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GROUP SAFETY PUBLICATION

Safety of power transformers, power supply units and similar –

Part 1: General requirements and tests

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International Electrotechnical Commission
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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**SAFETY OF POWER TRANSFORMERS, POWER SUPPLY UNITS
AND SIMILAR –****Part 1: General requirements and tests****FOREWORD**

- 1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 61558-1 has been prepared by IEC technical committee 96: Small power transformers, reactors and **power supply units** and special transformers, reactors and **power supply units**. Safety requirements.

It has the status of a group safety publication in accordance with IEC Guide 104: Guide for the drafting of safety standards, and the role of Committees with safety pilot functions and safety group functions (1984).

This consolidated version of IEC 61558-1 is based on the first edition (1997) [documents 96/47/FDIS and 96/70/RVD] and its amendment 1 (1998) [documents 96/106/FDIS and 96/109/RVD].

It bears the edition number 1.1.

A vertical line in the margin shows where the base publication has been modified by amendment 1.

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

This part 1 replaces Chapter I of IEC 60742 and IEC 60989.

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

If the functions of a transformer are covered by different parts 2 of IEC 61558, the relevant part 2 is applied to each function separately, so far as is reasonable. If applicable, the influence of the function on the other is taken into account.

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

Annexes L, M, N, P, Q, R, S, T, U and V are for information only.

In this standard, the following print types are used:

- requirements proper: in roman type;
- *test specifications: in italic type;*
- explanatory matter: in smaller roman type

In the text of the standard, the words in **bold** are defined in clause 3.

INTRODUCTION

In general, this International Standard covers safety requirements for transformers.

When elaborating this standard, the requirements of IEC 60364 were taken into account as far as possible, so that a transformer may be installed in accordance with these wiring rules. However, national wiring rules may differ.

This standard recognizes the internationally accepted level of protection against hazards such as electrical, mechanical and fire of transformers when operated as in normal use, taking into account the manufacturer's instructions. It also covers abnormal situations which can be expected in practice.

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

A transformer 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 requirement, and if found to be substantially equivalent, may be judged to comply with the safety principles of this standard.

Standards dealing with non-safety aspects of transformers are:

- CISPR 11 and CISPR 14 concerning radio interference suppression;
- IEC 61000-3-2 and IEC 61000-3-3 concerning electromagnetic compatibility.

The object of part 1 of IEC 61558 is to provide a set of requirements and tests which are considered to be generally applicable to most types of transformers, and which can be called up as required by the relevant part 2 of IEC 61558. Part 1 is thus not to be regarded as a specification by itself for any type of transformer, and its provisions apply only to particular types of transformers to the extent determined by the appropriate part 2.

The part 2 series, in referring to any of the clauses of part 1, specify the extent to which that part 2 is applicable and the order in which the tests are to be performed; they also include additional requirements as necessary. Each part 2 is self-contained and therefore does not contain references to other part 2.

Where the requirements of any of the clauses of part 1 are referred to in a part 2 by the phrase "This clause of part 1 is applicable", this phrase is to be interpreted as meaning that all requirements of that clause of part 1 apply, except any which are clearly inapplicable to the particular type of transformer covered by that part 2.

Each part 2 of IEC 61558 (containing requirements for a particular type of transformer) is published separately for ease of revision, and additional parts 2 will be added as and when a need for them is recognized.

SAFETY OF POWER TRANSFORMERS, POWER SUPPLY UNITS AND SIMILAR –

Part 1: General requirements and tests

1 Scope

1.1 This International Standard deals with all aspects of safety (such as electrical, thermal and mechanical) of:

- a) **Stationary** or **portable**, single-phase or polyphase, air-cooled (natural or forced) **isolating** and **safety isolating transformers**, **associated** or otherwise, having a **rated supply voltage** not exceeding 1 000 V a.c. and **rated frequency** not exceeding 1 MHz, the **rated output** not exceeding the following values.

NOTE 1 – For higher frequencies, this standard may be used as a guidance document.

For **isolating transformers**:

- 25 kVA for single-phase transformers;
- 40 kVA for polyphase transformers.

For **safety isolating transformers**:

- 10 kVA for single-phase transformers;
- 16 kVA for polyphase transformers.

The **no-load** output voltage and **rated output voltage** do not exceed:

- for **isolating transformers** 500 V a.c. or 708 V ripple free d.c.

NOTE 2 – For **isolating transformers**, the no-load **rated output voltage** may be up to 1 000 V a.c. or 1 415 V ripple free d.c. to be in accordance with the national wiring rules or for special purposes.

- for **safety isolating transformers** 50 V a.c. r.m.s. and/or 120 V ripple free d.c. between conductors or between any conductor and earth.

NOTE 3 – **Isolating** and **safety isolating transformers** are used where **double** or **reinforced insulation** between circuits is required by the installation rules or by the appliance specification (for example toys, bells, portable **tools**, handlamps).

Rated values for each type of transformer are indicated in the relevant part 2.

- b) **Stationary** or **portable**, single-phase or polyphase, air-cooled (natural or forced) **separating transformers**, auto-transformers, variable transformers and small reactors, associated or not, having a **rated supply voltage** not exceeding 1 000 V a.c., a **rated frequency** not exceeding 1 MHz, a rated no-load or load output voltage not exceeding 15 kV a.c. or d.c., and for **independent transformers** not less than 50 V a.c. and/or 120 V ripple free d.c. and a **rated output** not exceeding the following values:

- 1 kVA for single-phase transformers;
- 2 kVAR for single-phase reactors;
- 5 kVA for polyphase transformers;
- 10 kVAR for polyphase reactors;

unless otherwise specified in the relevant part 2.

NOTE 1 – **Separating transformers** are used where **double** or **reinforced insulation** between circuits is not required by the installation rules or by the appliance specification.

NOTE 2 – The technological development of transformers might imply a need to increase the higher limit of the **rated frequency**.

NOTE 3 – Normally, the transformers are intended to be associated with equipment to provide voltages different from the supply voltage for the functional requirement of the equipment. The safety insulation may be provided (or completed) by other features of the equipment, such as the **body**. Parts of **output circuits** may be connected to the **input circuit** or to protective earth.

c) **Power supply units** incorporating a transformer of types a) or b).

NOTE 1 – This may include units for transforming, rectifying, converting, frequency inverting or their combinations intended for power supplying electrical equipment, except for switch-mode power supplies.

NOTE 2 – Examples of **power supply units** are transformers, battery eliminators and converters for building-in or self-contained. In the latter case they can even be provided with integrated pins; intended to be introduced into fixed socket-outlets.

NOTE 3 – Requirements for transformers for switch-mode power supplies are contained in IEC 61558-2-17.

1.2 This standard is applicable to **dry type transformers**. The windings may be encapsulated or non-encapsulated.

NOTE 1 – For transformers filled with liquid dielectric or pulverised material, such as sand, requirements are under consideration.

This standard is also applicable to transformers associated with specific items of equipment, to the extent decided upon by the relevant IEC technical committees.

Transformers incorporating electronic circuits are also covered by this standard.

This standard does not apply to external circuits and their components connected to terminals or socket-outlets of the transformer.

NOTE 2 – Examples are wiring, fuses and switches.

NOTE 3 – Attention is drawn to the fact that:

- for transformers intended to be used in vehicles or on board ships or aircraft, additional requirements may be necessary;
- for transformers intended to be used in tropical countries, special requirements may be necessary;
- in locations where special environmental conditions prevail, particular requirements may be necessary in accordance with IEC 60364-5-51.

2 Normative references

The following normative documents contain provision which, through reference in this text, constitute provisions of this part of IEC 61558. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreement based on this part of IEC 61558 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60050(421):1990, *International Electrotechnical Vocabulary (IEV) – Chapter 421: Power transformers and reactors*

IEC 60051, *Direct acting indicating analogue electrical measuring instruments and their accessories*

IEC 60065:1985, *Safety requirements for mains operated electronic and related apparatus for household and similar general use*

IEC 60068-2-2:1974, *Environmental testing – Part 2: Tests – Test B: Dry heat*

IEC 60068-2-6:1995, *Environmental testing – Part 2: Tests – Test Fc and guidance: Vibration (sinusoidal)*

IEC 60068-2-32:1975, *Environmental testing – Part 2: Tests – Test Ed: Free fall (procedure 1)*

IEC 60068-2-63:1991, *Environmental testing – Part 2: Tests – Test Eg: Impact, spring hammer*

IEC 60076-1:1993, *Power transformers – Part 1: General*

IEC 60083:1975, *Plugs and socket-outlets for domestic and similar general use – Standards*

IEC 60085:1984, *Thermal evaluation and classification of electrical insulation*

IEC 60112:1979, *Method for determining the comparative and the proof tracking indices of solid insulating materials under moist conditions*

IEC 60127, *Miniature fuses*

IEC 60216, *Guide for the determination of thermal endurance properties of electrical insulating materials*

IEC 60227, *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V*

IEC 60245, *Rubber insulated cables of rated voltages up to and including 450/750 V*

IEC 60269-2:1986, *Low voltage fuses – Part 2: Supplementary requirements for fuses for use by authorized persons (fuses mainly for industrial application)*

IEC 60269-2-1:1987, *Low voltage fuses – Part 2: Supplementary requirements for fuses for use by authorized persons (fuses mainly for industrial application) – Sections I to III*

IEC 60269-3:1987, *Low voltage fuses – Part 3: Supplementary requirements for fuses for use by unskilled persons (fuses mainly for household and similar applications)*

IEC 60269-3-1:1994, *Low voltage fuses – Part 3: Supplementary requirements for fuses for use by unskilled persons (fuses mainly for household and similar applications) – Sections I to IV*

IEC 60309, *Plugs, socket-outlets and couplers for industrial purposes*

IEC 60317, *Specifications for particular types of windings wires*

IEC 60320, *Appliance couplers for household and similar general purposes*

IEC 60364-4-41:1992, *Electrical installations of buildings – Part 4: Protection for safety – Chapter 41: Protection against electrical shock*

IEC 60364-5-51:1994, *Electrical installations of buildings – Part 5: Selection and erection of electrical equipment – Chapter 51: Common rules*

IEC 60384-14:1993, *Fixed capacitors for use in electronic equipment – Part 14: Sectional specification: Fixed capacitors for electromagnetic interference suppression and connection to the supply mains*

IEC 60417:1973, *Graphical symbols for use on equipment. Index, survey and compilation of the single sheets*

IEC 60449:1973, *Voltage bands for electrical installations of buildings*

IEC 60454, *Specification for pressure-sensitive adhesive tapes for electrical purposes*

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

IEC 60536:1976, *Classification of electrical and electronic equipment with regard to protection against electric shock*

IEC 60536-2:1992, *Classification of electrical and electronic equipment with regard to protection against electric shock – Part 2: Guidelines to requirements for protection against electric shock*

IEC 60664-1:1992, *Insulation co-ordination for equipment within low voltage systems – Part 1: Principles, requirements and tests*

IEC 60664-3:1992, *Insulation co-ordination for equipment within low voltage systems – Part 3: Use of coating to achieve insulation co-ordination of printed board assemblies*

IEC 60691:1993, *Thermal-links – Requirements and application guide*

IEC 60695-2-1/0:1994, *Fire hazard testing – Part 2: Test methods – Section 1/sheet 0: Glow-wire test methods – General*

IEC 60695-2-1/1:1994, *Fire hazard testing – Part 2: Test methods – Section 1/sheet 1: Glow-wire end-product test and guidance*

IEC 60707:1981, *Method of test for the determination of the flammability of solid electrical insulating materials when exposed to an igniting source*

IEC 60730-1:1993, *Automatic electrical controls for household and similar use – Part 1: General requirements*

IEC 60738-1:1982, *Directly heated positive step-function temperature coefficient thermistors – Part 1: Generic specification*

IEC 60851, *Methods of test for windings wires*

IEC 60884-1:1994, *Plugs and socket-outlets for household and similar purposes – Part 1: General requirements*

IEC 60884-2-4:1993, *Plugs and socket-outlets for household and similar purposes – Part 2: Particular requirements for plugs and socket-outlets for SELV*

IEC 60898:1995, *Electrical accessories – Circuit-breakers for overcurrent protection for household and similar installations*

IEC 60906-1:1986, *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 60906-3:1994, *IEC System of plugs and socket-outlets for household and similar purposes – Part 3: SELV plugs and socket-outlets, 16 A 6 V, 12 V, 24 V, 48 V, a.c. and d.c.*

IEC 60947-7-1:1989, *Low-voltage switchgear and controlgear – Part 7: Ancillary equipment – Section 1: Terminal blocks for copper conductors*

IEC 60990:1990, *Methods of measurement of touch-current and protective conductor current*

IEC 60998-1:1990, *Connecting devices for low voltage circuits for household and similar purposes – Part 1: General requirements*

IEC 60998-2-1:1990, *Connecting devices for low voltage circuits for household and similar purposes – Part 2-1: Particular requirements for connecting devices as separate entities with screw-type clamping units*

IEC 60998-2-2:1991, *Connecting devices for low voltage circuits for household and similar purposes – Part 2-2: Particular requirements for connecting devices as separate entities with screwless-type clamping units*

IEC 60999-1:1990, *Connecting devices – Safety requirements for screw-type and screwless-type clamping units for electrical copper conductors – Part 1: General requirements and particular requirements for conductors from 0,5 mm² up to 35 mm² (included)*

IEC 61000-3-2:1995, *Electromagnetic compatibility (EMC) – Part 3: Limits – Section 2: Limitation of emission of harmonic currents in low-voltage power supply systems for equipment with rated current ≤16 A*

IEC 61000-3-3:1994, *Electromagnetic compatibility (EMC) – Part 3: Limits – Section 3: Limitation of voltage fluctuation and flicker in low-voltage power supply systems for equipment with rated current ≤16 A*

IEC 61032:1990, *Test probes to verify protection by enclosures*

IEC 61058-1:1990, *Switches for appliances – Part 1: General requirements*

IEC 61140:1992, *Protection against electric shock. Common aspects for installations and equipment*

ISO 3:1973, *Preferred numbers – Series of preferred numbers*

ISO 4046: 1978, *Paper, board, pulp and related terms – Vocabulary*

ISO 8820, *Road vehicles – Blade type fuse-links*

3 Definitions

Further definitions of transformers intended for particular use are indicated in the relevant parts 2.

When the term transformer is used it covers transformer, reactor and power supply where applicable.

When the terms voltage and current are used, they imply, for alternating voltages and currents, the r.m.s. values, unless otherwise specified; for direct voltages and currents, they imply the arithmetic mean value, unless otherwise specified.

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

3.1 Transformers

3.1.1 (power) transformer: A static piece of apparatus with two or more windings which, by electromagnetic induction, transforms a system of alternating voltage and current into another system of voltage and current usually of different values and at the same frequency for the purpose of transmitting electrical power. [IEV 421-01-01]

NOTE – Toroidal transformers are included in that definition.

3.1.2 isolating transformer: A transformer with **protective separation** between the **input** and **output windings**.

3.1.3 safety isolating transformer: An **isolating transformer** designed to supply **SELV** (safety extra-low voltage) or **PELV** (protective extra-low voltage) circuits.

3.1.4 separating transformer: A transformer with **input winding(s)** separated from the **output winding(s)** by at least **basic insulation**.

3.1.5 flush-type transformer: A transformer designed to be mounted in a flush-type mounting box.

3.1.6 associated transformer: A transformer designed to supply specific appliances or equipment or part of them, and either incorporated in or not incorporated in, but specially designed to be used only with the specific appliance(s) or equipment.

3.1.7 incorporated transformer: An **associated transformer** which is designed to be built into a specific appliance or equipment, the **enclosure** of which provides protection against electric shock.

3.1.8 transformer for specific use: An **associated transformer** which, without being incorporated in an appliance or equipment, is fixed to or delivered with the appliance or equipment.

3.1.9 short-circuit proof transformer: A transformer in which the temperature does not exceed the specified limits when the transformer is overloaded or short-circuited, and which continues to meet all requirements of this standard after the removal of the overload or short-circuit.

3.1.9.1 non-inherently short-circuit proof transformer: A **short-circuit proof transformer** equipped with a protective device which opens the **input circuit** or the **output circuit**, or reduces the current in the **input circuit** or the **output circuit** when the transformer is overloaded or short-circuited, and which continues to meet all requirements of this standard after the removal of the overload or short circuit and resetting or replacing of the protective device.

NOTE 1 – Examples of protective devices are fuses, **overload releases**, thermal fuses, thermal links, **thermal cut-outs** and PTC resistors and automatic break-off mechanical devices.

NOTE 2 – In case of protection by a device which cannot be replaced nor reset, the wording "continue to meet all requirements of this standard after removal of the overload" does not imply that the transformer continues to operate.

3.1.9.2 inherently short-circuit proof transformer: A **short-circuit proof transformer** not equipped with a device to protect the transformer and in which the temperature in the case of overload or short circuit, by construction, does not exceed the specified limits, and which continues to operate and meet all the requirements of this standard after the removal of the overload or short circuit.

3.1.10 non-short-circuit proof transformer: A transformer which is intended to be protected against excessive temperature by means of a protective device not provided with the transformer, and which continues to meet all the requirements of this standard after the removal of the overload or short circuit and resetting of the protective device.

3.1.11 fail-safe transformer: A transformer which, after abnormal use, permanently fails to function by an interruption of the **input circuit** but presents no danger to the user or surroundings.

3.1.12 portable transformer: Either a transformer which is moved while in operation, or a transformer which can easily be moved from one place to another while connected to the supply.

NOTE – A transformer which is mounted directly on a socket-outlet is deemed to be a **portable transformer**, even though it cannot be moved while connected to the supply.

3.1.13 hand-held transformer: A **portable transformer** intended to be held in the hand during normal use.

3.1.14 fixed transformer: A transformer which is intended to be used while fastened to a support or otherwise secured in a specific situation.

3.1.15 stationary transformer: Either a **fixed transformer** or a transformer having a mass exceeding 18 kg and not provided with one or more carrying handle(s).

3.1.16 ordinary transformer: An enclosed transformer without special protection against dust and moisture, but complying with verification by the standard test finger.

3.1.17 independent transformer: A transformer designed to supply unspecified appliances and which can be used without any additional **enclosure**. Such a transformer provides all necessary protection according to its marking.

NOTE – Such transformer can be either of the **portable** or **stationary** type.

3.1.18 dry-type transformer: A transformer of which the core and windings are not immersed in an insulating liquid.

3.1.19 power supply unit: An apparatus which takes power from the mains and from which one or more other apparatuses are fed.

NOTE – **Power supply units** may incorporate components for transforming, rectifying, converting, frequency inverting or combination thereof.

3.2 General terms

3.2.1 external flexible cable or cord: A **flexible cable or cord** for external connection to the **input** or **output circuit**, fixed to or assembled with the transformer according to one of the following methods of attachment:

- **type X attachment**, a method of attachment so that the **flexible cable or cord** can be replaced easily;

NOTE 1 – The supply cord may be especially prepared and only available from the manufacturer or his service agent.

NOTE 2 – A specially prepared cord may also include a part of the transformer.

NOTE 3 – The **type X attachment** includes both types X and M according to IEC 60742 and IEC 60989.

- **type Y attachment**, a method of attachment so that any replacement is intended to be made by the manufacturer, his service agent, or similar qualified person;

NOTE – **Type Y attachments** may be used either with ordinary flexible cables or cords, or with special cables or cords.

- **type Z attachment**, a method of attachment so that the **flexible cable or cord** cannot be replaced without breaking or destroying a part of the transformer.

3.2.2 power supply cord: An **external flexible cable or cord** used on the input side for supply purposes.

NOTE – **Power supply** cords are:

- fixed to or assembled with the transformer by **X, Y or Z attachment**, or
- **connected to the transformer by an appliance coupler**.

3.2.3 connecting leads: The end of a winding connecting the winding to a terminal.

NOTE – **Connecting leads** are considered as an internal wire.

3.2.4 body: This term is used in this standard as a general term; it includes all accessible metal parts, shafts, handles, knobs, grips and the like, accessible metal fixing screws and metal foil applied on accessible surfaces of insulating material; it does not include non-accessible metal parts.

3.2.5 accessible part: This term is used in this standard as a general term; it includes all parts which may be touched with the standard test finger after correct installation of the transformer.

3.2.6 detachable part: A part which can be removed without the aid of a **tool**.

3.2.7 non-detachable part: A part which can be removed only with the aid of a **tool**.

