminators, loaded to give its rated power or not loaded.*
- 4.2.9 *A battery eliminator having the dimensions specified for a standard battery or an assembly of such batteries is tested in a battery compartment of the most unfavourable design.*
A battery eliminator to be used inside apparatus, for which it is intended, is tested within such apparatus, according to the manufacturer's instructions.
- 4.2.10 *Apparatus intended to be used with optional detachable legs or stands supplied by the manufacturer of the apparatus are tested with or without the legs or stands fitted.*

4.3 Fault conditions

Operation under fault conditions denotes that, in addition to the normal operating conditions mentioned in Sub-clause 4.2, each of the following conditions is applied in turn and, associated with it, those other fault conditions which are a logical consequence.

Examination of the apparatus and its circuit diagram will generally show the fault conditions which should be applied. These are applied in sequence in the order which is most convenient.

- 4.3.1 *Short circuit across creepage distances and clearances if they are less than the values indicated by curve A in Table II.*

If an insulating part contains a groove of less than 1 mm width, the creepage distance is not measured over the surface of the groove but only across its width.

If a clearance consists of two or more air gaps in series separated by conductive parts, any gap of less than 1 mm width is ignored in computing the total distance unless the total distance as required in Table II is less than 1 mm. However, individual gaps of less than 0.5 mm are ignored.

This does not imply that dimensional requirements of insulations specified in Sub-clauses 9.3.7 and 9.3.8 can be ignored.

If an insulating barrier consists of two parts separated by a capillary slit, the path along the slit must be taken into account when measuring creepage distances and clearances.

The specified creepage distances and clearances are the minimum actual separations taking into account tolerances in assemblies and piece-parts.

Guidance for the determination of creepage distances and clearances involving enamelled wires is given in Sub-clause 4.3.3.

In the determination of creepage distances and clearances between accessible parts and live parts, when using the standard test finger, any accessible zone of a non-conductive part is considered as being covered with a conductive layer (see Figure 1, page 118, as an example).

The voltages mentioned in Table II are determined with the apparatus connected to the rated supply voltage after the steady state has been reached.

Creepage distances and clearances are measured with conductors and plugs in their normal positions.

Between conductors, one of which may be conductively connected to one pole of the supply mains, which are on a printed board complying with the pull-off and peel strength requirements specified in IEC Publication 249-2: Base Materials for Printed Circuits, Part 2: Specifications, the requirements for creepage distances and clearances are modified.

The dimensions of Table II are replaced by the values calculated from the formula:

$$\log d = 0.78 \log \frac{\hat{V}}{300}, \text{ with a minimum of } 0.5 \text{ mm.}$$

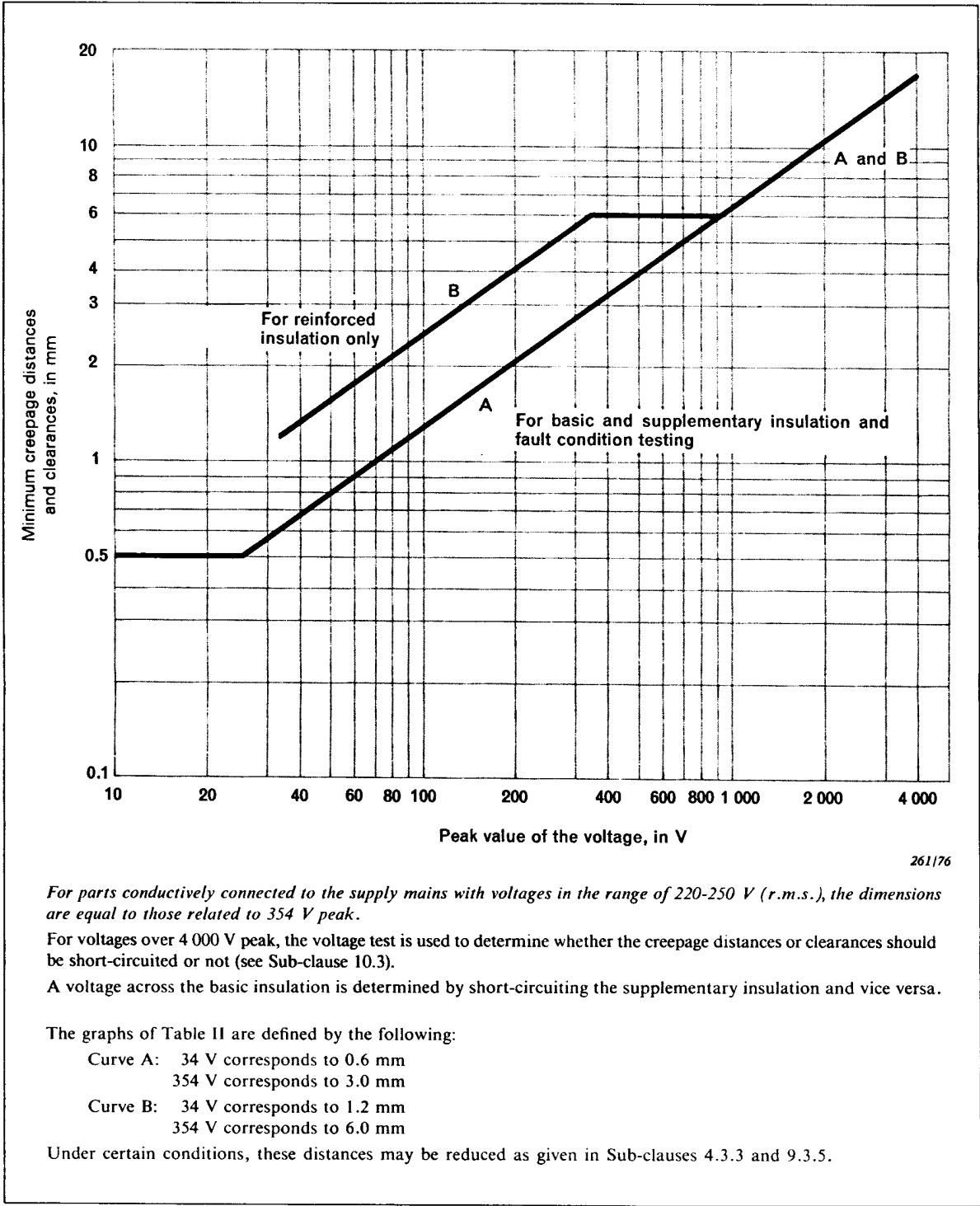
where d is the distance in millimetres and $\hat{V}$ the peak value of the voltage in volts. These distances can be determined by reference to Figure 13, page 129.