3.2.8 tool: A screwdriver, a coin, or any other object which may be used to operate a screw or similar fixing means.

3.2.9 enclosure: A part providing protection of the transformer against certain external influences and, in any direction, protection against direct contacts (see 3.1 of IEC 60529).

NOTE – Examples of external influences are mechanical impacts, corrosion, fungus, vermin, solar radiation, icing and moisture.

3.3 Operations and protections

3.3.1 all pole disconnection: Disconnection of all supply conductors by a single switching action.

NOTE 1 – A protective conductor is not considered to be a supply conductor.

NOTE 2 – A neutral conductor is considered to be a supply conductor.

NOTE 3 – National wiring rules may or may not require the disconnection of the neutral conductor.

3.3.2 thermal cut-out: A temperature sensitive device which limits the temperature of a transformer, or of parts of it, during abnormal operation by automatically opening the circuit or by reducing the current, and which is so constructed that its setting cannot be altered by the user.

3.3.3 self-resetting thermal cut-out: A **thermal cut-out** which automatically restores the current after the relevant part of the transformer has cooled down sufficiently, or the load has been removed.

3.3.4 non-self-resetting thermal cut-out: A **thermal cut-out** which requires resetting by hand, or replacement of a part, in order to restore the current.

3.3.5 thermal-link: **Thermal cut-out** which operates only once and then requires partial or complete replacement.

3.3.6 overload release: A current-operated switch which protects a circuit from overload by opening when the current in that circuit reaches a predetermined value and which remains in the open position.

3.3.7 working voltage: The highest r.m.s. value of the a.c. or d.c. voltage which may occur (locally) across any insulation at rated supply volts, transients being disregarded, in no-load conditions or under normal operating conditions.

NOTE 1 – When considering the insulation system between windings not intended to be connected together, the **working voltage** is considered to be the highest voltage occurring on any of these windings.

NOTE 2 – Attention is drawn to the fact that the **working voltage** to earth of the input may be different from the apparent value on single-phase systems with no neutral line, and on three-phase systems with no-earthed neutral when star connected, or when delta connection is used. The output voltage of a transformer may be artificially raised with respect to earth by conditions which occur in an appliance or equipment.

3.3.8 short-circuit voltage: The voltage to be applied to the **input winding**, when the windings are at ambient temperature, to produce in the short-circuited **output winding** a current equal to the **rated output current**.

NOTE – The **short-circuit voltage** is usually expressed as a percentage of the **rated supply voltage**.

3.3.9 continuous operation: Operation for an unlimited period.

3.3.10 short-time operation: Operation for a specified period, starting from cold, the intervals between each period of operation being sufficient to allow the appliance to cool down to approximately ambient temperature.

3.3.11 intermittent operation: Operation in a series of specified identical cycles.

3.4 Circuits and windings

3.4.1 input circuit: The circuit intended to be connected to the supply.

3.4.2 output circuit: A circuit to which the distribution circuit, appliance or other equipment is to be connected.

3.4.3 input winding: A winding of the **input circuit**.

3.4.4 output winding: A winding of the **output circuit**.

3.5 Ratings

3.5.1 rated supply voltage: The supply voltage (for polyphase supply, the phase-to-phase voltage) assigned to the transformer by the manufacturer for the specified operating conditions of the transformer.

3.5.2 rated supply voltage range: The supply voltage range assigned to the transformer by the manufacturer, expressed by its lower and upper limits.

3.5.3 rated frequency: The frequency assigned to the transformer by the manufacturer for the specified operating conditions of the transformer.

3.5.4 rated output current: The output current at **rated supply voltage** and **rated frequency**, assigned to the transformer by the manufacturer for the specified operating conditions of the transformer.

3.5.5 rated output voltage: The output voltage (for polyphase supply, the phase-to-phase voltage) at **rated supply voltage**, **rated frequency** and **rated output current**, at **rated power factor**, assigned to the transformer by the manufacturer for the specified operating conditions of the transformer.

3.5.6 rated power factor: The power factor assigned to the transformer by the manufacturer for the specified operating conditions of the transformer.

3.5.7 rated output: The product of the **rated output voltage** and the **rated output current** or, for polyphase transformers, $\sqrt{n}$ times the product of the **rated output voltage** and the **rated output current**, n being the number of phases. If the transformer has more than one **output winding** or a tapped **output winding**, the **rated output** denotes the maximum sum of the products of **rated output voltage** and **rated output current** for such circuits that may be loaded simultaneously.

3.5.8 rated ambient temperature t_a : The maximum temperature at which the transformer may be operated continuously under normal conditions of use.

NOTE – The value of the **rated ambient temperature** (t_a) does not preclude temporary operation of the transformer at a temperature not exceeding ($t_a + 10$) °C.

3.6 No-load values

3.6.1 no-load input: The input of the transformer when connected to **rated supply voltage** at **rated frequency**, with no load on the output.

3.6.2 no-load output voltage: The output voltage when the transformer is connected to **rated supply voltage** at **rated frequency**, with no load on the output.

3.7 Insulation

3.7.1 basic insulation: The insulation applied to **hazardous live parts** to provide basic protection against electric shock (see 2.1 of IEC 60536).

NOTE – **Basic insulation** does not necessarily include insulation used exclusively for functional purposes, for example wire enamel.

3.7.2 supplementary insulation: An independent insulation applied in addition to **basic insulation** in order to provide protection against electric shock in the event of failure of the **basic insulation** (see 2.2 of IEC 60536).

3.7.3 double insulation: Insulation comprising both **basic insulation** and **supplementary insulation** (see 2.3 of IEC 60536).

3.7.4 reinforced insulation: A single insulation system applied to **hazardous live parts**, which provides a degree of protection against electric shock equivalent to **double insulation** (see 2.4 of IEC 60536).

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

3.7.5 class I transformer: A transformer 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, such as an earthing terminal, are provided for the connection of accessible conductive parts to the protective earthing conductor in the fixed wiring of the installation, so that accessible conductive parts cannot become live in the event of a failure of the **basic insulation**.

NOTE – Class I transformers may have parts with **double** or **reinforced insulation**.

3.7.6 class II transformer: A transformer 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.

NOTE 1 – A **class II transformer** may be provided with means for maintaining the continuity of protective circuits, provided that such means are inside the transformer, and are insulated from accessible surfaces according to the requirements of **class II**.

NOTE 2 – In certain cases, it may be necessary to distinguish between "all insulated" and "metal encased" **class II transformers**.

NOTE 3 – A transformer having a durable and substantially continuous **enclosure** of insulating material which envelops all metal parts, with the exception of small metal parts, such as nameplates, screws and rivets, which are isolated from **hazardous live parts** by insulation at least equivalent to **reinforced insulation**, is called an all insulated **class II transformer**.

NOTE 4 – A transformer having a substantially continuous metal **enclosure**, in which **double insulation** is used throughout, except for those parts where **reinforced insulation** is used because the application of **double insulation** is manifestly impracticable, is called a metal encased **class II transformer**.

NOTE 5 – If a transformer with **double insulation** and/or **reinforced insulation** throughout has an earthing terminal, it is deemed to be of **class I** construction.

3.7.7 class III transformer: A transformer in which protection against electric shock relies on supply at **SELV**, and in which voltages higher than those of **SELV** are not generated.

NOTE – The classification I, II or III does not refer to the insulation system between **input windings** and **output windings**.

3.7.8 clearance: The shortest distance in air between two conductive parts (see 1.3.2 of IEC 60664-1).

NOTE – For the purpose of determining a **clearance** to **accessible parts**, the accessible surface of an insulating **enclosure** is to be considered conductive as if it were covered by a metal foil wherever it can be touched by the standard test finger (see figure 2).

3.7.9 creepage distance: The shortest distance (through air) along the surface of an insulating material between two conductive parts (see 1.3.3 of IEC 60664-1).

NOTE – For the purpose of determining a **creepage distance** to **accessible parts**, the accessible surface of an insulating **enclosure** is to be considered conductive as if it were covered by a metal foil wherever it can be touched by the standard test finger (see figure 2).

3.7.10 pollution: Any addition of foreign matter, solid, liquid, or gaseous, that can result in a reduction of dielectric strength or surface resistivity of the insulation (see 1.3.11 of IEC 60664-1).

3.7.11 micro-environment: The immediate environment of the insulation, which particularly influences the dimensioning of the **creepage distances** or **clearances** (see 1.3.12.2 of IEC 60664-1).

NOTE – The **micro-environment** of the **creepage distance** or **clearance** and not the environment of the equipment determines the effect on the insulation. The **micro-environment** might be better or worse than the environment of the equipment. It includes all factors influencing the insulation, such as climatic and electromagnetic factors and generation of **pollution**, etc.

3.7.12 Degrees of pollution (see 2.5.1 of IEC 60664-1)

For the purpose of evaluating **clearances** and **creepage distances** the following **degrees of pollution** in the **micro-environment** are established.

3.7.12.1 pollution degree 1 (P1): No **pollution** or only dry, non-conductive **pollution** occurs. The **pollution** has no influence.

3.7.12.2 pollution degree 2 (P2): Only nonconductive **pollution** occurs, except that occasionally a temporary conductivity caused by condensation is to be expected.

NOTE – Transformers having a reasonably tight **enclosure** are considered to have **pollution degree 2 (P2)**, hermetic sealing is not required.

3.7.12.3 pollution degree 3 (P3): Conductive **pollution** occurs, or dry nonconductive **pollution** occurs which becomes conductive due to the condensation which is to be expected.

3.7.13 protective separation: Separation between circuits by means of basic and supplementary protection (**basic insulation** plus **supplementary insulation** or **protective screening**) or by an equivalent protective provision (for example **reinforced insulation**) (see 2.9 of IEC 60536-2).

3.7.14 protective screening: Separation from **hazardous live parts** by means of an interposed conductive screen, connected to the means of connection for an external protective conductor (see 2.8 of IEC 60536-2).

3.7.15 ELV (extra-low voltage): A voltage not exceeding the upper limit of voltage band 1 (see IEC 60449).

3.7.16 SELV: A voltage which does not exceed 50 V a.c. or 120 V ripple free d.c. between conductors, or between any conductor and earth, in a circuit which is isolated from the supply mains by such means as a **safety isolating transformer**.

NOTE 1 – Maximum voltage lower than 50 V a.c. or 120 V ripple-free d.c. may be specified in particular requirements, especially when direct contact with **live parts** is allowed.

NOTE 2 – The voltage limit should not be exceeded at any load between full load and no-load when the source is a **safety isolating transformer**.

NOTE 3 – "Ripple-free" is conventionally an r.m.s. ripple voltage not more than 10 % of the d.c. component; the maximum peak value does not exceed 140 V for a nominal 120 V ripple-free d.c. system and 70 V for a nominal 60 V ripple-free d.c. system.

3.7.17 SELV-circuit: An **ELV** circuit with **protective separation** from other circuits, and which has no provisions for earthing of the circuit nor of the exposed conductive parts

3.7.18 PELV-circuit: An **ELV** circuit with **protective separation** from other circuits and which, for functional reasons, may be earthed and/or the exposed conductive parts of which may be earthed.

NOTE – **PELV-circuits** are used where the circuits are earthed and **SELV** is not required.

3.7.19 FELV-circuit: An **ELV** circuit having the **ELV** voltage for functional reasons and not fulfilling the requirements for **SELV** or **PELV**.

3.7.20 live part: A part from which a current can be drawn.

3.7.21 hazardous live part: A **live part** which, under certain conditions of external influences, can give an electric shock (see 4.3 of IEC 61140).

4 General requirements

4.1 Transformers shall be so designed and manufactured that when used, installed and maintained according to the manufacturer's instructions, they cause no danger which could reasonably be foreseen to persons or surroundings, even in the event of such careless use as may occur in normal service.

In general, compliance is checked by carrying out all the relevant tests.

4.2 A transformer shall comply with a part 2. If, however, an appropriate part 2 for a particular transformer or group of transformers does not exist, the nearest applicable part 2 may be used as a guide to the requirements and tests. Where the design of a transformer is such that two or more parts 2 are applicable, the transformer shall comply with both or all of the appropriate parts 2.

5 General notes on tests

5.1 Tests according to this standard are type tests.

NOTE – Recommendations for routine tests are given in annex L.

Each sample transformer shall comply with all the relevant tests. In order to reduce the testing time and allow for any tests which may be destructive, the manufacturer may submit additional transformers or parts of transformers, provided that they are of the same materials and designs as the original transformer, and that the results of the tests are the same as if carried out on an identical transformer. Where the test for compliance is shown as being "by inspection", this shall include any necessary handling.

Transformers intended to be used with non-detachable flexible cables or cords are tested with the flexible cable or cord connected to the transformer.

5.2 Tests are carried out on specimens as delivered and installed as in normal use taking into account the manufacturer's installation instructions. If it is not necessary to do the tests of 14.3, 15.5 and 16.4, the number of specimens is one for all **rated outputs**.

For components tested under conditions prevailing in the transformer, the number of specimens is that required by the relevant standard.

If the tests of 14.3 have to be made, three additional specimens are needed. A further three specimens are needed if the tests have to be repeated.

For testing a series of transformers, see annex B.

All specimens shall withstand all the relevant tests, except as mentioned in 14.3.

If the tests of 15.5 have to be made, they are carried out on three additional specimens. These specimens are used only for the tests of 15.5.

NOTE 1 – For **associated transformers**, the equipment standard may prescribe other numbers of specimens to be tested.

NOTE 2 – Additional specimens may also be necessary if other tests require partial destruction of the transformer.

NOTE 3 – In case of non-replaceable and non-resettable protective devices the compliance is checked on a specially prepared specimen.

If the tests of 16.4 have to be made they are carried out on four additional specimens.

5.3 Tests are carried out in the order of the clauses and subclauses, unless otherwise specified.

5.4 If the test results are not influenced by the temperature of the ambient air, the ambient temperature is, in general, maintained at $(20 \pm 5) ^\circ\text{C}$. Otherwise and if, however, 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, the ambient temperature is, in case of doubt, maintained at $(23 \pm 2) ^\circ\text{C}$ or $t_a \pm 2 ^\circ\text{C}$ for transformers with t_a marking.

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

5.5 For a.c., test voltages are of substantially sine wave form, and, if not otherwise specified, have a frequency of 50 Hz or 60 Hz.

NOTE – Unless otherwise specified in a given part 2, the frequency of test voltage for a.c. with frequency above 1 kHz is under consideration.

5.6 Transformers designed for more than one **rated supply voltage**, for a **rated supply voltage range** or for more than one **rated frequency**, are tested, unless otherwise specified in this standard, at the supply voltage or frequency that imposes the most severe conditions for the transformer in the test concerned.

5.7 As far as possible, measurements are made with instruments which do not appreciably affect the values to be measured; if necessary, corrections for their influence are made.

5.8 Unless otherwise specified, transformers intended to be used with **external flexible cable or cords** are tested with a **cord(s)** (see definition 3.2.1) connected to the transformer.

5.9 If **class I transformers** have accessible metal parts which are not connected to a protective earthing terminal or protective earthing contact, and are not separated from **hazardous live parts** by an intermediate metal part which is connected to an earthing terminal or earthing contact, such parts are checked for compliance with the appropriate requirements specified for **class II transformers** in this standard.

5.10 A **flush-type transformer** is tested with an appropriate flush-mounting box of insulating material. This box is placed in an **enclosure** as indicated in figure 1, made from plywood, with a thickness of 20 mm, the inside being painted dull black, the distance between the back of the mounting box and the rear wall of the **enclosure** being 5 mm.

5.11 **Transformers for specific use** for which there are no relevant appliance or equipment standards are tested as transformers for general use, their rating being considered as the power consumption and power factor of the appliance(s) or equipment for which they are designed.

5.12 **Associated transformers** for use in an appliance or equipment shall comply with the relevant part 2 of this standard, and the conditions under which they are used in the appliance or equipment shall be in accordance with their marking. However, if they are used in an appliance or equipment for which a relevant appliance or equipment standard exists, they may be tested under the conditions present in the appliance or equipment for which they are intended.

Consequently, a transformer tested under conditions present in the appliance or equipment for which it is intended has to comply with the following clauses, subclauses or parts thereof, all other clauses, subclauses or parts thereof being considered to be covered by the relevant product standard:

1 – 2 – 3 – 4 – 5.1 – 5.2 – 5.3 – 5.4 – 5.5 – 5.6 – 5.7 – 5.12 – 7.1 – 7.2 – 7.5 – 7.6 – 8.2 – 8.11 – 14.1 – 14.2, except for table 1 all requirements starting with the first: external **enclosures**..., – 14.3 – 15.1, restricted to the first box of table 3 – 18.1 – 18.2 – 18.3, except items 3 and 4 of table 8 – 18.4 – 19.1 – 19.12 – 20.9 – 26.1 – 26.2 – 26.3 – annexes A, C, D, G, L, M, N, P.

NOTE – Attention is drawn to the fact that if the appliance or equipment standard does not include tests for short-circuit or overload protection of the transformer, relevant tests of clause 15 may have to be made.

5.13 *IP00 transformers, the use of which is not known, are tested without adding an enclosure.*

For these transformers, the relevant requirements of clauses 9 and 17 are not applicable.

5.14 *IP00 transformers, the use of which is known, are tested mounted in accordance with the manufacturer's instructions.*

6 Ratings

Ratings are indicated in the relevant part 2 for different types of transformers.

NOTE – If values other than the ones indicated as preferred values are chosen, it is recommended, where applicable, that they be taken from the R10 series (see ISO 3).

7 Classification

Transformers are classified:

7.1 According to their protection against electric shock:

- **class I transformers;**
- **class II transformers;**
- **class III transformers.**

NOTE – **Incorporated transformers** are not classified; their degree of protection against electric shock is determined by the way in which the transformer is incorporated.

7.2 According to short-circuit protection or protection against abnormal use:

- **inherently short-circuit proof transformers;**
- **non-inherently short-circuit proof transformers;**
- **non-short-circuit proof transformers;**
- **fail-safe transformers.**

7.3 According to the degree of protection ensured by the **enclosure** and defined in accordance with IEC 60529 (IP system, for further information see annex Q).

7.4 According to their mobility:

- **stationary transformers;**
- **fixed transformers;**
- **portable transformers;**
- **hand-held transformers.**

7.5 According to their time of operation:

- **continuous operation;**
- **short-time operation;**
- **intermittent operation.**

7.6 According to the intended use:

7.6.1 Associated

- incorporated;
- for specific use.

7.6.2 Independent

8 Marking and other information

8.1 Transformers shall be marked with:

a) **rated supply voltage(s)** or **rated supply voltage range(s)** in volts;

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

NOTE 1 – Example 115 V – 230 V: the transformer is suitable for any value within the marked range

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

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

NOTE 3 – This requirement is also applicable to transformers with provisions for connection to both single-phase and polyphase supplies.

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

b) **rated output voltage(s)** in volts or kilovolts;

For transformers incorporating a rectifier, the **rated output voltage** after the rectifier shall be marked with the arithmetic mean value. If, however, the output voltage is given as an r.m.s. value, this shall be stated.

NOTE 4 – An r.m.s. value is distinguished from an arithmetic mean value by the use of r.m.s. in the marking.

c) **rated output** in volt-amperes or kilovolt-amperes and VAR or kVAR for reactors;

NOTE 5 – For transformers incorporating a rectifier, the output may be expressed in watts, instead of volt-amperes or kilovolt-amperes.

d) **rated output current(s)** in amperes or milliamperes as an alternative to the marking of the **rated output**;

e) **rated frequency(ies)** in hertz;

f) **rated power factor**, if other than unity for transformer above 25 VA;

g) symbol or abbreviation DC for nature of output current for transformers incorporating a rectifier;

h) symbol indicating the kind of transformer as indicated in the relevant part 2;

i) name or trade mark of the manufacturer or responsible vendor;

j) model or type reference;

k) vector group in accordance with IEC 60076-1 (for three-phase transformers if required);

- l) symbol for **class II** construction, for **class II transformers** only;
- m) symbol for **class III** construction, for **class III transformers** only;
- n) indication of the protection index IP, if other than IP00 or **ordinary transformers**;
- o) rated maximum ambient temperature t_a , if other than 25 °C;

NOTE 6 – It is recommended that the values of t_a are given in steps of 5 °C for $t_a \leq 50$ °C and in steps of 10 °C for $t_a > 50$ °C.

p) transformers for **short-time operation** or **intermittent operation** shall be marked with the rated operating time or with the rated operating time and the rated resting time respectively, unless the operating time is limited by the construction of the transformer or corresponds to the operating conditions specified in the relevant part 2.