This reduction in creepage distances is permitted only as far as overheating is concerned (see Sub-clause 11.2).

The above reduced values apply to the conductors themselves, but not to mounted components or associated soldered connections.

Coverings of lacquer or the like on printed boards are ignored when calculating the distances.

TABLE II



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4.3.2 *Short-circuit across, or if applicable, interruption of:*

- heaters in electronic tubes;
- insulation between heaters and cathodes of electronic tubes;
- spacings in electronic tubes, excluding picture tubes;
- semiconductor devices.

Interruption of filaments in dial lamps.

If electronic tubes are so constructed that a short circuit between certain electrodes is highly improbable or even impossible, the electrodes concerned need not be short-circuited.

4.3.3 *Short circuit across insulation consisting of covering of lacquer, enamel or textile. Such coverings are ignored in assessing the creepage distances and clearances specified in Table II. However, if enamel forms the insulation of a wire and withstands the voltage test prescribed for Grade 2 of IEC Publication 317: Specifications for Particular Types of Winding Wires, Clause 13, it is considered as contributing 1 mm to those creepage distances and clearances.*

This sub-clause does not imply a need to short-circuit the insulation between turns of coils, insulating sleeves or tubings.

4.3.4 *Short circuit across variable air capacitors and electrolytic capacitors.*

4.3.5 *Short circuit across insulating parts, the short-circuiting of which might cause an infringement of the requirements regarding protection against electric shock or overheating, with the exception of insulating parts which comply with the requirements of Sub-clause 10.3.*

4.3.6 *Short circuit or disconnection, whichever is more unfavourable, of capacitors, resistors or inductors other than transformers and motors, the short-circuiting or disconnection of which might cause an infringement of the requirements regarding protection against electric shock or overheating.*

These fault conditions do not apply to:

- resistors complying with the requirements of Sub-clauses 11.2 and 14.1;
- inductors complying with the requirements of Sub-clause 14.3;
- capacitors complying with the requirements of Sub-clause 14.2, provided that the voltage at their terminals does not exceed 354 V (peak).

In order to determine which are the insulating parts and the components (mentioned in Sub-clauses 4.3.5 and 4.3.6), the short-circuiting or disconnection of which might cause an infringement of the requirements regarding protection against electric shock or overheating, the apparatus is inspected and its circuit diagram is studied.

4.3.7 *Loosening, by a quarter of a turn, unlocked screws or similar devices which are used for fixing covers over live parts.*

4.3.8 *Stopping of forced cooling.*

4.3.9 *For audio amplifiers:*

- the connection of the most unfavourable load impedance to the output terminals, including short circuit;
- the apparatus operated so as to deliver any output power from zero up to the non-clipped output power to the rated load impedance using the standard signal described in Sub-clause 4.1.5.

4.3.10 *Locking of moving parts of apparatus provided with:*

- motors having a locked rotor torque smaller than the full load torque;
- motors intended to be started by hand;
- motors with moving parts which can be jammed by mechanical failures or by handling of the equipment, if such a failure or handling is probable.