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

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

In addition, the manufacturer shall be prepared to provide the purchaser with the following information (in the literature or otherwise):

- for **stationary transformers** with a **rated output** exceeding 1 000 VA, the **short-circuit voltage** expressed as a percentage of the **rated supply voltage**;
- the electrical function of the transformer.

NOTE 7 – If the transformer has more than one **output winding**, the **short-circuit voltage** to be marked is the lowest value for the various windings.

NOTE 8 – Additional markings are allowed provided they do not give rise to misunderstanding.

8.2 Transformers with protection index IP00, or **associated transformers**, may be marked with only the name (or trade mark) of the manufacturer or responsible vendor and the type reference (or catalogue reference). Other characteristics shall then be given in the data sheets of the transformer or in the manufacturer's instructions delivered with the transformer.

NOTE 1 – The name of the manufacturer or responsible vendor and the type reference may be replaced by a code.

This information shall be such that a replacement transformer can be supplied, which will be fully interchangeable with the original transformer.

NOTE 2 – Fully interchangeable implies electrically, mechanically, dimensionally and functionally.

8.3 If the transformer can be adjusted to suit different **rated supply voltages**, the voltage to which the transformer is adjusted shall be easily and clearly discernible.

8.4 Transformers with tapped or multiple **output windings** shall be marked with:

- the **rated output voltage** for each tapping or winding, unless the transformer is intended for special purposes involving frequent changes in output voltage;
- the **rated output** for each tapping or winding, unless it is the same for every tapping or winding.

The arrangement of the connections necessary to obtain the various output voltages shall be clearly indicated on the transformer.

8.5 Transformers which are declared to be **short-circuit proof transformers**, and which comply with the requirements for such transformers, shall be marked with the symbol for **short-circuit proof transformers**.

Non-inherently short-circuit proof transformers with incorporated fuses and **non-short-circuit proof transformers** designed to be protected by fuses shall, in addition, be marked with the rated current, amperes or milliamperes, of the protecting fuse-link, followed or preceded by the symbol for the time current characteristics of the fuses in accordance with the relevant publication, if applicable.

Non-inherently short-circuit proof transformers with incorporated replaceable protective devices other than fuses, and **non-short-circuit proof transformers** designed to be protected with protective devices other than fuses shall, in addition, be marked with the manufacturer's model or type reference of the device, and/or rating of the device.

NOTE – **Non-inherently short-circuit proof transformers** with non-replaceable devices need no additional marking regarding the protective device.

The marking shall be sufficient to ensure correct replacement of the protective device.

In the case where replaceable protective devices other than fuses are used, information about its installation shall be given in an instruction sheet or the like accompanying the transformer.

Transformers which are declared to be **fail-safe transformers**, and which comply with the requirements for such transformers, shall be marked with the symbol for **fail-safe transformer**.

8.6 Terminals intended exclusively for the neutral conductor shall be indicated by the symbol for neutral.

Earthing terminals shall be indicated by the symbol for earthing.

Terminals of **input** and **output windings** shall be clearly identified.

If any point of a winding or a terminal is connected to the frame or core, it shall be marked with the relevant symbol.

8.7 Transformers shall be provided with markings clearly indicating the manner in which the transformer is to be connected, unless it is evident from the design of the transformer.

8.8 For transformers with type **X**, **Y** and **Z attachments**, the instruction sheet shall contain the substance of the following information:

- for **type X attachments** having a specially prepared cord:

"If the **external flexible cable or cord** of this transformer is damaged, it shall be replaced by a special cord or assembly available from the manufacturer or his service agent";

- for **type Y attachments**:

"If the **external flexible cable or cord** of this transformer is damaged, it shall be replaced by the manufacturer or his service agent or a similar qualified person in order to avoid a hazard";

- for **type Z attachments**:

"The **external flexible cable or cord** of this transformer cannot be replaced; if the cord is damaged, the transformer should be scrapped".

8.9 Transformers for indoor use only shall be marked with the relevant symbol.

As there is no symbol available for the time being (under consideration) the manufacturer shall put in the instruction sheet the wording: "for indoor use only".

8.10 class II transformers shall be marked with the graphical symbol 5172 of IEC 60417 placed adjacent to the supply information, for example on the rating plate, so that it is obvious that the symbol is part of the technical information, and it can in no way be confused with the manufacturer's name or any other identification (see 5.2.2.3 of IEC 60536-2).

8.11 When symbols are used on equipment or in instructions, they shall be as follows:

Symbol	Explanation	IEC 60417
V*	Volts	
A*	Amperes	
VA or (VAR)*	Volt amperes (or volt-amperes reactive for reactors)	
W*	Watts	
Hz*	Hertz	
PRI	Input	
SEC	Output	
— — —	Direct current	5031
N	Neutral	
~	Single-phase a.c.	5032
3 ~	Three-phase a.c.	
3/N ~	Three-phase + neutral a.c.	
cos φ	Power factor	
	Class II construction	5172
	Class III construction	5180
	Fuse-link (add symbol for time-current characteristics)	5016
t_a	Rated maximum ambient temperature	
	Frame or core terminal	5020
	Protective earth (ground)	5019
IPXX	IP number**	
under consideration	For indoor use only	
* Multiple or submultiples are allowed. ** The X used in the IP number in this scheme indicates a missing numeral in the example, but both of the appropriate numerals shall be marked on the transformer, if applicable. Additional and supplementary letters mentioned in IEC 60529 may be used if necessary.		

8.12 The different positions of regulating devices and the different positions of switches shall be indicated by figures, letters or other visual means.

If figures are used for indicating the different positions, the "off" position shall be indicated by the figure 0 and the position for a greater output, input, etc. shall be indicated by a higher figure.

The figure 0 shall not be used for any other indication. Indications used shall be comprehensible without a knowledge of languages, national standards, etc.

8.13 Marking shall not be placed on screws or other easily removable parts.

Marking shall, with the exceptions mentioned below, be clearly discernible when the transformer is ready for use.

Marking related to terminals shall be so positioned that it is clearly discernible, if necessary after removal of the cover; it shall be such that there can be no confusion between input terminals and output terminals.

Marking related to interchangeable protective devices shall be positioned adjacent to the bases of these devices, and shall be clearly discernible after removal of any cover and the protective device.

Compliance with the requirements of 8.1 to 8.13 is checked by inspection.

8.14 If it is necessary to take special precautions for installation or use, details of these shall be supplied.

8.15 Marking shall be durable and easily legible.

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

The petroleum spirit to be used for the test is aliphatic solvent hexane with a contents of aromatics of maximum 0,1 % volume, a kauributanol value of 29, initial boiling point approximately 65 °C, dry point approximately 69 °C and specific gravity of 0,68 g/cm³.

Marking made by moulding, pressing or engraving is not subjected to this test.

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

9 Protection against accessibility to hazardous live parts

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

Compliance is checked by the tests of 9.1 and 9.2.

9.1 *In order to verify that a **live part** is not **hazardous 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. In addition, discharge shall be measured between pins of the connecting device of the transformer, if any, and/or between the secondary conductors where they are accessible 5 s after the interruption of the supply.*

*The **live part** is not **hazardous live** if where separated from the supply by double or reinforced insulation or in conformity with 19.8:*

- a) the voltage does not exceed 35 V (peak) a.c. or 60 V ripple free d.c., or*
- b) the touch-current measured with the measuring network according to annex J, expressed as voltages U_1 and U_2 , does not exceed the following values:*
 - for a.c.: $U_1 = 35$ V (peak) and $U_2 = 0,35$ V (peak);*
 - for d.c.: $U_1 = 1,0$ V.*

NOTE 1 – The limit values of $U_2 = 0,35$ V (peak) for a.c. and $U_1 = 1,0$ V for d.c. corresponds to the values 0,7 mA (peak) a.c. and 2,0 mA d.c.

The limit value $U_1 = 35$ V (peak) for a.c. corresponds to the value 70 mA (peak) a.c. for higher frequencies.

and in addition, when b) is applicable:

- c) the discharge does not exceed 50 μ C for stored voltages between 60 V and 15 kV, or*
- d) the energy of discharge does not exceed 350 mJ for stored voltages exceeding 15 kV.*

The measurement with the measuring network for the touch-current shall be carried out in accordance with annex J.

NOTE 2 – It is recommended that for apparatus intended to be used in tropical climates, the values given in a) and b) above be halved.

NOTE 3 – To avoid unnecessarily high touch-current when several appliances are interconnected, it is recommended that the individual touch-current values are not higher than needed for functional reasons.

9.2 Transformers with a protection index other than IP00 shall be so constructed and enclosed that there is adequate protection against accidental contact with **hazardous live parts** and, for **class II transformers**, with metal parts separated from **hazardous live parts** by **basic insulation** only. This requirement applies even after removal of **detachable parts**, except for:

- lamps with caps other than E10;
- type D fuse-carriers.

The insulating properties of lacquer, enamel, paper, cotton, oxide film on metal parts and sealing compound shall not be relied upon to give the required protection against accidental contact with **hazardous live parts**.

NOTE 1 – Self-hardening resins are not regarded as sealing compound.

Shafts, handles, operating levers, knobs and the like shall not be **hazardous live**.

*Compliance is checked by inspection and by the relevant tests of IEC 60529. For **ordinary transformers**, the test is made with the standard test finger shown in figure 2 only.*

*In addition, apertures in **class II transformers** and apertures in **class I transformers** other than those in metal parts connected to an earthing terminal are tested with the test pin shown in figure 3.*

The test finger and the test pin are applied, without appreciable force, in every possible position.

The test finger of figure 2 is applied without appreciable force, the transformer being in every possible position except that transformers normally used on the floor and having a mass exceeding 40 kg are not tilted. Through openings, the test finger is applied to any depth that the finger 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 finger, the force on the finger in the straight position is increased to 20 N. If the finger then enters the opening, the test is repeated with the finger in the angled position.

*It shall not be possible to touch bare **hazardous live parts** or **hazardous live parts** protected only by lacquer, enamel, paper, cotton, oxide film or **sealing compound**, with the test finger. For **class II transformers**, it shall not be possible to touch metal parts separated from **hazardous live parts** by **basic insulation** only with the test finger.*

*It shall not be possible to touch bare **hazardous live parts** with the test pin.*

NOTE 2 – This requirement does not apply to lamp caps or socket-outlets.

NOTE 3 – In case of doubt, an electrical contact indicator, with a voltage not less than 40 V, is used with a test pin.

10 Change of input voltage setting

Transformers with more than one **rated supply voltage** shall be so constructed that the voltage setting cannot be changed without the aid of a **tool**.

Transformers which can be set to different **rated supply voltages** shall be so constructed that the indication of the voltage to which the transformer is set is discernible on the transformer when it is ready for use.

Compliance is checked by inspection.

NOTE – The requirement concerning the voltage setting is met if a **tool** is needed to remove a cover before the voltage setting can be changed.

11 Output voltage and output current under load

11.1 When the transformer is connected at **rated supply voltage**, at **rated frequency**, and loaded with an impedance which would give **rated output** at **rated output voltage** and, for a.c. current, at **rated power factor**, the output voltage shall not differ from the rated value by more than:

- a) 10 % for the output voltage of **inherently short-circuit proof transformers** with one **rated output voltage**;
- b) 10 % for the highest output voltage of **inherently short-circuit proof transformers** with more than one **rated output voltage**;
- c) 15 % for the other output voltages of **inherently short-circuit proof transformers** with more than one **rated output voltage**;
- d) 5 % for the output voltages of other transformers.

For transformers with rectifiers, the above percentage values are raised by 5.

*Compliance is checked by measuring the output voltage when steady state conditions are established, the transformer being connected to **rated supply voltage**, at **rated frequency**, and loaded with an impedance which would give **rated output** at **rated output voltage** and **rated power factor**.*

For transformers incorporating a rectifier, the output voltage is measured at the terminals of the d.c. circuit by means of a voltmeter giving the arithmetical mean value, unless the effective (r.m.s.) value is specifically stated (see 8.1).

*For transformers with more than one **rated supply voltage**, the requirement is applicable for each of the **rated supply voltages**.*

*For transformers with multiple **output windings**, the loads are applied to every multiple section simultaneously, unless otherwise declared.*

11.2 If a transformer is marked with **rated output**, **rated output voltage**, **rated output current** and **rated power factor**, these values shall be substantially in agreement with each other.

If no **rated output current** is assigned to the transformer, the **rated output current** for the purpose of this specification can be calculated from the **rated output** and the **rated output voltage**.

Compliance is checked by calculation.

12 No-load output voltage

The relevant specifications are given in the parts 2 for the different types of transformers.

*For transformers incorporating a rectifier, the output voltages are measured on both sides of the rectifier if they are connected to terminals or terminations. The measurement at the input terminals of the rectifier is made if they are accessible to the user. The **output voltage** is measured at the terminals of the circuit with a voltmeter giving the arithmetic mean value, unless the effective (r.m.s.) value is specifically stated (see 8.1).*

13 Short-circuit voltage

If there is a marking for **short-circuit voltage**, the **short-circuit voltage** measured shall not deviate by more than 20 % from the value calculated from this marking.

*Compliance is checked by measuring the **short-circuit voltage**, the transformer being at ambient temperature.*

14 Heating

14.1 Transformers and their supports shall not attain excessive temperature in normal use.

Compliance is checked by the test of 14.2. Moreover, the following conditions apply to the windings.

14.1.1 *If the manufacturer has neither stated which classified material has been used, nor stated any value of t_a (see 3.5.8), and the measured temperature does not exceed the value given in table 1 for class A material, the tests of 14.3 are not made.*

*However, if the measured temperature exceeds the value given in table 1 for class A material, the **live parts** of transformers (core and windings) are submitted to the tests of 14.3. The temperature of the heating cabinet is chosen according to table 2. The temperature value to be chosen in table 2 is the next highest value to the measured temperature value.*

14.1.2 *If the manufacturer has not stated which classified material has been used but has stated a value of t_a , and the measured temperature does not exceed the value given in table 1 for class A material, taking the value of t_a into account (see 14.2), the tests of 14.3 are not made.*

*However, if the measured temperature, taking the value of t_a into account, exceeds the value given in table 1 for class A material, the **live parts** of transformers (core and windings) are submitted to the tests of 14.3. The temperature of the heating cabinet is chosen according to table 2, taking the value of t_a into account. The temperature value to be chosen in table 2 is the next highest value to the calculated temperature value.*

14.1.3 *If the manufacturer has stated which classified material has been used but has not stated any value of t_a , and the measured temperature does not exceed the relevant value given in table 1, the tests of 14.3 are not made.*

However, if the measured temperature exceeds the value given in table 1, the transformer is deemed not to comply with the requirements of 14.1.

14.1.4 *If the manufacturer has stated which classified material has been used and has stated a value of t_a , and the measured temperature does not exceed the relevant value given in table 1, taking the value of t_a into account, the tests of 14.3 are not made.*

However, if the measured temperature, taking the value of t_a into account, exceeds the value given in table 1, the transformer is deemed not to comply with the requirements of 14.1.

14.2 Temperatures are determined under the following conditions when steady state is established.

The test and the measurements are made in a draught-free location having dimensions such that the test results are not influenced. If the transformer has a t_a rating, the test is made at $t_a \pm 5^\circ\text{C}$.

Portable transformers are placed on a dull black painted plywood support. **Stationary transformers** are mounted as in normal use, on a dull black painted plywood support. The support is approximately 20 mm thick, and has dimensions which are at least 200 mm in excess of those of the orthogonal projection of the specimen on the support.

Transformers which are provided with integral pins intended to be introduced into fixed socket-outlets are tested in a flush-mounted socket-outlet mounted in a box on a dull black painted plywood support as indicated in figure 1.

Flush type transformers are tested as described in 5.10.

Transformers with a protection index other than IP00 are tested in their enclosure.

Transformers with a protection index IP00, the application of which is not known, are tested as described in 5.13.

NOTE 1 – In the case of transformers with a protection index IP00, the temperature of the support is measured, but the values given in tables 1 and 3 are not considered.

Transformers with terminals for **type X attachment** with a specially prepared cord and for **type Y** and **type Z attachments** shall have the connections subjected to a pull of 5 N immediately before the heating test is carried out.

Transformers are connected to **rated supply voltage** and loaded with an impedance which would give **rated output**, at **rated output voltage** and, for a.c. current, at **rated power factor**; then the supply voltage is increased by 6 %. After this voltage increase, no change is made in the circuit. The test is repeated under no-load condition if this is a more unfavourable situation.

Associated transformers are operated under the conditions occurring when the appliance or other equipment is operated under the conditions of normal use indicated in the relevant specification.

The temperatures of windings are determined by the resistance method.

NOTE 2 – One of the methods consists of measuring each winding separately, and of determining the resistance of windings at the end of the test 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 to ascertain the resistance at the instant of switching off.

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

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

where

$x = 234,5$ for copper;

$x = 225$ for aluminium;

Δt is the temperature rise, above t_2 so that the maximum temperature equal $\Delta t + t_2$;

R_1 is the resistance at the beginning of the test, at temperature t_1 ;

R_2 is the resistance at the end of the test, when steady conditions have been established;

t_1 is the ambient temperature at the beginning of the test;

t_2 is the ambient temperature at the end of the test.

At the beginning of the test, the windings shall be at ambient temperature.

When determining the temperature of windings, the ambient temperature is measured at such a distance from the specimen so as not to influence the temperature reading. At this point, the temperature of the air shall not vary by more than 10 °C during the test.

For transformers with more than one **input or output winding**, or a tapped **input or output winding**, the results to be considered are those showing the highest temperature.

Other temperatures are determined by means of thermocouples so chosen and positioned that they have the minimum effect on the temperature of the part under test.

Thermocouples used for determining the temperature of the surface of supports are attached to the back of small blackened discs of copper or brass of 1 mm thick and 15 mm diameter which are flush with the surface.

The temperature of electrical insulation (other than that of windings) is determined on the surface of the insulation at places where failure could establish a contact between **hazardous live parts** and accessible metal parts, or a reduction of **creepage distances** or **clearances** below the values specified in clause 26.

During the test, the temperature shall not exceed the values shown in table 1 when the transformer is operated at its **rated ambient temperature** (25 °C or t_a). In those cases where the temperature in the test area differs from the **rated ambient temperature**, this difference shall be taken into account when applying the limits in table 1 and when establishing the test temperatures in 27.1 and 27.4.

Table 1 – Values of maximum temperatures in normal use

Parts	Temperature °C
Windings, (bobbins and laminations in contact therewith), if the insulation system is:	
– of class A material ¹⁾	100
– of class E material	115
– of class B material	120
– of class F material	140
– of class H material	165
– of other material ²⁾	–
External enclosures ³⁾ (which can be touched with the standard test finger) of stationary transformers , if of:	
– metal	70
– other material	80
External enclosures ³⁾ (which cannot be touched with the standard test finger) of stationary transformers	85
External enclosures ³⁾ , handles and the like of portable transformers :	
– if, in normal use, these parts are continuously held (for example for hand held transformers):	
• of metal	55
• of other material	75
– if, in normal use, these parts are not continuously held:	
• of metal	60
• of other material	80
Terminals for external conductors and terminals of switches	70
Insulation of internal and external wiring ⁴⁾ :	
– of rubber	65
– of polyvinyl chloride	70
Parts the deterioration of which could affect safety ⁴⁾ :	
– of rubber (other than insulation of wiring)	75
– of phenolformaldehyde	105
– of ureaformaldehyde	85
– of impregnated paper and fabric	85
– of impregnated wood	85
– of polyvinyl chloride (other than insulation of wiring), polystyrene and similar thermo-plastic material	65
– of varnished cambric	75
Supports	85
Printed boards ⁴⁾ :	
– bonded with phenol-formaldehyde, melamine-formaldehyde, phenol-furfural or polyester	105
– bonded with epoxy	140

1) The material classification is in accordance with IEC 60085 and IEC 60216; however, the values have been adjusted to take into account the fact that, in these tests, the temperatures are mean and not hot-spot values.

2) If other materials than those specified in IEC 60085 and IEC 60216 are used, they shall withstand the test of 14.3.

3) If any component is part of the external surface of the transformer, the temperature of that component shall not exceed the value specified for the appropriate external **enclosure**.

4) The grades of rubber and polyvinyl chloride insulation are those covered by IEC 60245 and IEC 60227, respectively.

If other materials are used, they shall not be exposed to temperatures in excess of those which have been proved permissible for these materials.

NOTE 3 – Attention is drawn to the fact that protective devices may incorporate heating elements having a surface temperature exceeding the permissible maximum temperature for the affected insulation system.

*Immediately after the test, the specimen shall withstand a dielectric strength test as specified in 18.3, the test voltage being applied between **input** and **output circuits** only.*

*For **class I transformers**, care is taken that other insulation is not stressed by a voltage exceeding the relevant value specified in 18.3.*

*After the test the electrical connections shall not have worked loose, **creepage distances** and **clearances** shall not have been reduced to less than the values specified in clause 26, sealing compound shall not have flowed out, and overload protection devices shall not have operated.*

14.3 When applicable (see 14.1, 19.12.3 and 26.3), the **live parts** of the transformer (core and windings) are subjected to the following cycling test, each cycle consisting of a heat run, a moisture treatment, and a vibration test. Measurements according to 14.3.4 are made after each cycle.

The number of specimens is as indicated in 5.2. The specimens are subjected to 10 test cycles.

14.3.1 Heat run

Depending on the type of insulation, the specimens are kept in a heating cabinet for one combination of time and temperature specified in table 2. The 10 cycles are carried out with the same combination.

The temperature in the heating cabinet is maintained within a tolerance of ± 3 °C.

Table 2 – Test temperature and testing time (in days) per cycle

Test temperature °C	Temperature for the insulation system °C				
	100	115	120	140	165
220					4
210					7
200					14
190				4	
180				7	
170				14	
160			4		
150		4	7		
140		7			
130	4				
120	7				
Corresponding classification according to IEC 60085 and IEC 60216	A	E	B	F	H

14.3.2 Moisture treatment

The specimens are submitted for two days (48 h) to a moisture treatment according to 17.2.

14.3.3 Vibration test

Specimens are fastened in their normal position of use to the vibration generator, as specified in IEC 60068-2-6, by means of straps round the **enclosure**. The direction of vibration is vertical, and the severity is:

duration: 30 min;
amplitude: 0,35 mm;
frequency range: 10 Hz, 55 Hz, 10 Hz;
sweep rate: approximately one octave per minute.

14.3.4 Measurements

After each cycle, the insulation resistance is measured according to 18.1 and 18.2. A dielectric strength test according to 18.3 and 18.4 is made. After the heat tests, the specimens are allowed to cool down to ambient temperature before the moisture treatment is made.

The values of the test voltage for the dielectric test according to clause 18 are, however, reduced to 35 % of the specified values and the testing times doubled, except that the test according to 18.4 shall be made with a test voltage of at least 1,2 times the **rated supply voltage**. A specimen is considered not to comply with the test if the no-load current or the ohmic component of the **no-load input** deviates from the corresponding value, obtained during the first measurement, by more than 30 %. If, after the completion of all 10 cycles, one or more specimens have failed, the transformer is considered as not complying with the endurance test.

15 Short circuit and overload protection

15.1 Transformers shall not become unsafe due to short circuits and overloads which may occur in normal use.

Compliance is checked by inspection and by the following tests, which are carried out immediately after the test according to 14.2 at the same ambient temperature, and without changing the position of the transformer, at 1,06 times the **rated supply voltage**, or, for **non-inherently short-circuit proof transformers**, at any value of the supply voltage between 0,94 times and 1,06 times the **rated supply voltage**:

- for **inherently short-circuit proof transformers**, by the tests of 15.2;
- for **non-inherently short-circuit proof transformers**, by the tests of 15.3;
- for **non-short-circuit proof transformers**, by the tests of 15.4;
- for **fail-safe transformers**, by the tests of 15.5;
- for transformers combined with a rectifier, the tests of 15.2 or 15.3 are made twice, once with the short circuit applied on one side of the rectifier, and again with the short circuit applied on the other side of the rectifier;

– for transformers with more than one **output winding** or a tapped **output winding**, the results to be considered are those showing the highest temperature. In the first case, all windings which are intended to be loaded at the same time are loaded at **rated output** and then the chosen **output winding** is short-circuited.

For the tests of 15.2, 15.3 and 15.4, the temperatures shall not exceed the values given in table 3 when the transformer is operated at its **rated ambient temperature** (25 °C or t_a). In the cases where the temperature in the test area differs from the **rated ambient temperature**, this difference shall be taken into account when applying the limits in table 3.

Table 3 – Maximum values of temperatures under short-circuit or overload conditions

Insulation classification	A	E	B	F	H
	Maximum temperature °C				
Winding protected inherently	150	165	175	190	210
Winding protected by protective device:					
– during the time T given in table 4 ¹⁾	200	215	225	240	260
– after the first hour, peak value ²⁾	175	190	200	215	235
– after the first hour, arithmetic mean value ²⁾	150	165	175	190	210
External enclosures (which can be touched with the standard test finger)			105		
Rubber insulation of wiring			85		
PVC insulation of wiring			85		
Supports (i.e. any area on the pine plywood surface covered by the transformer)			105		
1) After the tests of 15.3.3, these values may be exceeded due to the thermal inertia of the transformer.					
2) Does not apply to the tests of 15.3.3					

During the test, the transformer shall not emit flames, molten metal, poisonous or ignitable gas in hazardous amounts, and temperatures shall not exceed the values shown in table 3.

During and after all the tests the transformer shall comply with clause 9.

After the tests, the insulation, when it has cooled down to approximately ambient temperature, shall withstand the dielectric strength test in 18.3.

NOTE – The humidity treatment of 17.2 is not applied before this dielectric strength test.

15.2 Inherently short-circuit proof transformers are tested by short-circuiting the **output windings** until steady-state conditions are reached.

15.3 Non-inherently short-circuit proof transformers are tested as follows:

15.3.1 The output terminals are short-circuited. The incorporated overload protection device shall operate before the temperature exceeds the values shown in table 3 for any value of the supply voltage between 0,94 times and 1,06 times the **rated supply voltage**.

15.3.2 If protected by a fuse in accordance with either IEC 60269-2 or IEC 60269-3, or a technically equivalent fuse, the transformer is loaded for a time T and with a current equal to k times the current marked on the transformer as the rated current of the protection fuse-link, where k and T have the values shown in table 4.

Table 4 – Values of T and k for fuses

Values marked as rated current I_n of protecting fuse-link for gG A	T h	k
$I_n \leq 4$	1	2,1
$4 < I_n < 16$	1	1,9
$16 \leq I_n \leq 63$	1	1,6
$63 < I_n \leq 160$	2	1,6
$160 < I_n \leq 200$	3	1,6
NOTE 1 – For cylindrical fuses gG type B for use by unskilled persons (IEC 60269-3-1), and for fuses for use by authorised persons with fuses-links for bolted connections (IEC 60269-2-1), the value of k is 1,6 for $I_n < 16$ A.		
NOTE 2 – For D-type fuses for use by unskilled persons (IEC 60269-3-1) for a rated current of 16 A, the value of k is 1,9.		

15.3.3 If protected by miniature fuses in accordance with IEC 60127, or by road vehicles blade type electric fuse-links according to ISO 8820, or by a technically equivalent fuse, the transformer is loaded for a period corresponding to the longest pre-arcing time with the relevant current as specified in the appropriate standard sheet.

NOTE – A technically equivalent fuse is a fuse-link having the same time-current characteristic as one of those indicated in IEC 60127 or in ISO 8820.

15.3.4 If protected by a circuit-breaker in accordance with IEC 60898, or a technically equivalent circuit-breaker, the transformer is loaded for the time indicated in IEC 60898 with a current equal to 1,45 times the value of the rated current of the circuit-breaker.

15.3.5 If protected by an overload protection device other than a fuse according to IEC 60127 or IEC 60269, or a circuit-breaker, the transformer is loaded by a current equal to 0,95 times the value of the lowest current which causes the device to operate, until steady-state conditions are reached.

15.3.6 For the tests of 15.3.2, 15.3.3 and 15.3.4, the fuse-link is replaced by a link of negligible impedance.

For the tests of 15.3.5, the test current is obtained at ambient temperature, commencing at 1,1 times the rated tripping current, which is slowly decreased in steps of 2 % until the current value is obtained for which the overload protection device does not operate.

If non-self resetting **thermal cut-outs** which can be neither reset nor replaced are used, the test current of one specimen shall be increased in steps of 5 %. After each step, the transformer shall reach steady-state conditions. This is continued until the **thermal cut-out** operates. This current value is noted. The test is repeated with the other specimens using 0,95 times the noted value.

15.4 Non-short-circuit proof transformers are tested as indicated in 15.3. The correct protective device specified by the manufacturer is fitted to the relevant **input** or **output circuit**.

Associated **non-short-circuit proof transformers** are tested under the most unfavourable conditions of normal use with the correct protective device specified by the manufacturer fitted in the **input** or **output circuit**, and in the most unfavourable load conditions for the type of equipment or circuit for which the transformer is designed. Examples of unfavourable load conditions are: continuous, short-time, or intermittent functioning.

15.5 Fail-safe transformers

15.5.1 Three additional specimens are used only for the following test. Transformers used in the other tests are not subjected to this test.

Each of the three specimens is mounted as for normal use on a 20 mm thick dull black painted plywood surface. Each transformer is operated at 1,06 times the **rated input voltage**, the **output winding** which produced the highest temperature during the test of 14.2 being initially loaded with 1,5 times the **rated output current** (or, if this is not possible, the maximum value of the output current obtainable) until steady-state conditions are reached, or the transformer fails (whichever occurs first).

If the transformer fails, it shall comply, during and after the tests, with the criteria given in 15.5.2.

If the transformer does not fail, the time to reach steady-state conditions is noted, and the chosen **output winding** is then short-circuited. The test is continued until the transformer fails. Each specimen shall do so within a time duration, for this part of the test is no longer than that necessary to attain steady-state conditions, but not exceeding 5 h.

The transformers shall fail safely and comply, during and after the tests, with criteria given in 15.5.2.

15.5.2 At any time during the tests of 15.5.1:

- the temperature of any part of the **enclosure** of the transformers which may be touched with the standard test finger shall not exceed 175 °C;
- the temperature of the plywood support shall nowhere exceed 125 °C;
- the transformers shall not emit flames, molten material, glowing particles, or burning drops of insulating material.

After the tests of 15.5.1, and after cooling down to ambient temperature:

- the transformers shall withstand a dielectric strength test, the test voltage being 35 % of the values according to clause 18 table 8. The test is made input-to-**body** for all kinds of transformers and, in addition, input-to-output for **safety isolating, isolating and separating transformers**;
- **enclosures**, if any, shall show no holes allowing the standard test finger (figure 2) to touch bare **hazardous live parts**. In case of doubt, contact with bare **hazardous live parts** is detected by means of an electrical contact indicator, the voltage being not less than 40 V.

If the transformer fails any part of this subclause, the transformer is considered as not complying with the endurance test.

16 Mechanical strength

16.1 Transformers shall have adequate mechanical strength, and be so constructed as to withstand such rough handling as may be expected in normal use.

Compliance is checked by the tests of 16.2 for **stationary transformers** and by the tests of 16.2, 16.3 and 16.4, as appropriate, for **portable transformers**.

After the tests, the transformer shall show no damage within the meaning of this standard. In particular, **hazardous live parts** shall not have become accessible, when tested as described in 9.2. Insulating barriers shall not have been damaged, and handles, levers, knobs and the like shall not have moved on their shafts.

NOTE 1 – Damage to the finish, small dents which do not reduce **creepage distances** or **clearances** below the values specified in clause 26, and small chips which do not adversely affect the protection against electric shock or moisture, are ignored.

NOTE 2 – Cracks not visible with normal vision or corrected vision without magnification, and surface cracks in fibre reinforced mouldings and the like are ignored.

In addition, as regards the test of 16.4, bending of the pins during the test is ignored.

16.2 The transformer, with covers and the like fitted, is held firmly against a rigid support and is subjected to three blows from a spring-operated impact hammer according to IEC 60068-2-63 with the energy of $(0,5 \pm 0,05)$ J applied to every point of the exterior that protects **hazardous live parts** and is likely to be weak, including handles, levers, switch knobs and the like, by pressing the hammer nose perpendicularly to the surface. Before applying the blows, the fixing screws of bases and covers are tightened with a torque equal to two-thirds of that specified in table 11.

If there is a doubt as to whether a defect has occurred by the application of the preceding blows, the 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.

Parts of IP00 transformers, which are not accessible when the transformer is mounted in an appliance or other equipment, are not subjected to the test.

16.3 Portable transformers are held in their normal position of use, and are then allowed to fall from a height of 25 mm onto a smooth steel plate at least 5 mm thick, placed on a flat concrete support. One hundred falls are carried out at a rate not exceeding one fall per 5 s.

The height shall be measured from the part of the specimen nearest to the test surface when the specimen is suspended prior to letting it fall.

The method of releasing the specimen shall be such as to allow free fall from the position of suspension, with a minimum of disturbance at the moment of release.

If the transformer is provided with fixed **external flexible cable or cord(s)**, they are cut to a length of 100 mm.

16.4 Transformers which are provided with integrated pins, intended to be introduced into fixed socket-outlets, shall have adequate mechanical strength. The following tests are carried out instead of the test of 16.3:

Compliance is checked by the following tests:

a) The test is carried out on three specimens, in a tumbling barrel as described in IEC 60068-2-32. If the transformer is provided with fixed external cord(s) they are cut to a length of 100 mm. Each specimen is tested individually.

The barrel is turned at a rate of five revolutions per minute, 10 falls per minute thus taking place, the number of falls being:

- 50 if the mass of the specimen does not exceed 250 g,
- 25 if the mass of the specimen exceeds 250 g.

After the test, the specimen shall show no damage within the meaning of this standard, but it need not be operable.

Small pieces may have broken off, provided that the protection against electric shock is not affected.

Distortion of pins and damage to the finish and small dents which do not reduce the **creepage distances** or **clearances** below the values specified in 26.1 of IEC 60884-1 are neglected.

All three specimens shall withstand the test.

b) The pins shall not turn when a torque of 0,4 Nm is applied, first in one direction for 1 min and then in the opposite direction for 1 min.

NOTE –This test is not carried out when rotation of the pins does not impair the safety in the sense of this standard.

c) A pull force as given in table 5 is applied without jerks for 1 min on each pin in turn, in the direction of the longitudinal axis of the pin.

The pull force is applied within a heating cabinet at a temperature of $(70 \pm 2) ^\circ\text{C}$, 1 h after the device has been placed in the heating cabinet.

Table 5 – Pull force on pins

Rating of the equivalent plug type	Number of poles	Pull force N
Up to and including 10 A 130/250 V	2	40
	3	50
Above 10 A up to and including 16 A 130/250 V	2	50
	3	54
Above 10 A up to and including 16 A/440 V	3	54
	More than 3	70

For the purpose of this test, protective earth contacts, irrespective of their number, are considered as one pole.

After the test, and after the device has cooled down to ambient temperature, no pin shall have been displaced in the **body** of the device by more than 1 mm.

Tests b) and c) are carried out on a new sample.

17 Protection against harmful ingress of dust, solid objects and moisture

17.1 The **enclosure** of a transformer shall provide the degree of protection against ingress of dust, solid objects and moisture in accordance with the classification of the transformer and the IP number marked on the transformer.

NOTE – An explanation of the IP numbering system is given in annex Q.

Compliance is checked by the appropriate test specified in 17.1.1, and for other IP ratings by the appropriate test specified in IEC 60529.

Before the test of second characteristic numeral, with the exception of IPX8, the transformer shall be switched on under **rated output** conditions and brought to a stable operating temperature at rated voltage.

The water for the test shall be at a temperature of $15\text{ °C} \pm 10\text{ °C}$.

Transformers shall be mounted and wired as in normal use with, where relevant, a suitable plug inserted in the **output circuit**.

Transformers not provided with an **external flexible cable or cord** are fitted with external wiring, as specified in clause 22, the most unfavourable type and cross-sectional area being used.

For tests of 17.1.1 A to J, a **fixed transformer** intended for mounting with its **body** in contact with a surface shall be tested on a board equal in overall size to the projection of the transformer, if not otherwise specified.

Transformers having provisions for draining water by means of drain holes shall be mounted with the lowest drain hole open unless otherwise specified in the manufacturer's installation instructions. Ventilation openings are left open during the test.

Portable transformers, wired as in normal use, shall be placed in the most unfavourable position of normal use.

Glands, if any, shall be tightened with a torque equal to two-thirds of that applied to glands in the test of 25.6.

After completion of the tests, the transformer shall withstand the dielectric strength test specified in 18.3 and inspection shall show:

- a) no deposit of talcum powder in dust-proof transformers, so that, if the powder were conductive, the insulation would fail to meet the requirements of this standard;
- b) no deposit of talcum powder inside **enclosures** for dust-tight transformers;
- c) no trace of water on **live parts** or on insulation where it could become a hazard for the user or surroundings, for example where it could reduce the **creepage distances** below the values specified in clause 26;
- d) no accumulation of water in drip-proof, rain-proof, splash-proof and jet-proof transformers, so as to impair safety;
- e) no trace of water entered in any part of a watertight transformer;
- f) no entry into the transformer by the relevant test probe for solid-object-proof transformers.

17.1.1 Tests

A Solid-object-proof transformers (first characteristic IP numeral 2) shall be tested with the standard test finger specified in IEC 60529 and the test pin specified in figure 3 according to the requirements of clauses 9 and 26.

NOTE – Ordinary transformers are not required to be tested with the sphere specified in IEC 60529.

B Solid-object-proof transformers (first characteristic IP numerals 3 and 4) shall be tested at every possible point (excluding gaskets) with a probe according to test probe C or D of IEC 61032, applied with a force as follows:

Table 6 – Solid-object-proof transformer test

	Test probe according to IEC 61032	Probe wire diameter mm	Application force
First IP numeral 3	C	$2,5^{+0,05}_0$	3 N ± 10 %
First IP numeral 4	D	$1^{+0,05}_0$	1 N ± 10 %

The end of the probe wire shall be cut at right angles to its length and be free from burrs.

C Dust-proof transformers (first characteristic IP numeral 5) are tested in a dust chamber similar to that shown in figure 2 of IEC 60529, in which talcum powder is maintained in suspension by an air current; during the test the vacuum pump as shown is not connected. The chamber shall contain 2 kg of powder for every cubic metre of its volume. The talcum powder used shall pass through a square-meshed sieve whose nominal wire diameter is 50 μm , and whose nominal free distance between wire is 75 μm , and shall have a range of particle size down to and including 1 μm with at least 50 % by weight less than 5 μm . It should not have been used for more than 20 tests.

The test shall be carried out as follows:

- a) the transformer is suspended outside the dust chamber and operated at **rated output** until operating temperature is achieved;*
- b) the transformer, while still operating, is placed with the minimum disturbance in the dust chamber;*
- c) the door of the dust chamber is closed;*
- d) the fan/blower causing the talcum powder to be in suspension is switched on;*
- e) after 1 min the transformer is switched off and allowed to cool for 3 h while the talcum powder remains in suspension.*

NOTE –The 1 min interval between the switching on of the fan/blower and the switching off of the transformer is to ensure that the talcum powder is properly in suspension around the transformer during initial cooling, which is most important with smaller transformers. The transformer is operated initially as in item a) to ensure that the test chamber is not overheated.

D Dust-tight transformers (first characteristic IP numeral 6) are tested in accordance with C.

E Drip-proof transformers (second characteristic IP numeral 1) are subjected for 10 min to an artificial rainfall of 3 mm/min by means of a device as shown in figure 3 of IEC 60529, falling vertically from a height of 200 mm above the top of the transformer.

F Rain-proof transformers (second characteristic IP numeral 3) are sprayed with water for 10 min by means of a spray apparatus as shown in figure 4 of IEC 60529. The radius of the semi-circular tube shall be as small as possible and compatible with the size and position of the transformer.

The tube shall be perforated so that jets of water are directed towards the centre of the circle, and a water pressure at the inlet of the apparatus shall be approximately 80 kN/m².

The tube shall be caused to oscillate through an angle of 120°, 60° on either side of the vertical, the time for one complete oscillation (2 × 120°) being about 4 s.

The transformer shall be mounted above the pivot line of the tube so that the ends of the transformer receive adequate coverage from the jets. The transformer shall be turned about its vertical axis during the test at a rate of 1 rev/min.

After this 10 min period, the transformer shall be switched off and allowed to cool naturally while the water spray is continued for a further 10 min.