4.3.11 *Continuous operation of motors, relay coils or the like, intended for short-time or intermittent operation, if continuous operation may occur accidentally.*

4.3.12 *Short-circuit of the capacitors of the auxiliary winding circuit of motors, with the exception of self-healing capacitors (e.g. of the metallized paper type).*

4.3.13 *For terminal devices of apparatus, for example, battery eliminators, supplying power to the apparatus, except for mains socket-outlets directly connected to the supply mains, connection of the most unfavourable load impedance, including short circuit.*

- 4.3.14 *Simultaneous connection to alternative types of supply permitted by the design, unless this is prevented by the construction.*

5. Marking

5.1 General

The apparatus shall be marked in accordance with the requirements of Sub-clauses 5.2, 5.3, 5.4 and 5.6.

The marking shall be:

- easily discernible on the apparatus when ready for use, in such a way that there can be no misunderstanding;
- indelible and legible.

Compliance is checked by inspection and by the following test.

The marking shall not be removed when rubbed lightly with a piece of cloth soaked with petroleum spirit or water.

The information should preferably be put on the exterior of the apparatus, excluding the bottom. It is, however, permissible to put it on another place that is easily accessible by hand, e.g. under the lid or under an easily removable turntable of a record-player, or on the exterior of the bottom of a small and light apparatus, provided that the location of the marking is given in the instructions for use.

Letter symbols for quantities and units shall be in accordance with IEC Publication 27: Letter Symbols to be Used in Electrotechnology.

Graphical symbols shall be in accordance with IEC Publication 417: Graphical Symbols for Use on Equipment. Index, Survey and Compilation of the Single Sheets.

Fuse holders shall be marked in accordance with Sub-clause 14.5.2.

Mains switches shall be marked in accordance with Sub-clause 14.6.7.

Where user instructions are necessary for the safe use of the apparatus, they should be provided either permanently on the equipment or as a separate document. These instructions shall be written in the official language/s of the member country in which the apparatus is supplied.

Compliance is checked by inspection.

5.2 Identification

The apparatus shall be identified by:

- a) manufacturer's name or registered trade mark;
- b) model number or name.
- c) the double square symbol  (417-IEC-5172) in case of Class II apparatus.

Compliance is checked by inspection.

The symbol of item c) shall be so placed that it will be obvious that it is a part of the technical information and is unlikely to be confused with the maker's name or trademark.

5.3 Mains supply

The apparatus shall be marked with the following information:

- a) Nature of supply:
 - a.c. only with the symbol $\sim$;
 - d.c. only with the symbol — or == .
- b) Rated supply voltage or range of the rated supply voltages which can be applied without operating a voltage setting device.
- c) Apparatus which can be set to different rated supply voltages shall be so constructed that the indication of the voltage to which the apparatus is set is discernible on the apparatus when ready for use. If the apparatus is so constructed that the user can alter the supply voltage setting, the action of changing the setting shall change also the indication.

If the apparatus is provided with more than one voltage setting device, it shall be clear whether all devices shall be set for the same voltage.

- d) Rated mains frequency (or range of frequencies) in hertz, if safety is dependent on the use of the correct mains frequency.
- e) If there is a socket-outlet to provide power to other equipment, the voltage (if different from the supply voltage) and the power or current which may be drawn.

Compliance is checked by inspection.

- *f) If live parts are made accessible when a cover is removed or opened, a warning shall be displayed.

Compliance is checked by inspection.

- *g) For class I apparatus, the following information shall be given in the user instructions and on a label attached to the free end of the mains flexible cord, if this is permanently connected to the apparatus; otherwise the label shall be attached to or near the mains input terminals:

WARNING: THIS APPARATUS MUST BE EARTHED

- *h) For class I apparatus supplied with a flexible cord having cores coloured green-and-yellow, brown, and blue a label shall state the following:

IMPORTANT. The wires in this mains lead are coloured in accordance with the following code:

Green-and-yellow	: Earth
Blue	: Neutral
Brown	: Live

In addition the user instructions and label shall include the substance of the following:

As the colours of the wires in the mains lead of this apparatus may not correspond with the coloured markings identifying the terminals in your plug proceed as follows:

The wire which is coloured green-and-yellow must be connected to the terminal in the plug which is marked by the letter E or by the safety earth symbol  or coloured green or green-and-yellow.

The wire which is coloured blue must be connected to the terminal which is marked with the letter N or coloured black.

The wire which is coloured brown must be connected to the terminal which is marked with the letter L or coloured red.

- *i) For class II apparatus supplied with a flexible cord having two cores only, the user instructions shall be as specified in Sub-clause 5.3 h) but omitting reference to the earth core, making it clear that neither core is to be connected to the earth terminal of a three-pin plug.