G Splash-proof transformers (second characteristic IP numeral 4) are sprayed from every direction with water for 10 min by means of the spray apparatus shown in figure 4 of IEC 60529 and described in F. The transformer shall be mounted under the pivot line of the tube so that the ends of the transformer receive adequate coverage from the jets.

The tube shall be caused to oscillate through an angle of almost 360°, 180° on either side of the vertical, the time for one complete oscillation ($2 \times 360^\circ$) being about 12 s. The transformer shall be turned about its vertical axis during the test at a rate of 1 rev/min.

The support for the equipment under test shall be grid shaped in order to avoid acting as a baffle. After this 10 min period, the transformer shall be switched off and allowed to cool naturally, while the water spray is continued for a further 10 min.

H Jet-proof transformers (second characteristic IP numeral 5) are switched off and immediately subjected to a water jet for 15 min from all directions by means of a hose, having a nozzle with the shape and dimensions shown in figure 6 of IEC 60529, the dimension D' being 6,3 mm. The nozzle shall be held 3 m away from the sample.

The water pressure at the nozzle shall be approximately 30 kN/m².

I Water-tight transformers (second characteristic IP numeral 7) are switched off and immediately immersed for 30 min in water, so that there is at least 150 mm of water above the top of the transformer, and the lowest portion is subjected to at least 1 m head of water. Transformers shall be held in position by their normal fixing means.

NOTE – This treatment is not sufficiently severe for transformers intended for operation under water.

*J Pressure watertight transformers (second characteristic IP numeral 8) are heated either by operating or by other suitable means, so that the temperature of the transformer **enclosure** exceeds that of the water in the test tank by between 5 °C and 10 °C.*

The transformer shall then be switched off and subjected to a water pressure of 1,3 times that pressure which corresponds to the rated maximum immersion depth for a period of 30 min.

17.2 Transformers shall be proof against humid conditions which may occur in normal use.

Compliance is checked by the humidity treatment described in this subclause, followed immediately by the tests of clause 18.

*Transformers intended for fixed connection to the supply are tested with the cable fitted but with cable entries open. If knock-outs are provided, one of them is opened. Transformers intended to be used with an **external flexible cable or cord** are tested with the cord and cord entries correctly fitted.*

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

The humidity treatment is carried out in a humidity cabinet containing air with a relative humidity maintained between 91 % and 95 %. The temperature of the air, at all places where specimens can be located, is maintained to within 1 °C of any convenient value t between 20 °C and 30 °C.

Before being placed in the humidity cabinet, the specimen is brought to a temperature between t and $(t + 4)$ °C.

The specimen is kept in the cabinet for:

- two days (48 h) for **ordinary transformers** and transformers with protection index IP20, or lower;*
- seven days (168 h) for other transformers.*

In most cases, the specimens may be brought to the specified temperature by keeping them at this temperature for at least 4 h before the humidity treatment.

NOTE – A relative humidity between 91 % and 95 % can be obtained by placing a saturated solution of sodium sulphate (Na_2SO_4) or potassium nitrate (KNO_3) in water, the solution having a sufficiently large contact surface with the air in the humidity cabinet. In order to achieve the specified conditions within the cabinet, it is necessary to ensure constant circulation of the air and, in general, to use a cabinet which is thermally insulated.

After this treatment and the tests of clause 18, the transformer shall show no damage within the meaning of this standard.

18 Insulation resistance and dielectric strength

18.1 The insulation resistance and the dielectric strength of transformers shall be adequate.

Compliance is checked by the tests of 18.2 to 18.4 which are made immediately after the test of 17.2, in the humidity cabinet or in the room in which the specimen was brought to the prescribed temperature, after reassembling those parts which may have been removed.

18.2 *The insulation resistance is measured with a d.c. voltage of approximately 500 V applied, the measurement being made 1 min after application of the voltage.*

The insulation resistance shall be not less than that shown in table 7.

Table 7 – Values of insulation resistance

Insulation to be tested	Insulation resistance MΩ
Between hazardous live parts and the body :	
– for basic insulation	2
– for reinforced insulation	7
Between input circuits and output circuits (basic insulation)	2
Between input circuits and output circuits (double or reinforced insulation)	5
Between each input circuit and all other input circuits connected together	2
Between each output circuit and all other output circuits connected together	2
Between hazardous live parts and metal parts of class II transformers which are separated from hazardous live parts by basic insulation only	2
Between metal parts of class II transformers which are separated from hazardous live parts by basic insulation only, and the body	5
Between two metal foils in contact with the inner and outer surfaces of enclosures of insulating material	2

18.3 Immediately after the test of 18.2, the insulation is subjected for 1 min to a voltage of substantially sine-wave form at 50/60 Hz. The value of the test voltage and the points of application are given in table 8.

Resistors, capacitors and other components are disconnected before carrying out the test.

Table 8 – Table of test voltages

Application of test voltage	Working voltage V*				
	<50	150	300	600	1 000
1) Between live parts of input circuits and live parts of output circuits (basic insulation)	250	1 400	2 100	2 500	2 750
2) Between live parts of input circuits and live parts of output circuits (double or reinforced insulation)	500	2 800	4 200	5 000	5 500
3) Over basic or supplementary insulation between: a) live parts of different polarity b) live parts and the body if intended to be connected to protective earth c) accessible conductive parts and a metal rod of the same diameter as the flexible cable or cord (or metallic foil wrapped round the cord) inserted inside inlet bushing, cord guards and anchorage, and the like d) live parts and an intermediate conductive part e) intermediate conductive parts and the body	250	1 400	2 100	2 500	2 750
4) Over reinforced insulation between the body and live parts	500	2 800	4 200	5 000	5 500
* Values of test voltage for intermediate values of working voltage are found by interpolation between tabulated values.					

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

No flashover or breakdown shall occur during the test, corona effects and similar phenomena being disregarded. Diagrams showing examples of the application of test voltages are shown in annex N.

The high-voltage transformer used for the test shall be capable of supplying a current of at least 200 mA when the output terminals are short-circuited. The **overload releases** of the circuit shall not operate for any current less than 100 mA. The voltmeter used to measure the value of the test voltage shall be of class 2.5 according to IEC 60051.

Care shall be taken that the voltage applied for the test between **input** and **output circuits** does not over-stress other insulation. If it is stated by the manufacturer that a **double insulation** system exists between **input** and **output circuits**, such as from **input circuit** to core and from core to **output circuit**, each insulation is then tested separately according to the test voltage of item 3 of table 8. The same applies to a **double insulation** between input and the **body**.

For class II situations incorporating both **reinforced insulation** and **double insulation**, care shall be taken that the voltage applied to the **reinforced insulation** does not over-stress the **basic or supplementary insulation**.

18.4 After the test of 18.3, one **input circuit** is connected to a voltage equal to double the **rated supply voltage**, at double the **rated frequency** for 5 min. No load is connected to the transformer. During the test, polyfilar windings, if any, are connected in series.

A higher test frequency may be used; the duration of the period of connection, in minutes, then being equal to 10 times the **rated frequency** divided by the test frequency, but not less than 2 min.

During the test, there shall be no breakdown of the insulation between turns of a winding, between **input** and **output circuits**, between adjacent **input** or **output circuits**, or between the windings and any conductive core.

19 Construction

19.1 The **input** and **output circuits** as specified in the relevant part 2 in general shall be separated by insulation, and the construction in general shall be such that there is no possibility of any connection, except by deliberate action, between these circuits, either directly or indirectly, through other metal parts.

19.2 Materials which burn fiercely, such as celluloid, shall not be used in the construction of transformers.

Cotton, silk, paper and similar fibrous material shall not be used as insulation, unless impregnated.

Wax and similar impregnates shall not be used, unless suitably restrained from migration.

Compliance is checked by inspection and, in case of doubt regarding fiercely burning materials, by the glow-wire test of 27.2.

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

Wood, even if impregnated, shall not be used as **supplementary** or **reinforced insulation**.

19.3 **Portable transformers** shall be either **short-circuit proof** or **fail-safe transformers**.

Compliance is checked by inspection.

19.4 Provisions shall be taken to prevent contact between accessible metal parts and conduits or metal sheaths of supply wiring for **class II transformers**.

Compliance is checked by inspection.

19.5 Parts of **class II transformers**, which serve as **supplementary insulation** or **reinforced insulation** and which might be omitted during reassembling after routine servicing, shall either:

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

Compliance is checked by inspection and by manual test.

NOTE 1 – Sleeving may, however, be used as **supplementary insulation** on internal wiring, if it is retained in position by positive means.

NOTE 2 – A sleeve is considered to be fixed by positive means if it can be removed only by breaking or cutting, or if it is clamped at both ends.

NOTE 3 – Routine servicing includes replacement of switches, protective devices and of **power supply cords** when the type of attachment allows this.

NOTE 4 – Lining metal **enclosures** with a coating of lacquer or with material in the form of a coating which does not withstand the test of 19.10 is not considered to be adequate for the purpose of these requirements.

19.6 **Class I** and **class II transformers** shall be so constructed that, should any wire, screw, nut, washer, spring or similar part become loose or fall out of position, they cannot, in normal use, become so disposed that **creepage distances** or **clearances** over **supplementary insulation** or **reinforced insulation** or the distance between input and output terminals are reduced to less than 50 % of the value specified in clause 26.

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

NOTE – For the purpose of this requirement:

- it is not expected that two independent fixings will become loose at the same time;
- parts fixed by means of screws or nuts provided with locking washers are regarded as not liable to become loose, provided these screws or nuts are not removed during the replacement of the supply flexible cable or cord, or other routine servicing;
- conductors connected by soldering are not considered to be adequately fixed unless they are held in place near to the termination by means such as hooking in, independently of the solder;
- screwless terminals complying with IEC 60998-2-2 are considered to provide adequate fixing of the conductor without any additional means;
- wires connected to terminals are not considered to be adequately secured, unless an additional fixing of an appropriate type is provided near to the terminal; in the case of stranded conductors, this additional fixing is to clamp the insulation and not the conductor only;
- short rigid wires are not regarded as liable to come away from a terminal if they remain in position when the terminal screw is loosened.

19.7 Parts connected to accessible metal parts by resistors or capacitors shall be separated from the **hazardous live parts** by **double insulation** or **reinforced insulation**.

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

19.8 Resistors or capacitors connected between **hazardous live parts** and accessible metal parts shall consist of at least two separate components whose impedance is unlikely to change significantly during the lifetime of the transformer. If any one of the components is short-circuited or open-circuited, the values specified in clause 9 shall not be exceeded.

Compliance is checked by inspection and by measurement.

NOTE – Resistors complying with 14.1 of IEC 60065 and capacitors complying with IEC 60384-14 are considered to be appropriate components. One capacitor complying with the requirements of class Y1 of IEC 60384-14 is also considered to be sufficient.

19.9 Insulating material separating **input** and **output windings**, and parts of natural or synthetic rubber used as **supplementary insulation** in **class II transformers**, shall be either resistant to ageing or so arranged and dimensioned that, whatever cracks may occur, **creepage distances** are not reduced below the values specified in clause 26.

Compliance is checked by inspection, by measurement and, in case of doubt concerning the ageing properties of rubber, by the following test.

Rubber parts are aged in an atmosphere of oxygen under pressure. The specimens are suspended freely in an oxygen bomb, the effective capacity of the bomb being at least 10 times the volume of the specimens. The bomb is filled with commercial oxygen not less than 97 % pure, to a pressure of (210^{+7}_0) N/cm².

The specimens are kept in the bomb, at a temperature of (70^{+1}_0) °C for four days (96 h). Immediately afterwards, they are taken out of the bomb and left at ambient temperature, avoiding direct daylight, for at least 16 h.

After the test, the specimens are examined and shall show no cracks with normal vision or corrected vision without magnification

NOTE – In case of doubt with regard to materials other than rubber, a special test may be made (c.f. 14.3 and 26.3).

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

19.10 When protection of **hazardous live parts** against accidental contact is ensured by an insulating coating, this coating shall be capable of withstanding the following tests.

a) Ageing test

The coated part is subjected to the conditions described in section one (test Ba) of IEC 60068-2-2, at a temperature of (70 ± 2) °C for a period of seven days (168 h).

After this treatment, the part is allowed to cool to ambient temperature and inspection shall show that the coating has not loosened or shrunk away from the base material.

b) 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 coating is subjected to a blow, applied to any point of the layer that is likely to be weak, from a spring-operated impact hammer according to IEC 60068-2-63 with an energy of $(0,5 \pm 0,05)$ J.

After this test, the coating shall not be damaged. In particular, it shall show no cracks visible with normal vision, or corrected vision without magnification.

c) 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 $(0,25 \pm 0,02)$ mm.

Scratches are made by drawing the pin along the surface at a speed of about 20 mm/s as shown in figure 4. The pin is so loaded that the force exerted along its axis is $(10 \pm 0,5)$ N. The scratches are at least 5 mm apart and at least 5 mm from the edge of the specimen.

After this test, the coating shall neither have loosened nor be pierced, and it shall withstand a dielectric strength test as specified in clause 18, the test voltage being applied between the base material and a metal foil in contact with the layer.

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

19.11 Handles, operating levers, knobs and the like shall be of insulating material or be adequately covered by **supplementary insulation**, or separated from their shafts or fixing by such insulation, if their shafts or fixing are likely to become live in the event of an insulation fault.

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

19.12 Winding construction

19.12.1 In all types of transformer, precautions shall be taken to prevent:

- undue displacement of **input** or **output windings** or the turns thereof;
- undue displacement of internal wiring or wires for external connections;
- undue displacement of parts of windings or of internal wiring, in the event of rupture of wires or loosening of connections;

Compliance is checked by inspection and by the tests of clause 16.

The last turn of each winding shall be prevented from being displaced.

NOTE 1 – Means of prevention may be:

- positive means such as tape, suitable bonding agent, or anchoring the wire;
- or process technology.

NOTE 2 – A **protective screen**, if necessary, in order to prevent eddy current losses due to creation of a short turn, should be so arranged that both edges can neither simultaneously touch each other nor touch an iron core.

19.12.2 Where serrated tape is used as insulation, it is assumed that the serration of the different layers will coincide. For distance through insulation, the reduced values of table 13, table C.1 and table D.1 may be used if one additional layer of serrated tape and one additional layer without serration placed at the location of the serration are used.

NOTE 1 – An example is given in M.2.1 b).

Where cheekless bobbins are used, the end turns of each layer shall be prevented from being displaced.

NOTE 2 – Each layer can, for example, be interleaved with adequate insulation material projecting beyond the end turns of each layer and, moreover:

- either the winding(s) may be impregnated with hard-baking or cold-setting material, substantially filling the intervening spaces and effectively sealing-off the end turns;
- or the winding(s) may be held together by means of insulating material or by process technology.

Compliance is checked by inspection and by the tests of clauses 16, 17, and 18.

19.12.3 Insulated winding wires, the insulation of which provides **basic, supplementary or reinforced insulation**, shall meet the following requirements.

These additional requirements are applicable to all types of transformers for **basic or supplementary insulation** taken separately, and to transformers for switch mode power supplies for all types of insulation even in combination.

NOTE – Additional requirements are under consideration to apply this technology to all types of transformers, including combination of insulation.

Insulated winding wires of wound parts shall meet the following requirements:

- a) where the insulation on the winding wire is used to provide **basic or supplementary insulation** in a wound component without additional interleaved insulation:
 - the insulated wire (for example polyimide or insulation of equivalent quality) shall comply with annex K;
 - the insulation of the conductor shall consist of at least two layers;
- b) where the insulation on the winding wire is used to provide **double or reinforced insulation** in a wound part:
 - the insulated wire (for example polyimide or insulation of equivalent quality) shall comply with annex K;
 - the insulation of the conductor shall consist of at least three layers;
 - two adjacent insulated wires that are adjacent to each other are considered to be separated by **double insulation** if the insulation of each conductor is rated for the **working voltage**;
- c) the manufacturer shall demonstrate that the wire in the finished component has been subjected to 100 % routine dielectric strength test as in K.3.

For windings giving **double or reinforced insulation**, the following additional tests and requirements shall be fulfilled:

- thermal cycling test in accordance with 14.3;
- test from 27.3 – Resistance to heat, abnormal heat, fire and tracking;
- in table 13, table C.1 and table D.1, box 2) c), no value is required.

19.13 Handles, operating levers and the like shall be fixed in a reliable manner so that they will not become loose as a result of heating, vibration, etc. which may occur in normal use.

Compliance is checked by inspection and by the tests of clauses 14 and 16.

19.14 Covers providing protection against electric shock shall be securely fixed. The fixing shall be achieved by at least two independent means, one of which at least requires the use of a **tool**.

Compliance is checked by inspection and by manual test.

NOTE 1 – The cover may incorporate a means, such as a notch or a rim, which forms one of the required fixing means.

NOTE 2 – Screws may be used as means requiring the use of a **tool**, but knurled nuts or screws, even if they have provision for sealing, are not suitable.

19.15 Transformers provided with pins intended to be introduced into fixed socket-outlets shall not impose undue strain on these socket-outlets.

Compliance is checked by inserting the transformer, as in normal use, into a fixed socket-outlet complying with IEC 60083, the socket-outlet being pivoted about the horizontal axis through the central lines of the contact tubes at a distance of 8 mm behind the engagement face of the socket-outlet.

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

19.16 **Portable transformers** with a **rated output** not exceeding 200 VA shall either be an **ordinary transformer** or have a protection index IP20 or higher. For **ordinary transformers** and transformers having a protection index of IPX0, it shall be stated in the instructions for use that such transformers are only intended for indoor use.

Portable transformers having a **rated output** exceeding 200 VA but not exceeding 2,5 kVA for single-phase transformers, or not exceeding 6,3 kVA for polyphase transformers, shall have a protection index IPX4 or higher.

Portable transformers having a **rated output** exceeding 2,5 kVA for single-phase transformers, or exceeding 6,3 kVA for polyphase transformers, shall have a protection index IP21 or higher.

19.17 Transformers having a protection index from IPX1 up to and including IPX6 shall have an effective drain hole at least 5 mm in diameter or 20 mm² in area, with a width of at least 3 mm.

The drain hole is not required if the transformer, including winding and core, is completely filled with insulating materials.

Transformers having a protection index IPX7 or higher shall be totally enclosed when installed in the correct manner.

19.18 Transformers having a protection index higher than IPX1 shall be provided with a moulded-on plug, if any.

19.19 **Class I transformers** designed for connection by means of a flexible cable or cord, shall be provided with a non-detachable flexible cable or cord with earthing conductor and a plug with earthing contact.

Compliance with the requirements of 19.16 to 19.19 is checked by inspection, by measurement, and by the tests of 17.1.

19.20 **Live parts** of **SELV-** and **PELV-circuits** shall be electrically separated from each other and from other circuits. Arrangements shall ensure electrical separation not less than between the **input** and the **output circuit** of a **safety isolating transformer**, taking the relevant **working voltage** into account.

NOTE 1 – This requirement does not exclude the connection of **PELV-circuit** to earth.

NOTE 2 – In particular, electrical separation not less than that provided between the **input** and the **output windings** of a **safety isolating transformer** is necessary between the **live parts** of electrical equipment such as relays, contactors, auxiliary switches, and any part of higher voltage circuit.

*Compliance is checked by compliance with 19.20.1 for **SELV-circuits** and 19.20.2 for **PELV-circuits***

19.20.1 Live parts of SELV-circuits shall not be connected to earth, to **live parts**, or protective conductors forming part of other circuits.

Exposed conductive parts of **SELV-circuits** shall not intentionally be connected to:

- earth; or
- protective conductors or exposed conductive parts of another circuit; or
- extraneous conductive parts, except where electrical equipment is inherently required to be connected to extraneous conductive parts, and it is ensured that those parts cannot attain a voltage exceeding the nominal voltage specified for **SELV**.

NOTE – If the exposed conductive parts of **SELV-circuits** are liable to come into contact, either fortuitously or intentionally, with the exposed conductive parts of other circuits, protection against electric shock no longer depends solely on protection by **SELV**, but also on the protective measures to which the latter exposed conductive parts are subjected.

If the nominal voltage exceeds 25 V a.c. or 60 V ripple-free d.c., protection against direct contact shall be provided by insulation capable of withstanding a test voltage for **double** or **reinforced insulation** according to table 8.

If the nominal voltage does not exceed 25 V a.c. or 60 V ripple-free d.c., protection against direct contact is generally unnecessary. However, it may be necessary under certain conditions of external influences (see relevant part 2).

19.20.2 For PELV-circuits, the following requirements shall be fulfilled.

Protection against direct contact shall be ensured by insulation capable of withstanding a test voltage for **double** or **reinforced insulation** according to table 8.

NOTE – This requirement implies that **PELV-circuits** have to be insulated even for voltages below 25 V a.c. or 60 V ripple-free d.c. Exempted are **live parts** directly connected to earth.

19.21 For FELV-circuits, the following requirements shall be fulfilled to ensure protection against both direct and indirect contact.

NOTE – Such conditions may, for example, be ensured when the circuit contains equipment (such as transformers, relays, remote-control switches, contactors) insufficiently insulated with respect to circuits at higher voltages.

Protection against indirect contact shall be provided by insulation corresponding to the minimum test voltage required for the primary circuit.

19.22 Class II transformers shall not be provided with means for protective earthing.

However, a fixed **class II transformer** intended for looping-in may have an internal terminal for maintaining the electrical continuity of an earthing conductor not terminating in the transformer, provided that the terminal is insulated from the accessible metal parts by class II insulation.

Compliance is checked by inspection.

19.23 Class III transformers shall not be provided with means for protective earthing.

Compliance is checked by inspection.

20 Components

20.1 Components such as switches, plugs, fuses, lampholders, capacitors and flexible cables and cords shall comply with the relevant IEC standard as far as it reasonably applies.

Appliance couplers for mains supply shall comply with IEC 60320 for IPX0 transformers and IEC 60309 for other transformers.

Automatic controls shall comply with IEC 60730-1 unless they are tested with the appliance.

Thermal-links shall comply with IEC 60691 as far as reasonable.

Switches shall comply with IEC 61058 as stated in annex F.

The testing of these components is, in general, carried out separately, according to the relevant standard, as follows:

- components marked with individual ratings are checked to establish that they suit the conditions which may occur in the transformer, including inrush current. The component is then tested in accordance with its marking, the number of specimens being that required by the relevant standard;*
- components not marked with individual ratings are tested under the conditions occurring in the transformer, including inrush current, the number of specimens being, in general, that required by the relevant standard;*
- where no IEC standard exists for the relevant component, or where the component is not marked, or where the component is not used in accordance with its marking, the component is tested under the conditions occurring in the transformer; the number of specimens being, in general, that required by a similar specification.*

NOTE – Fuses according to IEC 60127 and IEC 60269 are allowed to be continuously loaded by a current not exceeding 1,1 times the rated value.

Components incorporated in or supplied with the transformers are subjected to all tests of this standard as part of the transformer.

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

20.2 Switches intended to disconnect the transformer from the supply shall disconnect all poles and shall have a contact separation of at least 3 mm in each pole.

The requirements with regard to all-pole disconnection and contact separation do not apply to transformers which are intended to be connected to the supply by means of a flexible cable or cord and a plug, or to transformers accompanied by an instruction sheet stating that such means for disconnection shall be incorporated in the fixed wiring.

Compliance is checked by inspection.

20.3 Socket-outlets in the **output circuit** shall be such that there is no dangerous compatibility between such a socket-outlet and a plug intended for direct connection to a socket-outlet which could be used for the **input circuit** in relation to installation rules, voltages and frequencies.

Plugs and socket-outlets for **SELV** shall comply with the requirements of IEC 60906-3.

Plugs and socket-outlets for **PELV** systems shall comply with the following requirements:

- plugs shall not be able to enter socket-outlets of other standardized voltage systems;
- socket-outlets shall not admit plugs of other standardized voltage systems;
- socket-outlets shall not have a protective earthing contact.

NOTE – This does not preclude the use of socket-outlets incorporating functional bonding contact.

Plugs and socket-outlets for **FELV** systems shall comply with the following requirements:

- plugs shall not be able to enter socket-outlets of other standardized voltage systems; and
- socket-outlets shall not admit plugs of other standardized voltage systems.

Compliance is checked by inspection and by manual test.

20.4 Thermal cut-outs, overload releases, fuses and other overload protecting devices shall have adequate breaking capacity.

Compliance is checked by the relevant test of 20.5 or 20.6.

20.5 Thermal cut-outs shall meet one of the following requirements.

20.5.1 The **thermal cut-out** when tested as a separate component shall comply with the requirements and tests of IEC 60730-1 as far as applicable.

For the purpose of this standard the following applies.

- a) The **thermal cut-out** shall be of type 1 or type 2 (see 6.4 of IEC 60730-1).
- b) The **thermal cut-out** shall have at least micro-disconnection (type 2B) (see 6.4.3.2 and 6.9.2 of IEC 60730-1).
- c) The **thermal cut-out** shall have a trip free mechanism in which contacts cannot be prevented from opening against a continuation of a fault (type 2E) (see 6.4.3.5 of IEC 60730-1).

- d) The number of cycles of automatic action shall be:
- 3 000 cycles for **thermal cut-outs with self-resettable reset**;
 - 300 cycles for **thermal cut-outs that are non-self-resettable**, and which are reset when the transformer is disconnected, and for **thermal cut-outs** which can be reset by hand without the use of a **tool** to reach the reset (see 6.11.10 of IEC 60730-1);
 - 30 cycles for **thermal cut-outs** with no automatic reset, and which cannot be reset by hand without the use of a **tool** to reach the reset (see 6.11.11 of IEC 60730-1).
- e) The **thermal cut-out** shall be tested as designed for a long period of electrical stress across insulating parts (see 6.14.2 of IEC 60730-1).
- f) The characteristics of the **thermal cut-out** with regard to:
- the ratings of the **thermal cut-out** (see clause 5 of IEC 60730-1);
 - the classification of the **thermal cut-out** according to:
 - 1) nature of supply (see 6.1 of IEC 60730-1),
 - 2) type of load to be controlled (see 6.2 of IEC 60730-1),
 - 3) degree of protection provided by **enclosures** against ingress of solid objects and dust (see 6.5.1 of IEC 60730-1),
 - 4) degree of protection provided by **enclosures** against harmful ingress of water (see 6.5.2 of IEC 60730-1),
 - 5) **pollution** situation for which the **thermal cut-out** is suitable (see 6.5.3 of IEC 60730-1),
 - 6) comparative tracking index for which the **thermal cut-out** is suitable (see 6.13 of IEC 60730-1),
 - 7) maximum ambient temperature limit (see 6.7 of IEC 60730-1)

shall be appropriate for the application in the apparatus under normal operating conditions and under fault conditions.

20.5.2 The **thermal cut-out** when tested as a part of the transformer shall:

- have at least micro-disconnection according to IEC 60730-1 withstanding a test voltage according to 13.2 of IEC 60730-1;
- have a trip free mechanism in which contacts cannot be prevented from opening against a continuation of a fault;
- be aged for 300 h at a temperature corresponding to the ambient temperature of the **thermal cut-out** when the transformer is operated under normal operating conditions at an ambient temperature of 35 °C or, where relevant, $t_a + 10$ °C;
- be subjected to a number of cycles of automatic action as specified under 20.5.1 for **thermal cut-outs** tested as a separate component, by establishing the relevant fault condition(s).

The tests are carried out on three samples.

Compliance is checked by inspection and by the specified tests in the given order.

During these tests, no sustained arcing shall occur, and there shall be no damage from other causes.

After the test, the **thermal cut-out** shall show no damage in the sense of this standard; in particular, it shall show no deterioration of its **enclosure**, no reduction of **clearances** and **creepage distances**, and no loosening of electrical connections or mechanical fixing.

20.5.3 A PTC resistor of the indirect heating type is considered in this standard as a **non-self-resetting thermal cut-out**.

Compliance is checked by the following test:

The transformer is connected for 48 h (two days) at 1,1 times the rated input voltage with the output terminals short-circuited.

- After 48 h, the transformer shall be allowed to cool down to approximately ambient temperature; this test shall be repeated five times at the maximum ambient temperature declared for the transformer.*
- The same test cycles shall be repeated but at 0,9 times the rated input voltage and the minimum ambient temperature declared for the transformer.*

During the part of the cycle where the transformer is under load, the PTC shall operate and stay in high impedance position until the supply is switched off. At the end of the test, the transformer shall withstand the test of clause 18, shall show no damage, and shall work correctly in the sense of this standard.

20.6 Thermal-links shall meet one of the following requirements.

20.6.1 The **thermal-link**, when tested as a separate component, shall comply with the requirements and tests of IEC 60691.

If the **thermal-link** is tested according to IEC 60691, the following applies:

Its characteristics with regard to:

- the ambient conditions (see 6.1 of IEC 60691);
- the circuit conditions (see 6.2 of IEC 60691);
- the ratings of the **thermal-link** (see 8 b) of IEC 60691);
- the suitability for sealing in, or use with, impregnating fluids or cleaning solvents (see 8 c) of IEC 60691);

shall be appropriate for the application in the apparatus under normal operating conditions and under short-circuit and overload conditions.

Compliance is checked according to the test specification of IEC 60691, by inspection and measurement.

20.6.2 The **thermal-link** when tested as a part of the transformer:

- shall be aged for 300 h at a temperature corresponding to the ambient temperature of the **thermal-link** when the transformer is operated under normal operating conditions at an ambient temperature of 35 °C or, where relevant, $t_a + 10$ °C;
- shall be subjected to those fault condition(s) of the transformer which cause the **thermal-link** to operate. During the test, no sustained arcing and no damage in the sense of this standard shall occur;
- shall be capable of withstanding two times the voltage across the disconnection, and have an insulation resistance of at least 0,2 MΩ when measured with a voltage equal to two times the voltage across the disconnection.

The test is made 10 times; no failure is allowed.

The **thermal-link** is replaced, partially or completely, after each test.

Where the **thermal-link** is not replaceable, the test is made on three new specimens.

Compliance is checked by inspection and by specified tests in the given order.

20.7 Self-resetting devices shall not be used unless it is certain that there will be no hazards, mechanical, electrical or otherwise, resulting from their operation.

Compliance is checked by inspection.

20.8 Thermal cut-outs intended to be reset by a soldering operation shall not be used for overload protection.

Compliance is checked by inspection.

20.9 Overload protection devices shall not operate when the supply voltage is switched on.

Compliance is checked by the following test.

*The transformer, with no load, is connected to a voltage equal to 1,06 times **rated supply voltage**. The supply voltage is then switched on and off 20 times at intervals of approximately 10 s.*

The supply source shall be such that there is no appreciable drop in voltage as a result of inrush current.

21 Internal wiring

21.1 Internal wiring and electrical connections between different parts of the transformer shall be adequately protected or enclosed.

Wire-ways shall be smooth and free from sharp edges, burrs, flashes etc. which may damage the insulation of conductors.

21.2 Openings in sheet metal through which insulated wires pass shall have rounded edges with a radius not less than 1,5 mm, or the openings shall be provided with bushing of insulating material.

21.3 Bare conductors shall be so fixed that the distance from one another and from the **enclosure** is adequately maintained.

Compliance with the requirements of 21.1 to 21.3 is checked by inspection.

21.4 Internal wiring shall not work loose when external wires are connected to the input or output terminals.

Compliance is checked by inspection and by the test of 23.3.

21.5 Insulated conductors which, in normal use, are subjected to a temperature exceeding the limiting values given in 14.2 shall have an insulation of heat-resisting and non-hygroscopic material, if compliance with this standard is likely to be impaired by deterioration of the insulation.

Compliance is checked by inspection and, if necessary, by additional tests; the temperature is determined during the test of 14.2.

22 Supply connection and other external flexible cables or cords

22.1 All cables, flexible cords and connecting means referred to in clause 22 shall have appropriate current and voltage ratings suitable for the ratings of the transformers to which they are connected.

Compliance is checked by inspection.

22.2 Separate entries shall be provided for the input and output wiring.

Inlet and outlet openings for external wiring shall be so designed that the protective covering of the cord can be introduced without risk of damage.

Inlet and outlet openings for flexible cables or cords shall be of insulating material, or be provided with bushing of insulating material which is substantially free from ageing effects under conditions expected in service. The openings of bushings shall be so shaped as to prevent damage to the cord.

Bushings for external wiring shall be reliably fixed, and shall be such that they are unlikely to be damaged by the material in which they are mounted.

Bushings shall not be of natural rubber unless they form part of a cord guard (see 22.9).

NOTE – These requirements do not preclude the use of removable bushings.

Compliance is checked by inspection.

22.3 **Fixed transformers** shall be so designed that, after the transformer has been fixed to its support in the normal way, it shall be possible to connect the rigid or flexible conductors of the external wiring.

Transformers other than those intended to be permanently connected to fixed wiring may be provided with an appliance inlet on the input side.

The space for the wires inside the transformer shall be adequate to allow the conductors to be easily introduced and connected, and the cover, if any, fitted without risk of damage to the conductors or their insulation.

It shall be possible to connect the external supply wires to terminals without their insulation coming into contact with **hazardous live parts** of a different polarity from that of the relevant wire, including **live parts** of the **output circuits**.

Compliance is checked by inspection and by an installation test with conductors of the largest cross-sectional area corresponding to the rated connecting capacity of the terminals.

22.4 Portable transformers, other than those intended to be mounted directly on a socket-outlet, shall be provided with a **power supply cord** (see 3.2.1) having a length between 2 m and 4 m.

Portable transformers which are permitted to be provided with a **power supply cord** having a cross-sectional area of 0,5 mm² are excepted from this requirement.

Compliance is checked by inspection.

22.5 Power supply cords of transformers with protection index IPX0 shall be not lighter than ordinary tough rubber sheathed flexible cable or cords (code designation 53 of IEC 60245-1), or ordinary polyvinyl chloride sheathed flexible cable or cords (code designation 53 of IEC 60227-1).

22.6 Power supply cords may be a cord set fitted with an appliance coupler in accordance with IEC 60320, provided that the transformer is a single-phase **portable transformer**, having an input current at **rated output** not exceeding 16 A.

22.7 The nominal cross-sectional area of **external flexible cable or cords** shall be not less than that shown in table 9.

Table 9 – Nominal cross-sectional areas of external flexible cable or cords

Input or output current at rated output A	Nominal cross-sectional areas mm ²
Up to and including 3*	0,5
Over 3 up to and including 6	0,75
Over 6 up to and including 10	1
Over 10 up to and including 16	1,5
Over 16 up to and including 25	2,5
Over 25 up to and including 32	4
Over 32 up to and including 40	6
Over 40 up to and including 63	10
* These cords may be used as power supply cords if their length does not exceed 2 m between the point where the cord or cord guard enters the transformer and the entry to the plug.	
NOTE – In Japan, cords having a nominal cross-sectional area of 0,5 mm ² are not allowed for external power supply cord .	

Compliance is checked by inspection and by measurement.

22.8 Power supply cords of **class I transformers** shall be provided with a green/yellow covered core, which is connected to the earthing terminal of the transformer and to the earthing contact of the plug, if any.

Power supply cords of single-phase **portable transformers** having an input current at **rated output** not exceeding 16 A shall be provided with a plug complying with IEC 60083 or IEC 60906-1. Other **portable transformers** may be provided with a plug complying with IEC 60309.

Compliance is checked by inspection.

22.9 External flexible cable or cords shall be attached to the transformer by **type X, Y or Z attachments** unless otherwise specified in the relevant part 2.

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

22.9.1 For **type Z attachments**, moulding the **enclosure** of the transformer and the **external flexible cable or cord** together shall not affect the insulation of the cord.

Compliance is checked by inspection.

22.9.2 Inlet openings shall be so designed and shaped, or shall be provided with an inlet bushing, so that the protective covering of the **external flexible cable or cord** can be introduced without risk of damage.

The insulation between the conductor and the **enclosure** shall consist of the insulation of the conductor and, in addition:

- for **class I transformers**, at least **basic insulation**;
- for **class II transformers**, at least **double or reinforced insulation**.

NOTE 1 – The sheath of an **external flexible cable or cord** equivalent to at least that of a cord complying with IEC 60227 or 60245 is regarded as a **basic insulation**.

NOTE 2 – A lining of insulating material is regarded as a **supplementary insulation** if it complies with the relevant requirements.

NOTE 3 – In the case of metal **enclosures**, a bushing of insulating material is regarded as a **supplementary insulation** if it complies with the relevant requirements.

NOTE 4 – An **enclosure** of insulating material is regarded as **reinforced insulation**, in which case two separate insulations are not necessary.

Compliance is checked by inspection and by manual test.

22.9.3 Inlet bushings shall:

- be so shaped as to prevent damage to the **external flexible cable or cord**;
- be reliably fixed;
- not be removable without the aid of a **tool**;
- not be of natural rubber, except if it is an integral part of the rubber sheath of the **external flexible cable or cord** for **type X** with a special cord, **type Y** and **type Z attachments** for **class I transformers**.

Compliance is checked by inspection and by manual test.

22.9.4 Transformers provided with cords which are moved while in operation shall be constructed so that the cord is adequately protected against excessive flexing where it enters the transformer. Cord guards, if any, shall be of insulating material and be fixed in a reliable manner.

Compliance is checked by the following test which is made on an apparatus having an oscillating member as shown in figure 7.

The part of the transformer comprising the cord entry, the cord guard, if any, and the **external flexible cable or cord** is fixed to the oscillating member so that, when the latter 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 cross-sectional area exceeding 0,75 mm²;
- 5 N for other cords.

The distance A shown in figure 7, between the axis of oscillation and the point where the cord guard enters the transformer, is adjusted so that when the oscillating member moves over its full range, the cord and load make the minimum lateral movement.

The oscillating member is moved through an angle of 90° (45° on either side of the vertical), the number of flexings for **type Z attachments** being 20 000, and for other attachments 10 000. The rate of flexing is 60 per min.

NOTE 1 – A flexing is one movement of 90°.

The cord and its associated parts are turned through an angle of 90° after half the number of flexings, unless a flat cord is fitted.

During the test, the conductors are loaded with the maximum rated current of the circuit in question, at rated voltage.

NOTE 2 – Current is not passed through the earthing conductor.

The test shall not result in:

- a short circuit between the conductors;
- breakage of more than 10 % of the strands of any conductor;
- separation of the conductor from the terminal;
- loosening of any cord guard;
- damage, within the meaning of this standard, to the cord or cord guard;
- broken strands piercing the insulation and becoming accessible.

NOTE 3 – Conductors include earthing conductors.

NOTE 4 – A short circuit between conductors of the cord is considered to occur if the current exceeds a value equal to twice the rated maximum current of the circuit in question.

22.9.5 Stationary transformers intended for use with an **external flexible cable or cord** and **portable transformers** shall have cord anchorages so that the conductors are relieved from strain, including twisting, where they are connected within the transformer, and so that the insulation of the conductors is protected from abrasion.

For **type X attachments**, glands shall not be used as cord anchorages in **portable transformers** unless they have provision for clamping all types and sizes of cables and cords which might be used as **external flexible cable or cords**. Production methods, such as moulded-on designs, tying the cord into a knot or tying the ends with string, are not allowed; labyrinths or similar means are permitted, provided that it is clear how the **external flexible cable or cord** is to be assembled.

For **type X attachments**, the cord anchorage shall be so designed or located that:

- replacement of the cord is possible easily;
- it is clear how the relief from strain and the prevention of twisting are to be obtained;
- it is suitable for the different types of cord which may be connected, unless the transformer is designed so that only one type of cord can be fitted;
- the whole flexible cable or cord with its covering, if any, is capable of being mounted into the cord anchorage;
- it does not damage the cord and is unlikely to be damaged when it is tightened or loosened in normal use;
- the cord cannot touch the clamping screws of the cord anchorage if these screws are accessible or electrically connected to accessible metal parts;
- 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 transformer;
- screws, if any, which have to be operated when replacing the cord do not serve to fix any other component, unless, when omitted or incorrectly mounted, they render the transformer inoperative or clearly incomplete, or unless the parts intended to be fastened by them cannot be removed without the aid of a **tool** during the replacement of the cord;
- for **class I transformers**, it is of insulating material or, if of metal, is provided with an insulating lining if an insulation fault on the cord could make accessible metal parts live;
- for **class II transformers**, it is of insulating material or, if of metal, is insulated from accessible metal parts by insulation complying with the requirements for **supplementary insulation**.

For **type X** with a special cord, **type Y** and **type Z attachments**, the cores of the **external flexible cable or cord** shall be insulated from accessible metal parts by insulation complying with the requirements for **basic insulation** for **class I transformers**, and complying with the requirements for **supplementary insulation** for **class II transformers**.