5.4 Terminal devices

Terminal devices shall be marked with the following symbols:

- a) Protective earth terminal, if any:  (417-IEC-5019);
- b) terminal devices which are live under normal operating conditions, with the exception of terminals for mains supply and mains socket-outlets:  (417-IEC-5036).

The flash shall point to the terminal device.

This symbol may only be used to indicate the existence of a live terminal and may not be used to label non-live terminals for the purpose of avoiding more stringent insulation requirements.

Compliance is checked by inspection; the marking of a protective earth terminal need not be discernible from the outside (see Sub-clause 15.2).

For information purposes, it may be useful:

- 1) to mark apparatus suitable for both a.c. and d.c. with the symbol  (417-IEC-5033)
- 2) to mark each terminal device of an independent loudspeaker with any two of the following:
 - the rated input voltage or range of rated input voltages;
 - the rated input impedance or range of input impedances;
 - the rated input power;

*Items f) to i) of sub-clause 5.3 are shown as UK Special National Conditions in HD 195.S6.

3) to give, for the testing of audio amplifiers the following:

- rated output power;
- rated temperature-limited output power;
- rated load impedances, or rated output voltages, of all output circuits;
- minimum input voltage for rated output power;
- minimum input voltage for rated temperature-limited output power;
- range of signal frequencies for which the apparatus is designed.

5.5 Where in a manufacturer's service documentation, for example in circuit diagrams or lists of components, a symbol is used to indicate that a specific component shall be replaced only by the component specified in that documentation for safety reasons, the following symbol shall be used:



This symbol shall not be placed on components or on printed boards.

Compliance is checked by inspection.

5.6 Instructions for use

For mains powered apparatus which can also be powered by batteries, the instructions for use shall state that the apparatus shall not be exposed to dripping or splashing.

Compliance is checked by inspection.

6. Ionizing radiations

The apparatus shall be so constructed that personal protection against ionizing radiation is provided.

Compliance is checked by measuring the radiation produced by the apparatus.

The exposure rate at any readily accessible point is determined under normal operating conditions, by means of a radiation monitor with an effective area of 10 cm², at a distance of 5 cm from the outer surface of the apparatus.

All controls accessible from the outside by hand or by a screwdriver or any other tool, and those internal adjustments or pre-sets which are not locked in a reliable manner, are adjusted so as to give maximum radiation whilst maintaining an intelligible picture for 1 h, at the end of which the measurement is made.

Soldered joints and paint lockings are examples of adequate locking.

The exposure rate shall not exceed 36 pA/kg (0.5 mR/h) (ICRP Publication 15 [1969], Clause 289).*

A picture is considered to be intelligible if the following conditions are met:

- a scanning amplitude of at least 70% of the usable screen width;
- a minimum luminance of 50 cd/m² with locked blank raster provided by a test generator;
- a horizontal resolution corresponding to at least 1.5 MHz in the centre, with a similar vertical degradation;
- not more than one flashover per 5 min.

7. Heating under normal operating conditions

7.1 In normal use, no part of the apparatus shall attain an unsafe temperature.

Compliance is checked by measuring the temperature under normal operating conditions when a steady state has been attained.

In general, a steady state is assumed to be attained after 4 h operation.

Temperatures are determined:

- in the case of windings, by the change-in-resistance method.
- in other cases, by any other suitable method.

Care should be taken that during the measurement of the resistance of windings the influence of circuits or loads connected to these windings is negligible.

* International Commission for Radiological Protection.

Temperature rises shall not exceed the values given in Column I of Table III.

Fuse-links, if any, shall not operate during the test.

- 7.2 Insulating material supporting parts conductively connected to the supply mains shall be resistant to heat if, in normal use, these parts carry a current exceeding 0.5 A and might dissipate substantial heat due to imperfect contact.

Compliance is checked by subjecting the insulating material to the test specified under a) in Note 6 to Table III.

The softening temperature of the insulating material shall be at least 150 °C.

In those cases where two groups of conductors, each supported by insulating parts, can be rigidly connected or joined together (e.g. by plug and socket), one only of the insulating parts need meet the test. Where one of the insulating parts is fixed in the apparatus, this part must meet the test.

Examples of parts which might dissipate substantial heat in normal use are contacts of switches and of voltage adaptors, screw terminals and fuse holders.

TABLE III

Parts of the apparatus	Permissible temperature rise K			
	Moderate climates		Tropical climates	
	Normal operating conditions I	Fault conditions II	Normal operating conditions I	Fault conditions II
External parts				
Metal parts knobs, handles, etc.	30	65	20	55
enclosure (Note 1)	40	65	30	55
Non-metallic parts knobs, handles, etc. (Note 2)	50	65	40	55
enclosures (Note 1, Note 2)	60	65	50	55
Inside of enclosures of wood of insulating material	60 (Note 3)	90 (Note 3)	50 (Note 3)	80 (Note 3)
Windings (Note 4)				
Wires insulated with non-impregnated silk, cotton, etc.	55	75	45	65
Wires insulated with impregnated silk, cotton, etc.	70	100	60	90
Oleoresinous enamelled wires	70	135	60	125
Wires enamelled with polyvinylformaldehyde or polyurethane resins	85	150	75	140
Core laminations	As for the relevant windings			
Supply cords and wiring				
Insulated with ordinary polyvinyl chloride not under mechanical stress	60	100	50	90
under mechanical stress	45	100	35	90
Insulated with natural rubber	45	100	35	90
Other insulations (Note 4, Note 7) except thermoplastic				
Non-impregnated paper	55	70	45	60
Non-impregnated cardboard	60	80	50	70
Impregnated cotton, silk, paper and textile, urea resins	70	90	60	80
Laminates, bonded with phenol-formaldehyde resins, phenol-formaldehyde mouldings with cellulose fillers	85	110	75	100
Phenol-formaldehyde mouldings with mineral fillers	95	130	85	120
Laminates bonded with epoxy resins	120	150	110	140
Natural rubber	45	100	35	90
Thermoplastic materials (Note 5)	(Note 6)			

The values of the temperature rises are based upon a maximum ambient temperature of 35 °C for moderate climates and of 45 °C for tropical climates, but the measurements are made under normal operating conditions.

Notes 1. — For areas having no dimension exceeding 5 cm and which are not likely to be touched in normal use, temperature rises up to 65 K (55 K for tropical climates) are allowed under normal operating conditions.

2. — *If these temperature rises are higher than those allowed by the class of the relevant insulating material, the nature of the material is the governing factor.*
3. — *The permissible temperature rises for the inside of enclosures of insulating material are those indicated for the relevant materials.*
4. — *For the purpose of this standard, the permissible temperature rises are based on the recommendations in IEC Publication 85: Thermal Evaluation and Classification of Electrical Insulation. The materials quoted above are shown only as examples. If materials other than those listed in IEC Publication 85 are used, the maximum temperatures should not exceed those which have been proved to be satisfactory.*
5. — *Natural and synthetic rubbers are not considered as being thermoplastic materials.*
6. — *Due to their wide variety, it is not possible to specify permissible temperature rises for thermoplastic materials. While the matter is under consideration, the following method shall be used:*
 - a) *a softening temperature of the material is determined on a separate specimen, under the conditions specified in ISO Standard 306, modified as follows:*
 - *the depth of penetration is 0.1 mm;*
 - *the total thrust of 10 N is applied before the dial gauge is set to zero or its initial reading noted.*
 - b) *the temperature limits to be considered for determining the temperature rises are:*
 - *under normal operating conditions, a temperature 10 °C lower than the softening temperature as obtained under a);*
 - *under fault conditions, the softening temperature itself.*
7. — *The table does not apply to materials used in the construction of resistors.*
8. — *The possibility of raising the values for wires and cables insulated with heat resistant polyvinyl chloride is under consideration.*

8. Heating at elevated ambient temperatures

8.1 Resistance to heat without external forces

The apparatus shall be sufficiently resistant to heat.

Compliance is checked under normal operating conditions, the ambient temperature however being between 35 °C and 40 °C.

For apparatus to be used under tropical conditions, the ambient temperature is between 45 °C and 50 °C.

The duration of the test is 4 h.

The test room or cabinet, with the apparatus in it, is brought to the temperature mentioned and maintained at that temperature during the test.

After the test, the apparatus shall show no damage within the meaning of this standard.

At the temperature attained during the test, sealing impregnating compounds shall not become fluid to such a degree that protection against electric shock hazard becomes insufficient.

Components failing during this test due to the ambient temperature being over 35 °C or 45 °C respectively, may be replaced in so far as their failure does not affect safety.

If a component is very sensitive to heat, it is advisable to carry out the test at a temperature as near as possible to 35 °C or 45 °C respectively.

If the premature operation of a temperature-limiting device would prevent the test from being carried out, this device is rendered inoperative.

8.2 Resistance to heat with external forces

The enclosure of the apparatus shall be sufficiently resistant to external forces at elevated temperatures.

Compliance is checked by the following tests, at the maximum temperature of each part of the enclosure attained during the test under Sub-clause 8.1.

By means of a rigid test finger according to Figure 3b, page 121, a force of 50 N, directed inwards, is applied for 10 s to different points of the surface, including textile coverings of loudspeakers.

By means of a test-hook as shown in Figure 4, page 122, a force of 20 N, directed outwards, is applied for 10 s, at all points where this is possible.

The apparatus need not be connected to the mains during these tests.

During the tests, the distances between accessible metal parts and live parts shall not become less than the values given in Table II or the reduced values specified in Sub-clause 9.3.5, where applicable. Live parts shall not become accessible and textile coverings shall not touch live parts.