This insulation may consist of:

- a separate insulating barrier fixed to the cord anchorage;
- a special lining fixed to the cord; or
- for **class I transformers**, the sheath of a sheathed cord.

For **type X** with a special cord and **type Y attachments**, the cord anchorage shall be so designed that:

- the replacement of the **external flexible cable or cord** does not impair compliance with this standard;
- the whole flexible cable or cord with its covering, if any, is capable of being mounted into the cord anchorage;
- it does not damage the cord and is unlikely to be damaged when it is tightened or loosened in normal use;
- the cord cannot touch clamping screws of the cord anchorage, if these screws are accessible or electrically connected to accessible metal parts;
- the cord is not clamped by a metal screw which bears directly on the cord;
- knots in the cord are not to be used;
- labyrinths or similar means are permitted, provided that it is clear how the **external flexible cable or cord** is to be assembled.

Compliance is checked by inspection and by the following test.

For **type X attachments**, except with a special cord, the transformer is fitted with a suitable **external flexible cable or cord**. The conductors are introduced into the terminals, the terminal screws, if any, being tightened just sufficiently to prevent the conductors from easily changing their position. The cord anchorage is used in the normal way, its clamping screws being tightened with a torque equal to two-thirds of that specified in table 11.

The tests are first made with the lightest permissible type of cord of the smallest cross-sectional area specified in table 9 and then with the next heavier type of cord of the largest cross-sectional area specified, unless the transformer is so designed that only one type of cord can be fitted.

For **type X** with a special cord, **type Y** and **type Z attachments**, the transformer is tested with the cord in place.

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

The cord is then subjected 25 times to a pull of the value shown in table 10. The pulls are applied in the most unfavourable direction without jerks, each time for 1 s.

Immediately afterwards, the cord is subjected for 1 min to a torque of the value shown in table 10.

Table 10 – Pull and torque to be applied to external flexible cable or cords

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

The cord shall not be damaged during the tests.

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

Creepage distances and **clearances** shall not be reduced below the values specified in clause 26.

For the measurement of the longitudinal displacement, a mark is made on the cord which is subjected to a pull, at a distance of approximately 20 mm from the cord anchorage or other suitable point, before starting the tests.

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

22.9.6 The space for the supply cables or the **external flexible cable or cord** provided inside, or added as a part of the transformer for the connection:

a) to fixed wiring and for **type X** and **Y attachments**:

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

b) to fixed wiring and for **type X attachments**, in addition:

- shall be adequate to allow the conductors to be easily introduced and connected;
- shall be so designed that covers, if any, giving access to terminals for external conductors can only be removed with the aid of a **tool**.

Compliance is checked by inspection and by manual tests.

23 Terminals for external conductors

23.1 Transformers intended to be permanently connected to fixed wiring, and transformers other than those provided with external flexible cords with **type Y** or **type Z attachments** shall be provided with terminals in which connection is made by means of screws, nuts or equally effective devices.

Terminals which are integral part of the transformer have to comply with IEC 60999-1 under the conditions prevailing in the transformer.

Other terminals shall be:

- either separately checked according to IEC 60998-2-1, IEC 60998-2-2 or IEC 60947-7-2 and used in accordance with their marking, or
- checked according to IEC 60999-1 under the conditions prevailing in the transformer.

For transformers with **type X attachment**, soldered connections may be used for external conductors, provided that the conductor is so positioned or fixed that reliance is not placed upon the soldering alone to maintain the conductor in position, unless barriers are provided so that **creepage distances** and **clearances** between **hazardous live parts** and other metal parts cannot be reduced to less than 50 % of the values specified in clause 26, should the conductor break away at the soldered joint.

For transformers with **type Y** and **type Z attachments**, soldered, welded, crimped and similar connections may be used for external conductors.

For **class II transformers**, the conductor shall be so positioned or fixed that reliance is not placed upon the soldering, crimping, or welding alone to maintain the conductor in position, unless barriers are provided so that **creepage distances** and **clearances** between **hazardous live parts** and other metal parts cannot be reduced to less than 50 % of the values specified in clause 26, should the conductor break away at the soldered or welded joint, or slip out of the crimped connections.

NOTE – In general, hooking-in before soldering is considered to be a suitable means for retaining the conductor of a flexible cable or cord in position, provided that the hole through which the conductor is passed is not unduly large.

23.2 Terminals for **type X** with a special cord, **Y** and **Z attachments** shall be suitable for their purpose.

Compliance with the requirements of 23.1, and 23.2 is checked by inspection and by applying a pull of 5 N to the connection immediately before the test of 14.2.

23.3 Terminals, other than those with **type Y** or **Z attachments**, shall be so fixed that, when the clamping means is tightened or loosened, the terminal does not work loose, internal wiring is not subjected to stress, and **creepage distances** and **clearances** are not reduced below the values specified in clause 26.

23.4 Terminals, other than those with **type Y** or **Z attachments**, shall be so designed that they clamp the conductor between metallic surfaces with sufficient contact pressure, and without damage to the conductor.

Compliance with the requirements of 23.3 and 23.4 is checked by inspection and by measurement after fastening and loosening 10 times a conductor of the largest cross-sectional area corresponding to the rated connecting capacity of the terminal, the torque applied being equal to two-thirds of the torque specified in clause 25.

NOTE – Locking with sealing compound, without other means of clamping, is not considered sufficient. However, self-hardening resins may be used to lock terminals which are not subjected to torsion in normal use.

23.5 Terminals provided for the connection to fixed wiring, and terminals with **type X attachment** shall be located near their associated terminals of different polarities and the earthing terminal, if any.

Compliance is checked by inspection.

23.6 Terminal blocks and similar devices shall not be accessible without the aid of a **tool**, even if their **hazardous live parts** are not accessible.

Compliance is checked by inspection and by manual test.

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

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

An 8 mm length of insulation is removed from the end of a flexible conductor having a nominal cross-sectional area as specified in clause 22. One wire of the stranded conductor is left free, and the other wires are fully inserted into and clamped in the terminal.

*The free wire is bent, without tearing the insulation back, in every possible direction, but without making sharp bends round barriers. The free wire of a conductor connected to a live terminal shall not touch any metal part which is accessible, or which is connected to an accessible metal part or, for **class II transformers**, any metal part which is separated from accessible metal parts by **supplementary insulation** only. The free wire of a conductor connected to an earthing terminal shall not touch any **hazardous live part**.*

Terminals without pressure plate shall be provided with at least two clamping screws if the current exceeds 25 A.

23.8 Terminal screws, other than screws of terminals for the connection of protective earthing conductors, shall not come into contact with any metal part which is accessible, or which is connected to an accessible metal part, or, for **class II transformers**, inaccessible metal parts, when the screw is loosened as far as possible.

Compliance is checked by inspection during the test of 23.2.

24 Provision for protective earthing

24.1 Accessible metal parts of **class I transformers** which may become live in the event of an insulation fault shall be permanently and reliably connected to a protective earthing terminal within the transformer.

Class II transformers shall have no provision for earthing the transformer.

Compliance is checked by inspection.

NOTE – If accessible metal parts are screened from **hazardous live parts** by metal parts which are connected to the protective earthing terminal, or if they are separated from **hazardous live parts** by **double insulation** or **reinforced insulation**, they are not, for the purpose of this requirement, regarded as likely to become live in the event of an insulation fault.

24.2 Protective earthing terminals for connection to fixed wiring, and protective earthing terminals with **type X attachment** shall comply with the requirements of clause 23. Their clamping means shall be adequately locked against accidental loosening, and it shall not be possible to loosen them without the aid of a **tool**.

Compliance is checked by inspection, by manual test and by the tests of clause 23.

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

24.3 All parts of the protective earthing terminal 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 that is in contact with these parts.

If the **body** of the protective earthing terminal is 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.

The **body** of the protective earthing terminal shall be of brass or other metal not less resistant to corrosion, unless it is a part of the metal frame or **enclosure**, in which case the screw or nut shall be of brass or other metal equally resistant to corrosion.

24.4 The connection between the protective earthing terminal and parts required to be connected thereto shall be of low resistance.

Compliance is checked by the following test.

A current derived from an a.c. source, having a no-load voltage not exceeding 12 V and equal to 1,5 times the rated input current or to 25 A, whichever is greater, is passed for 1 min between the protective earthing terminal and each of the accessible metal parts in turn.

NOTE 1 – Rated input current is determined as the quotient of the **rated output** by the **rated supply voltage** or, for polyphase transformers, by $\sqrt{n}$ times the **rated supply voltage**, n being the number of phase.

The voltage drop between the protective earthing terminal and the accessible metal part is measured, and the resistance calculated from the current and this voltage drop.

In no case shall the resistance exceed 0,1 Ω .

In case of doubt, after 1 min the test is carried out until steady state conditions have been established.

NOTE 2 – Care is taken that the contact resistance between the tip of the measuring probe and the metal part under test does not influence the test results.

NOTE 3 – The resistance of the supply flexible cable or cord, if used for convenience in the test, is not included in the resistance measurement.

NOTE 4 – The cores of IP00 transformers are considered to be not accessible.

24.5 For **class I transformers with external flexible cable or 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.

25 Screws and connections

25.1 Screwed connections, electrical or otherwise, shall withstand the mechanical stresses occurring in normal use.

Screws transmitting contact pressure, and screws which are likely to be tightened by the user and have a nominal diameter less than 2,8 mm, shall screw into metal.

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

Screws of insulating material shall not be used for any electrical connection.

Screws shall not be of insulating material if their replacement by a metal screw could impair **basic insulation** between **input** and **output circuit**, **supplementary insulation** or **reinforced insulation**, neither shall screws which may be removed when replacing a **power supply cord** be of insulating material if their replacement by a metal screw could impair **basic insulation**.

Compliance is checked by inspection and, for screws and nuts transmitting contact pressure or which are likely to be tightened by the user, by the following test.

The screws or nuts are tightened and loosened:

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

Screws in engagement with a thread of insulating material are completely removed and re-inserted each time.

When testing terminal screws and nuts, a flexible cable or cord of the largest cross-sectional area specified in table 9 is placed in the terminal. It is repositioned before each tightening.

The test is made by means of a suitable test screwdriver, spanner or key, applying a torque as shown in table 11, the appropriate column being:

- a) for metal screws without heads, if the tightened screw does not protrude from the hole I
- b) for other metal screws and for nuts II
- c) for screws of insulating material:
 - having a hexagonal head with the dimension across flats exceeding the overall thread diameter, or
 - with a cylindrical head and a socket for a key, the socket having a dimension across flats not less than 0,83 times the overall thread diameter, or
 - with a head having a slot or cross slots, the length of which exceeds 1,5 times the overall thread diameter II
- d) for other screws of insulating material III

Table 11 – Torque to be applied to screws and connections

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

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

During the test, no damage impairing the further use of the screwed connections shall occur.

NOTE 1 – Screws or nuts which are likely to be tightened by the user include screws intended to be operated when replacing **power supply cords** for **type X attachment**.

NOTE 2 – The shape of the blade of the test screwdriver shall suit the head of the screw to be tested. The screws and nuts should not be tightened in jerks.

25.2 Screws in engagement with a thread of insulating material shall have a length of engagement of at least 3 mm plus one-third of the nominal screw diameter or 8 mm, whichever is shorter.

Correct introduction of the screw into the screw hole or nut shall be ensured.

Compliance is checked by inspection and by the test of 25.1, the torque applied being, however, increased to 1,2 times the torque specified.

NOTE – The requirement with regard to correct introduction is met if introduction of the screw in a slanting manner is prevented, for example by guiding the screw by the part to be fixed, by a recess in the female thread, or by the use of a screw with the leading thread removed.

25.3 Electrical connections shall be so designed that contact pressure is not transmitted through insulating material other than ceramic or pure mica, unless there is sufficient resiliency in the metallic parts to compensate for any possible shrinkage or distortion of the insulating material.

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

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

Thread-cutting and thread-forming screws, when used to provide earthing continuity, shall be such that it is not necessary to disturb the connection in normal use, and at least two screws are used for each connection.

Compliance with the requirements of 25.3 and 25.4 is checked by inspection.

25.5 Screws which make a mechanical connection between different parts of the transformer shall be locked against loosening if the connection carries current, or forms part of the protective earthing circuit.

Rivets used for current-carrying connections shall be locked against loosening if these connections are subject to torsion in normal use.

Compliance is checked by inspection and by manual test.

NOTE 1 – Spring washers and the like may provide satisfactory locking.

NOTE 2 – For rivets, a non-circular shank or an appropriate notch may be sufficient.

NOTE 3 – Sealing compound which softens on heating provides satisfactory locking only for screw connections not subjected to torsion in normal use.

25.6 Screwed glands shall comply with the following test:

Screwed glands shall be fitted with a cylindrical metal rod having a diameter equal to the nearest whole number of millimetres below the internal diameter of the packing. The glands shall then be tightened by means of a suitable spanner, the force shown in table 12 being applied to the spanner for 1 min at a point 250 mm from the axis of the gland.

Table 12 – Torque test on glands

Diameter of test rod mm	Force	
	Metal glands N	Glands of moulded material N
Up to and including 14	25	15
Over 14 up to and including 20	30	20
Over 20	40	30

After the test, the transformer and the glands shall show no damage.

26 Creepage distances, clearances and distances through insulation

26.1 Creepage distances, clearances and distances through insulation shall be not less than the values shown in table 13, which are for insulating materials of group IIIa (see IEC 60664-1).

Compliance is checked by measurements under the provisions of 26.2 and 26.3.

NOTE 1 – For materials of groups I and II, see annexes C and D.

NOTE 2 – Table 13, table C.1 and table D.1 are applicable only for frequencies up to and including 30 kHz.

NOTE 3 – **Clearances, creepage distances** and distances through insulation for frequencies of more than 30 kHz are under consideration.

Creepage distances and **clearances** are measured, using the supply cable and cords for connection to fixed wiring and those for **type X attachment**, with maximum and minimum size conductors corresponding to the rated connecting capacity of the terminal. For **type X** with a special cord, **Y** or **Z attachments**, the supply cable and cords as delivered are used.

Where layers of serrated tapes are used, the value for **creepage distances** and **clearances** are determined as if the serration coincided through the different layers.

NOTE 4 – Diagrams showing some examples of the methods of measurement of **creepage distances** and **clearances** are to be found in annex A.

NOTE 5 – Diagrams showing some examples of points of measurement of **creepage distances** and **clearances** are given in annex P.

NOTE 6 – Details of the tests necessary to determine the separation of material groups are given in annex G.

NOTE 7 – Table 13, table C.1 and table D.1 take into consideration overvoltages category II for **basic insulation** and overvoltages category III for **double** or **reinforced insulation**.

Values for printed wiring, where failure may cause a hazard in the sense of this standard, shall be the same as unreduced values for **live parts** as in table 13, table C.1 and table D.1, except if the printed wiring complies with the requirements of IEC 60664-3.

If the **pollution** generates high and persistent conductivity caused, for instance, by conductive dust or by rain or snow, the **creepage distances** and **clearances**, as given for **pollution degree 3**, shall be further increased with a minimum **clearance** of 1,6 mm and a value of X in annex A of 4,0 mm.

26.2 Creepage distances (cr)

For windings which are covered with an adhesive bonding tape which adheres to the flanges of a coil former, the values of **creepage distances** are considered along the bonded surface of the adhesive bonding tape and the values are those stated for **pollution degree 1** (P1), provided that all insulating materials are classified according to IEC 60085 and IEC 60216.

Where an insulation barrier consisting of an uncemented pushed-on partition wall is used, **creepage distances** are measured through the joint. If the joint is covered by an adhesive bonding tape, in accordance with IEC 60454, one layer of adhesive bonding tape is required on each side of the wall in order to reduce the risk of tape folding over during production.

For transformers which are declared to have parts cemented (stuck) together, or enclosed or hermetically sealed against ingress of dust and moisture (for example impregnated or potted), and which satisfy the following tests, the minimum **creepage distances** in question can be the reduced values as stated for **pollution degree 1** (P1).

The reduced values shown in table 13, table C.1 and table D.1 can be used when separation is made by the use of impregnation, potting, or by the use of adhesive bonding tape covering the windings, provided that the tests of 4.1.1.2.1 of IEC 60664-1 are fulfilled.

In order to check whether the parts are adequately potted, impregnated or cemented together, the following tests are performed, as appropriate.

A) *To test the potting or the impregnation, three transformers are used.*

The specimens are subjected 10 times to the following sequence of temperature cycles:

68 h at the highest winding temperature $\pm 2\text{ }^{\circ}\text{C}$ measured in normal use plus 10 K with a minimum of $85\text{ }^{\circ}\text{C}$

1 h at $25\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$

2 h at $0\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$

1 h at $25\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$

*During each thermal cycling test a voltage of twice the value of the **working voltage** at 50 Hz or 60 Hz is applied to the specimens between the windings where the reduced values apply.*

Two of the three specimens are then subjected to the humidity treatment of 17.2 (48 h treatment) and the relevant dielectric strength test of 18.3, which is made at a voltage multiplied by the factor 1,25.

One of the three specimens is subjected to the relevant dielectric strength test of 18.3, which is made at a voltage multiplied by the factor 1,25, immediately at the end of the last period at highest temperature during the thermal cycling test.

B) *To check whether the parts are cemented (stuck) together, three specially prepared specimens, where winding wires are replaced by uninsulated wires without any impregnation or potting, are required. The windings have to be made in such a way that there is no possible flashover between **input** and **output windings** anywhere other than in the cemented joint to be tested.*

The specimens are subjected 10 times to the following sequence of temperature cycles:

68 h at the highest winding temperature $\pm 2\text{ }^{\circ}\text{C}$ measured in normal use plus 10 K with a minimum of $85\text{ }^{\circ}\text{C}$

1 h at $25\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$

2 h at $0\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$

1 h at $25\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$

Two of the three specimens are then subjected to the humidity treatment of 17.2 (48 h treatment) and the relevant dielectric strength test of 18.3; however, the test voltage is multiplied by 1,6.

One of the three specimens is subjected to the relevant dielectric strength test of 18.3; however, the test voltage is multiplied by 1,6 immediately after the last period at highest temperature during the thermal cycling test.

NOTE – The test voltage applied to the specimens for cemented parts is to be higher than the normal test voltages in order to ensure that if the surfaces are not cemented together, a breakdown occurs.

26.3 Distance through insulation (dti)

The distance through insulation shown in square brackets in boxes 2 and 7 of tables 13, C.1, and D.1 may be used, provided that the insulation is in thin sheet form and consists of at least three layers (separable or non-separable). If the layers are separate or separable, each layer shall fulfil the thermal material classification, as given in IEC 60085 and IEC 60216, of the transformer and, any combination of two thirds of the number of separate or separable layers, rounded down to the nearest full number, shall fulfil the mandrel test. If the layers are non-separable, the number of layers shall be at least three; the whole composite sheet shall fulfil the classification of the transformer, and the mandrel test.

Mandrel test

Three separate test specimens of thin sheets of 70 mm width shall be supplied by the manufacturer.

The test is carried out by fixing the thin sheet specimen on a mandrel made of steel, nickel plated, or brass with smooth surface finish as shown on figure 6.

A metal foil (aluminium or copper) $0,035\text{ mm} \pm 0,005\text{ mm}$ thick shall be placed close to the surface of the specimen and submitted to a pull of 1 N. The metal foil shall be so positioned that its borders are 20 mm away from the borders of the specimen and, when the mandrel is in its final position, it covers the edges upon which the specimen is lying by at least 10 mm. The specimen is submitted to a pull of 150 N at its free end by an appropriate clamping device.

The specimen shall be slowly rotated forwards and backwards three times by 230° without jerks. If the specimen breaks at the clamping device during the rotation, the test is repeated. If one or more specimens break at any other place, the test is not fulfilled. While the mandrel is in its final position, within the minute following the final positioning, a test voltage of 5,5 kV is applied, as described in 18.3, between the mandrel and the metal foil.

No flashover or breakdown shall occur during the test; corona effects and similar phenomena being disregarded.

The figures within square brackets in boxes 2 and 7 of table 13, table C.1 and table D.1 are used as follows:

- for transformers having a **rated output** greater than 100 VA, the figures in square brackets apply;
- for transformers having a **rated output** of 25 VA up to and including 100 VA, the figures in square brackets may be reduced to two-thirds of their value;
- for transformers having a **rated output** of less than 25 VA, the figures in square brackets may be reduced to one-third of their value.