After the tests, the apparatus shall show no damage in the sense of this standard.

The force shall be so exerted by the tip of the test finger as to avoid wedge or lever action.

A rigid test finger loaded as above should be applied around any opening, or at any place where deformation could cause an opening. At the same time, a jointed test finger is applied without force to determine if live parts have become accessible.

9. Shock hazard under normal operating conditions

9.1 Testing on the outside

9.1.1 General

Accessible parts shall not be live.

The following terminal devices shall not be live even if inaccessible:

- terminal devices for antenna and earth;
- any terminal device provided on the apparatus for the connection of a load and source transducer either directly or through an amplifier.

As an exception, a terminal device provided for the connection of an independent loudspeaker may be live but shall not be conductively connected to the supply mains.

- terminals of an antenna amplifier intended for the connection to a receiving apparatus;
- output terminals of battery-eliminators.

Other terminals shall not be live unless they are marked with the symbol of Item *b*) of Sub-clause 5.4.

This requirement does not apply to terminal devices provided for connecting the apparatus to a supply or to socket-outlets intended to provide power to other apparatus.

In order to determine whether a part is accessible (see Sub-clause 2.3), the jointed test finger according to Figure 3a, page 121, or the rigid test finger according to Figure 3b, is applied in every possible position, in case of doubt with a maximum force of 50 N, in a manner indicated in Sub-clause 8.2. The test is carried out on all outer surfaces, including the bottom.

An electrical contact indication with a voltage of approximately 40 V is recommended to show contact with conductive parts.

In order to verify that a part or terminal contact is not live, the following measurements are carried out between any two parts or contacts, then between any part or contact and either pole of the supply source used during the test. Discharges shall be measured to earth, immediately after the interruption of the supply, ensuring that the method of interruption of the supply does not break the connection to earth of one of the poles of the supply source.

The part or terminal contact is not live if:

- a) from terminal devices for antenna and for earth, the current measured through a non-inductive resistance of 2 000 Ω does not exceed 0.7 mA (peak) a.c. or 2 mA d.c. and moreover, from a terminal device for antenna the discharge does not exceed 4.5 μC ;*
- b) from each other part or contact, the current measured through a non-inductive resistance of 50 000 Ω does not exceed 0.7 mA (peak) a.c. or 2 mA d.c. and moreover:*

— for voltages between 34 V (peak) and 450 V (peak), the capacitance does not exceed 0.1 μF ;

— for voltages between 450 V (peak) and 15 kV (peak), the discharge does not exceed 45 μC ;

— for voltages over 15 kV (peak), the energy of the discharge does not exceed 350 mJ.

For frequencies above 1 kHz, the limit of 0.7 mA (peak) is multiplied by the value of the frequency in kilohertz but shall not exceed 70 mA (peak).

The values indicated for the capacitances are rated values.

The maximum current of 0.7 mA (peak), while safe, is within the perception range of some people. Under some conditions, particularly in tropical regions, where a comfort limit is desired, a value of 0.3 mA (peak) should be used.

The test under Item b) establishes that, if the voltage at the part exceeds 34 V (peak) a.c. or 100 V d.c., the source impedance is such that a current greater than 0.7 mA (peak) a.c. or 2 mA d.c. cannot be drawn through a resistance of 50 000 Ω .

9.1.2 Operating shafts

Live operating shafts shall be adequately protected.

Compliance is checked by means of a free hanging endless metal test chain of 2 mm diameter, having small links. It shall not be possible to make electrical contact with the shafts and the fixing screws thereon from the outside.

An example of the type of test chain is shown in Figure 5, page 122.

9.1.3 Ventilation holes

Ventilation and other holes over live parts shall be so designed that a suspended foreign body (for example a necklace) introduced into the apparatus shall not come into contact with any live part.

Compliance is checked by inserting through the holes a metal test pin with a diameter of 4 mm and a length of 100 mm. The test pin is suspended freely from one end, the penetration being limited to its length.

The test pin shall not become live.

9.1.4 Terminal devices

The use of a single-pole plug or a bare wire to make connection with a contact of a terminal device for earth, aerial, load transducers or source transducers, with the exception of those marked with the symbol Item b) of Sub-clause 5.4, shall not involve the risk of an electric shock.

Compliance is checked by the following test:

Within 25 mm measured from each bushing of the terminal device, a test pin according to Figure 6, page 122, is applied in every possible position, in case of doubt with a force of 10 N.

Each bushing is tested with a bare straight wire having a diameter of 1 mm and a length of 100 mm.

The pin and the wire shall not become live.

See also Sub-clause 15.1.2.

9.1.5 Pre-set controls

If a hole giving access to pre-set controls is marked as such on the enclosure and the setting of this control requires a screwdriver or other tool, the adjustment of the control shall not involve the risk of a shock.

Compliance is checked by inserting through the opening a metal test pin having a diameter of 2 mm and a length of 100 mm.

The test pin is applied in every possible position, in case of doubt with a force of 10 N. The pin shall not become live.

9.1.6 Mains voltage adjustment

The operation of changing by hand the setting for the voltage or nature of supply shall not involve a risk of electric shock.

Compliance is checked by application of the tests of Sub-clause 9.1.1.

9.1.7 Withdrawal of mains plug

Apparatus intended to be connected to the supply mains by means of a mains plug shall be so designed that there is no risk of electric shock when touching the pins or contacts of the plug after its withdrawal from the socket-outlet.

Compliance is checked by the following test:

The apparatus is operated under normal operating conditions. The mains switch, if any, is then moved to the off-position, unless it is more unfavourable to keep it in the on-position, and the apparatus is disconnected from the supply mains by means of the plug.

Two seconds after withdrawal of the plug, no pin shall be live, the measurement being made according to Item b) of Sub-clause 9.1.1, between a pin and any other contact on the plug.

In order to reasonably cover the most unfavourable situation the test may be repeated up to ten times.

9.2 Removal of protective covers

A part which becomes accessible by the removal by hand of a cover shall not be live.

This requirement applies also to internal parts of battery compartments which become accessible by the removal of a cover either by hand or with the use of a tool, coin etc., when replacing the batteries.

An exception is made in the case of batteries which are not intended to be replaced by the user (e.g. batteries for memories).

Compliance is checked by application of the tests of Sub-clause 9.1.1, except that discharges are measured 2 s after interruption of the supply.

Any removable part of a voltage setting device is considered to be a protective cover.

9.3 Constructional requirements

- 9.3.1 The insulation of live parts shall not be provided by hygroscopic materials, such as non-impregnated wood, paper and similar fibrous materials.

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

A specimen of the material, as specified in Clause 9 of IEC Publication 167: Methods of Test for the Determination of the Insulation Resistance of Solid Insulating Materials, is subjected to the conditions described in IEC Publication 68-2-3: Test Ca: Damp Heat, Steady State (temperature $40 \pm 2^\circ\text{C}$, relative humidity: 90% to 95%) the conditioning period being:

- 7 days (168 h) for apparatus to be used under tropical conditions;
- 4 days (96 h) for other apparatus.

After this test, the specimen shall withstand the tests of Sub-clause 10.3.

If necessary, the test is made on more than one specimen.

- 9.3.2 The apparatus shall be so constructed that there is no risk of an electric shock from accessible parts or from those parts rendered accessible following the removal by hand of a cover.

Compliance is met by satisfying the requirements of Sub-clause 9.3.3 or Sub-clause 9.3.4.

- 9.3.3 For Class I apparatus, the accessible metal parts (except for those parts of the apparatus which are of Class II, see Sub-clause 2.38) shall be separated from live parts by basic insulation meeting the requirements of Item a) of Sub-clause 9.3.4).

This requirement does not apply to insulation the short-circuiting of which does not cause any shock hazard for example, if one end of a secondary winding of a separating transformer is connected to an accessible metal part, the other end need not meet any special insulation requirement with regard to the same accessible metal part.

Class I apparatus shall be provided with a protective earth terminal or contact to which accessible metal parts shall be reliably connected, except those insulated from live parts by insulation meeting the requirements of Sub-clause 9.3.4 or those which are protected from becoming live by a metal part reliably connected to the protective earth terminal.

Examples of such a metal part are a metal screen in a transformer between the primary and the secondary windings (see Sub-clause 14.3.2), metal chassis, etc.

- 9.3.4 For Class II apparatus, the accessible parts shall be insulated from live parts either by double insulation specified under Item a) or by reinforced insulation specified under Item b).

This requirement does not apply to insulations, the short-circuiting of which does not cause any shock hazard for example, if one end of a secondary winding of a separating transformer is connected to an accessible metal part, the other end need not meet any special insulation requirement with regard to the same accessible metal part.

A component complying with the requirements of Sub-clause 14.1 or 14.3 may bridge basic, supplementary, double or reinforced insulations. Basic and supplementary insulations may each be bridged by a capacitor complying with the requirements of Sub-clause 14.2.

Double or reinforced insulations may be bridged by a single capacitor complying with the requirements of Sub-clause 14.2 if an appropriate and reliable procedure is employed to check the uniformity and continued conformance to the relevant specification for the current production. Alternatively, two capacitors of the same nominal value in series, each complying with the requirements of Sub-clause 14.2, are required.

Moreover, the external insulation of a capacitor of the insulated type shall not bridge reinforced insulation or double insulation used in the construction of the apparatus, unless the external insulation of this capacitor meets the requirements of Sub-clause 9.3.8.

A Quality Assessment System for capacitors complying with Sub-clause 14.2 is under consideration in the IEC.

A capacitor manufactured and approved according to the CECC system complies with the condition for use of a single capacitor.

- a) If accessible parts are separated from live parts by basic insulation and supplementary insulation, the following shall apply.

Each of these insulations shall comply with the requirements of Clause 10 and with the requirements for creepage distances and clearances specified in Sub-clause 9.3.5.

Internal insulations not complying with the requirements of Sub-clauses 9.3.6, 9.3.7 or 9.3.8 are neglected when computing the creepage distances and clearances.

Enclosures of wood not complying with the requirements of Sub-clause 9.3.1 are permitted as supplementary insulation if they withstand the dielectric strength test of Sub-clause 10.3 after the humidity treatment of Sub-clause 10.2.

- b) If accessible parts are separated from live parts by reinforced insulation, the following shall apply.

The insulation shall comply with the requirements of Clause 10. Moreover, it shall comply with the requirements for creepage distances and clearances specified in Sub-clause 9.3.5.

Internal insulations not complying with the requirements of Sub-clauses 9.3.6, 9.3.7 or 9.3.8 are neglected when computing the creepage distances and clearances.

An example of assessment of reinforced insulation is given in Figure 17, page 132.

- 9.3.5 Creepage distances and clearances shall be not less than the values indicated in Table II, except that they may be reduced by 1 mm if all the following three conditions are met:

- they are not between accessible metal parts of an enclosure and live parts, if such external forces, as can be expected in normal use, including transportation, may reduce them,
- they are maintained by rigid construction, and
- their insulation properties are not likely to be significantly affected by any deposition of conductive dust produced inside the apparatus, for example by the carbon brushes of commutator motors.

The minimum creepage distances and clearances shall not be reduced below two-thirds of the values given by the curves of Table II, after taking into account any reduction allowed for wire enamel according to Sub-clause 4.3.3, with a minimum of 0.5 mm for basic insulation and supplementary insulation, and with a minimum of 1 mm for reinforced insulation.

Compliance is checked by inspection and measurement.

The creepage distance and clearance are measured whilst a force of 2 N is applied to any live part (including live wires) and to any internal part connected to accessible parts (including wires connected to them) and at the same time a force of 50 N by means of the rigid test finger being applied to any point on the outside of the enclosure.

- 9.3.6 Insulating layers on live parts, or on the inside surface of accessible metal parts or on any other internal metal part, are deemed to provide adequate protection if they withstand the following three tests in the order given.

Such layers may be used as reinforced insulation, provided they are not under such mechanical stress which, at the normal operating temperature, would be likely to lead to deformation or deterioration of the insulating material.

Ageing test

The coated part is subjected to the conditions described in IEC Publication 68-2-2, Section One, Tests B: Dry Heat, at a temperature of 70 ± 2 °C and for a period of 7 days (168 h). After this treatment, the part is allowed to cool to room temperature and inspection shall show that the layer has not loosened or shrunk away from the base material.

Impact test

The part is then conditioned, for a period of 4 h, at a temperature of -10 ± 2 °C. While still at this temperature, the layer is subjected to a blow applied to any point of the layer that is likely to be weak, from a spring-operated impact hammer as shown in Figure 8, page 125.

After this test, the layer shall not be damaged; in particular, it shall show no cracks visible to the naked eye.

Scratch test

Finally, the part at the highest temperature attained under normal operating conditions is subjected to a scratch test.

The scratches are made by means of a hardened steel pin, the end of which has the form of a cone having a top angle of 40°, its tip being rounded with a radius of 0.25 ± 0.02 mm.

Scratches are made by drawing the pin along the surface at a speed of about 20 mm/s as shown in Figure 12, page 128. The pin is so loaded that the force exerted along its axis is 10 ± 0.5 N. The scratches are at least 5 mm apart and at least 5 mm from the edge of the specimen.

After this test, the layer shall neither have loosened nor be pierced, and it shall withstand a dielectric strength test as specified in Sub-clause 10.3, the test voltage being applied between the base material and a metal foil in contact with the layer.

The tests may be made on a separate specimen of the coated part.

The more stringent tests which are necessary for insulating layers on the outside of metal parts are under consideration.

- 9.3.7 a) The insulation between live conductors in wires or cables and accessible parts, or between live parts and conductors in wires or cables connected to accessible metal parts, shall have a thickness of at least 0.4 mm if made of polyvinyl chloride. Other materials are allowed provided that they withstand the dielectric strength test specified in Sub-clause 10.3 and that their thickness ensures an equivalent mechanical strength, where the construction so requires.
- b) In Class II apparatus, double insulation shall be provided between accessible parts and conductors in wires or cables conductively connected to the supply mains.

In the case of conductors in wires or cables connected to accessible metal parts, double insulation shall be provided between these conductors and parts conductively connected to the supply mains.