Smaller distances through the insulation may be used if it can be shown by the test of 14.3 that the materials have adequate mechanical strength and are resistant to ageing.

The requirements concerning distance through insulation do not imply that the prescribed distance shall be through solid insulation only. It may consist of a thickness of solid insulation plus one or more air layers.

Where serrated tape is used as insulation, it is assumed that the serration of the different layers will coincide. For distance through insulation, the reduced values of table 13, table C.1 and table D.1 may be used if one additional layer of serrated tape and one additional layer without serration, covering the location of the serration, are used.

Table 13 – Creepage distances (cr), clearances (cl) and distances through insulation (dti)
Material group IIIa ($175 \leq CTI < 400$)

P1 = pollution degree 1 P2 = pollution degree 2 P3 = pollution degree 3

Type of insulation	Measurement	Working voltages ²⁾															
		V															
		≥25 ≤50		100		150		300		600		1 000					
		Through winding enamel ¹⁾	Other than through winding enamel	Through winding enamel ¹⁾	Other than through winding enamel	cl	cr	cl	cr	cl	cr	cl	cr	cl	cr	cl	cr
1) Insulation between input and output circuits (basic insulation)	a) Creepage distances and clearances between live parts of input circuits and live parts of output circuits	P2	P3	P2	P3	0,2 0,8	1,2 1,9	0,5 0,8	1,4 2,2	1,5 1,5	1,6 2,5	3,0 3,0	3,0 4,7	5,5 5,5	6,0 9,5	8,0 8,0	10,0 16,0
		X	X			0,2 0,8	1,2 1,9	0,2 0,8	1,4 2,2	0,5 0,8	1,6 2,5	1,5 1,5	3,0 4,7	3,0 3,0	6,0 9,5	5,5 5,5	10,0 16,0
	Reduced values, see 26.2 (P1)					–	0,18	–	0,25	–	0,3	–	0,7	–	1,7	–	3,2
	b) Distances through insulation between input or output circuits and an earthed metal screen	X	X	X	X	dti										dti	
	c) Distances through insulation between input and output circuits	X	X	X	X	No requirements of thickness										dti	
2) Insulation between input and output circuits (double or reinforced insulation)	a) Creepage distances and clearances between live parts of input circuits and live parts of output circuits	X	X	X	X	0,5 0,8 0,2 0,8	1,4 2,2 1,4 2,2	1,5 1,5 0,5 0,8	2,0 3,2 2,0 3,2	3,0 3,0 1,5 1,5	3,0 4,7 3,0 4,7	5,5 5,5 3,0 9,5	6,0 9,5 6,0 9,5	8,0 8,0 5,5 19,2	12,0 19,2 12,0 19,2	14,0 14,0 8,0 8,0	20,0 32,0 20,0 32,0
	Reduced values, see 26.2 (P1)					–	0,25	–	0,4	–	0,7	–	1,7	–	4,0	–	7,5
	b) Distances through insulation between input or output circuits and an earthed metal screen, see 26.3	X	X	X	X	dti		dti		dti		dti		dti		dti	
						0,1 [0,05] ⁷⁾		0,2 [0,07] ⁷⁾		0,25 [0,08] ⁷⁾		0,5 [0,16] ⁷⁾		0,7 [0,19] ⁷⁾		1,0 [0,25] ⁷⁾	
	c) Distances through insulation between input and output circuits, see 26.3	X	X	X	X	0,2 ⁴⁾ [0,1] ⁵⁾ – ⁶⁾		0,3 ⁴⁾ [0,1] ⁵⁾ – ⁶⁾		0,5 ⁴⁾ [0,15] ⁵⁾ – ⁶⁾		1,0 ⁴⁾ [0,3] ⁵⁾ – ⁶⁾		1,5 ⁴⁾ [0,4] ⁵⁾ – ⁶⁾		2,0 ⁴⁾ [0,5] ⁵⁾ – ⁶⁾	

For notes, see page 157

Dimensions in millimetres

Table 13 (continued)

	Type of insulation	Measurement				Working voltages ²⁾											
		Through winding enamel ¹⁾		Other than through winding enamel		V											
		P2	P3	P2	P3	≥25 ≤50		100		150		300		600		1 000	
						cl	cr	cl	cr	cl	cr	cl	cr	cl	cr	cl	cr
3) Insulation between adjacent input circuits or insulation between adjacent output circuits ³⁾	Creepage distances and clearances	X	X	X	X	0,2 0,8	1,2 1,9	0,2 0,8	1,4 2,2	0,2 0,8	1,6 3,1	0,5 0,8	3,0 4,7	1,5 1,5	6,0 9,5	3,0 3,0	10 16
	Reduced values see 26.2 (P1)					–	0,18	–	0,25	–	0,3	–	0,7	–	1,7	–	3,2
4) Creepage distances and clearances between terminals for the connection of external cables and cords excluding those between screw terminals for input and for output circuits	a) Up to and including 6 A	X	X	X	X	3,0		3,6		4,0		6,0		9,0		12,5	
	b) Over 6 A up to and including 16 A	X	X	X	X	5,0		6,0		7,0		10,0		13,0		16,0	
	c) Over 16 A	X	X	X	X	10,0		11,0		12,0		14,0		17,0		20,0	
5) Basic or supplementary insulation	Between:																
	a) live parts of different polarity			X		0,2	1,2	0,5	1,4	1,5	1,6	3,0	3,0	5,5	6,0	8,0	10,0
	b) live parts and the body if intended to be connected to protective earth				X	0,8	1,9	0,8	2,2	1,5	2,5	3,0	4,7	5,5	9,5	8,0	16,0
	c) accessible metal parts and a metal rod of the same diameter as the flexible cable or cord (or metal foil wrapped around the cord) inserted inside inlet bushing, anchorage and the like	X				0,2	1,2	0,2	1,4	0,5	1,6	1,5	2,9	3,0	6,0	5,5	10,0
	d) live parts and an intermediate metal part		X			0,8	1,9	0,8	2,2	0,8	2,5	1,5	4,7	3,0	9,5	5,5	16,0
	e) an intermediate metal part and the body																
	Reduced values, see 26.2 (P1)					–	0,18	–	0,25	–	0,3	–	0,7	–	1,7	–	3,2

For notes, see page 157

Dimensions in millimetres

Table 13 (concluded)

	Type of insulation	Measurement				Working voltages ²⁾											
						V											
		Through winding enamel ¹⁾		Other than through winding enamel		≥25 ≤50		100		150		300		600		1 000	
		P2	P3	P2	P3	cl	cr	cl	cr	cl	cr	cl	cr	cl	cr	cl	cr
6) Reinforced or double insulation	Between the body and live parts			X		0,5	1,4	1,5	2	3,0	3,0	5,5	6,0	8,0	12,0	14,0	20,0
		X			X	0,8	2,2	1,5	3,2	3,0	4,7	5,5	9,5	8,0	19,2	14,0	32,0
			X			0,2	1,4	0,5	2	1,5	3,0	3,0	6,0	5,5	12,0	8,0	20,0
		X	X			0,8	2,2	0,8	3,2	1,5	4,7	3,0	9,5	5,5	19,2	8,0	32,0
	Between body and live parts of the output circuit if protected by additional provisions against transient voltages	X		X		0,2	1,4	0,2	2	0,5	3,0	1,5	6,0	3,0	12,0	5,5	20,0
			X		X	0,8	2,2	0,8	3,2	0,8	4,7	1,5	9,5	3,0	19,2	5,5	32,0
	Reduced values, see 26.2 (P1)					–	0,25	–	0,4	–	0,7	–	1,7	–	4,0	–	7,5
7) Distance through insulation (excluding insulation between input and output circuit)	a) Basic ⁸⁾	X	X	X	X	No requirement of thickness											
	b) Supplementary ⁸⁾					dti		dti		dti		dti		dti		dti	
		X	X	X	X	0,14 ⁴⁾ [0,05] ⁵⁾ – ⁶⁾		0,15 ⁴⁾ [0,05] ⁵⁾ – ⁶⁾		0,25 ⁴⁾ [0,08] ⁵⁾ – ⁶⁾		0,5 ⁴⁾ [0,15] ⁵⁾ – ⁶⁾		0,75 ⁴⁾ [0,20] ⁵⁾ – ⁶⁾		1,0 ⁴⁾ [0,25] ⁵⁾ – ⁶⁾	
	c) Reinforced	X	X	X	X	0,24 ⁴⁾ [0,1] ⁵⁾ – ⁶⁾		0,34 ⁴⁾ [0,1] ⁵⁾ – ⁶⁾		0,5 ⁴⁾ [0,15] ⁵⁾ – ⁶⁾		1,0 ⁴⁾ [0,3] ⁵⁾ – ⁶⁾		1,5 ⁴⁾ [0,4] ⁵⁾ – ⁶⁾		2,0 ⁴⁾ [0,5] ⁵⁾ – ⁶⁾	

NOTES

Dimensions in millimetres

- 1) Measurement through winding wire enamel if the winding wire complies at least with grade 1 of IEC 60317.
- 2) Values of **creepage distances** and **clearances** and distances through insulation may be found for intermediate values of **working voltages** by interpolation between the values in the table. No values are required for **working voltages** below 25 V as the voltage test of table 8 is considered sufficient.
- 3) These values do not apply:
 - inside each winding or between groups of windings intended to be permanently connected together, provided that the termination of windings to be connected together are at the same potential,
 - where the **working voltage** does not exceed 300 V and the winding wires comply at least with grade 1 of IEC 60317, even if the windings are intended to be connected in a series or parallel arrangement (e.g. input voltage 110/220 V).
- 4) For solid insulation.
- 5) In the case of insulation consisting of three layers.
- 6) In the case of insulation consisting of two separate layers (no glued layers are allowed in this case) and each layer passes the mandrel test of 26.3 at a voltage of 5,5 kV.
- 7) In the case of insulation consisting of two layers.
- 8) When **double insulation** is required between **input** and **output windings**, the total thickness through insulation shall be the same as shown in box 2 c) whether measured directly or via metal parts.
- 9) When the layers of insulation are made of turns of insulating tape, the winding of the tape should be such that at every place there is at least the required number of layers.
- 10) When a number is replaced by a dash in a column of the table it means that no value is required.

27 Resistance to heat, abnormal heat, fire and tracking

27.1 External **accessible parts** of insulating material, of which the deterioration might cause the transformer to become unsafe, shall be resistant to heat.

*Compliance is checked by subjecting **enclosures** and other external parts of insulating material to a ball-pressure test by means of the apparatus shown in figure 5.*

The surface of the part to be tested is placed in a horizontal position and a steel ball of 5 mm diameter is pressed against this surface with a force of 20 N.

The test is made in a heating cabinet at a temperature of $(70 \pm 2) ^\circ\text{C}$, or at a temperature of $(40 + \theta \pm 2) ^\circ\text{C}$, where θ is the temperature rise of the relevant part determined during the test of 14.2, whichever is the higher.

After 1 h the ball is removed from the specimen, which is then cooled down, within 10 s, to approximately ambient temperature by immersion in cold water. The diameter of the impression caused by the ball is measured and shall not exceed 2 mm.

NOTE – The test is not made on parts of ceramic material.

27.2 External **accessible parts** of insulating material shall be resistant to ignition and spread of fire.

*Compliance is checked by subjecting **enclosures** and other external **accessible parts** to the glow-wire test (see annex E).*

If possible, the specimen should be a complete transformer.

If the test cannot be made on a complete transformer, a suitable part should be cut from it.

*If it is necessary to take away parts of an **enclosure** or to cut off a suitable part to perform the test, care is taken to ensure that the standard test conditions are not significantly different from those occurring in normal use, with regard to shape, ventilation, effects of thermal stresses and of possible flames, burning droplets or glowing particles falling in the vicinity of the specimen.*

Any flame or glowing of the specimen shall extinguish within 30 s of withdrawing the glow-wire, and any burning or molten drops shall not ignite a single layer of tissue paper, as specified in 6.8 of ISO 4046, spread out horizontally (200 ± 5) mm below the specimen.

Only one specimen is tested. In case of doubt concerning the results, the test is repeated on two further specimens, both of which shall pass the test.

27.3 Parts of insulating material within the transformer **enclosure** of transformers of IP20 or higher shall not act as a source of ignition for the surroundings, even in the case of abnormal heat or fire caused by a fault in the transformer.

Compliance is checked by the tests of 27.3.1 and 27.3.2.

For this test two additional specially prepared specimens are necessary in which short-circuit winding(s) is/are built in, or can be caused from the outside by brought out leads.

The short circuit shall be chosen so that the unloaded transformer is supplied with 1,06 times the **rated input** voltage at ambient temperature, and that the input power (watt) is equal to the value of the **rated output**. Tolerance is $\pm 20\%$. The percentage of turns to be short-circuited is approximately equal to the **short-circuit voltage** expressed as a percentage of the **rated supply voltage**. The short circuit is made in the middle of the windings. In one sample the short circuit is applied to the **input winding**, and in the other sample on the **output winding**. If there is more than one winding, the short circuit is applied simultaneously to either all **input windings** or all **output windings**. During the test no adjustment is admitted.

This test is not carried out on transformers already covered by 15.5.

27.3.1 Portable transformers are placed on a dull black painted plywood support as described in 14.2.

Stationary transformers, which are not designed to be built in, are fixed in the most unfavourable position under normal use to a dull black painted plywood support as described in 14.2. When the most unfavourable position of use is vertical or on the ceiling, the **stationary transformer** and the support are placed in this position (200 ± 5) mm above a piece of white pinewood board, approximately 10 mm thick, covered with a single layer of tissue paper.

For transformers with self-resettable devices, all these protective devices are short-circuited.

For this test, the **input circuits** shall be protected by fuse or circuit-breaker with a rated current 10 times the rated current of the transformer, but at least 16 A.

The transformer, with its protective devices where applicable, is tested as specified above for 15 days but without load. The result shall be a definitive interruption in the circuit. If no definitive interruption occurs after this period, the supply is switched off.

If the non-self-resettable or replaceable protective device, if any, interrupts the circuit, the supply is switched off and the transformer is left to cool down for 2 h. Then the protective device is reset or replaced, the supply is switched on until the device interrupts the circuit or an interruption in the transformer occurs. If no interruption in the transformer occurs, 30 cycles are made in the case of resettable devices, or 10 cycles in the case of replaceable devices. Each cycle consists of supplying the transformer until the protective device interrupts the circuit and the power remains switched off for 2 h.

During the test no flames shall occur, and the transformer shall not act as a source of ignition for the surroundings. The temperature of the support shall not exceed 125 °C. If **stationary transformers** are placed in a vertical position or on the ceiling, burning drops, if any, shall not ignite the tissue paper or scorch the pinewood board.

27.3.2 After the test of 27.3.1 and after cooling down to ambient temperature, the following applies.

a) Transformers where a definitive interruption in the **input circuit** has occurred shall withstand a dielectric strength test, the test voltage being 35 % of the values according to table 8 of clause 18.

b) Transformers where no definitive interruption has occurred after the cycling test shall withstand the test voltages according to table 8 of clause 18.

The transformer shall show no holes allowing the standard test finger to touch **hazardous live parts** without appreciable force. In case of doubt, contact with **hazardous live parts** is shown by means of an electrical contact indicator, the voltage being not less than 40 V. If one specimen does not pass the test, the complete test has failed.

27.4 Parts of insulating material retaining current carrying parts in position shall be resistant to abnormal heat and to fire.

Compliance is checked by the following test.

Parts of insulating material are subjected to a ball pressure test as described in 27.1 but at a temperature of $(125 \pm 2) ^\circ\text{C}$ or at a temperature of $(40 + \theta \pm 2) ^\circ\text{C}$, where θ is the temperature rise of the relevant part determined during the test of 14.2, whichever is the higher.

NOTE – The test is not made on parts of ceramic material, or on bobbins, or on glass.

In addition, parts of insulating material retaining terminals for external conductors which carry a current of more than 0,5 A during normal operation shall comply with the glow-wire test described in 27.2, with the only difference that the glow-wire is electrically heated to $850 ^\circ\text{C}$.

27.5 For transformers with an IP rating other than IPX0, insulating parts retaining current carrying parts in position shall have resistance to tracking corresponding to at least material group IIIa if they are exposed to excessive moisture or deposition of dirt in normal use.

For material other than ceramics, compliance is checked by the tests of annex G.

No flashover or breakdown between electrodes shall occur before a total of 50 drops has fallen.

28 Resistance to rusting

Ferrous parts, the rusting of which might cause the transformer to become unsafe, shall be adequately protected against rusting.

NOTE This requirement applies to the outer surfaces of iron cores, but in that case protection by a coating of varnish is deemed to be adequate.

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

All grease is removed from the parts to be tested by immersion in trichloroethane for 10 min. The parts are then immersed for 10 min in a 10 % solution of ammonium chloride in water at a temperature of $(20 \pm 5) ^\circ\text{C}$. Without drying, but after shaking off any drops, the parts are placed for 10 min in a box containing air saturated with moisture at a temperature of $(20 \pm 5) ^\circ\text{C}$.

After all the parts have been dried for 10 min in a heating cabinet at a temperature of $(100 \pm 5) ^\circ\text{C}$; their surfaces shall show no signs of rust.

NOTE 1 – This requirement applies to the outer surfaces of iron cores, but in that case protection by a coating of varnish is deemed to be adequate.

NOTE 2 – Traces of rust on sharp edges and any yellowish film removable by rubbing are ignored.

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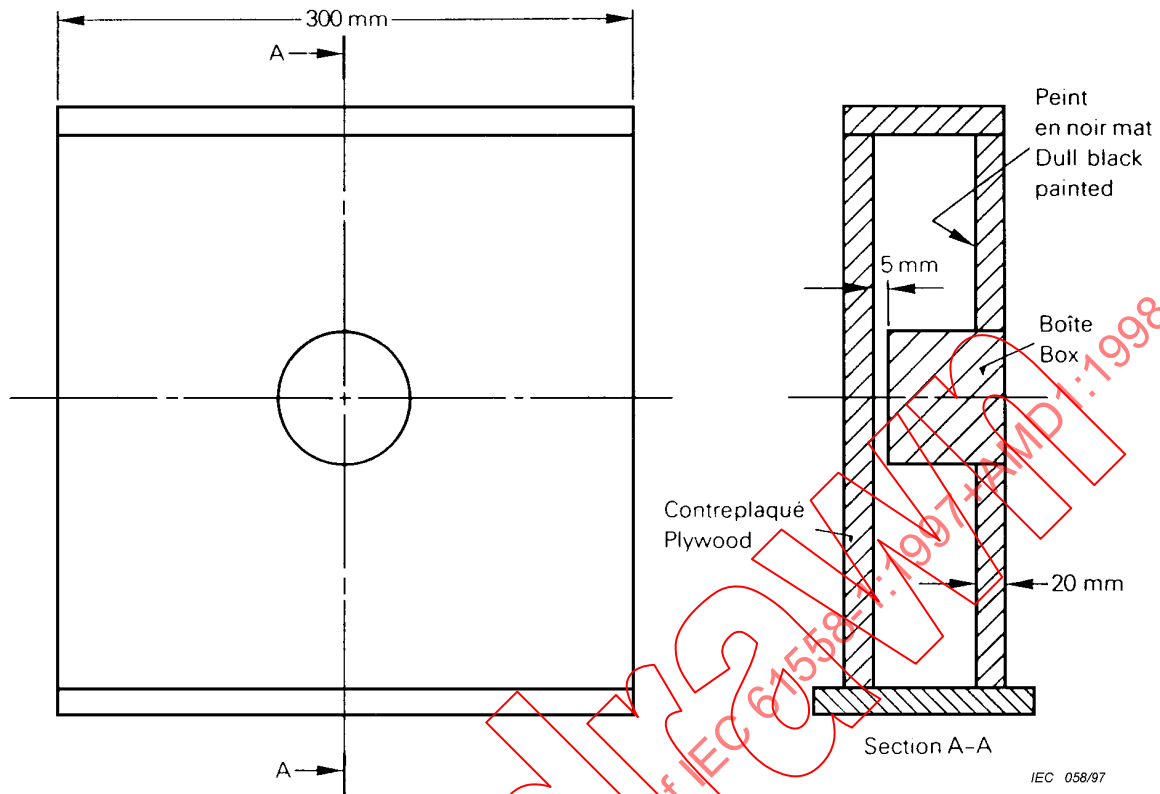
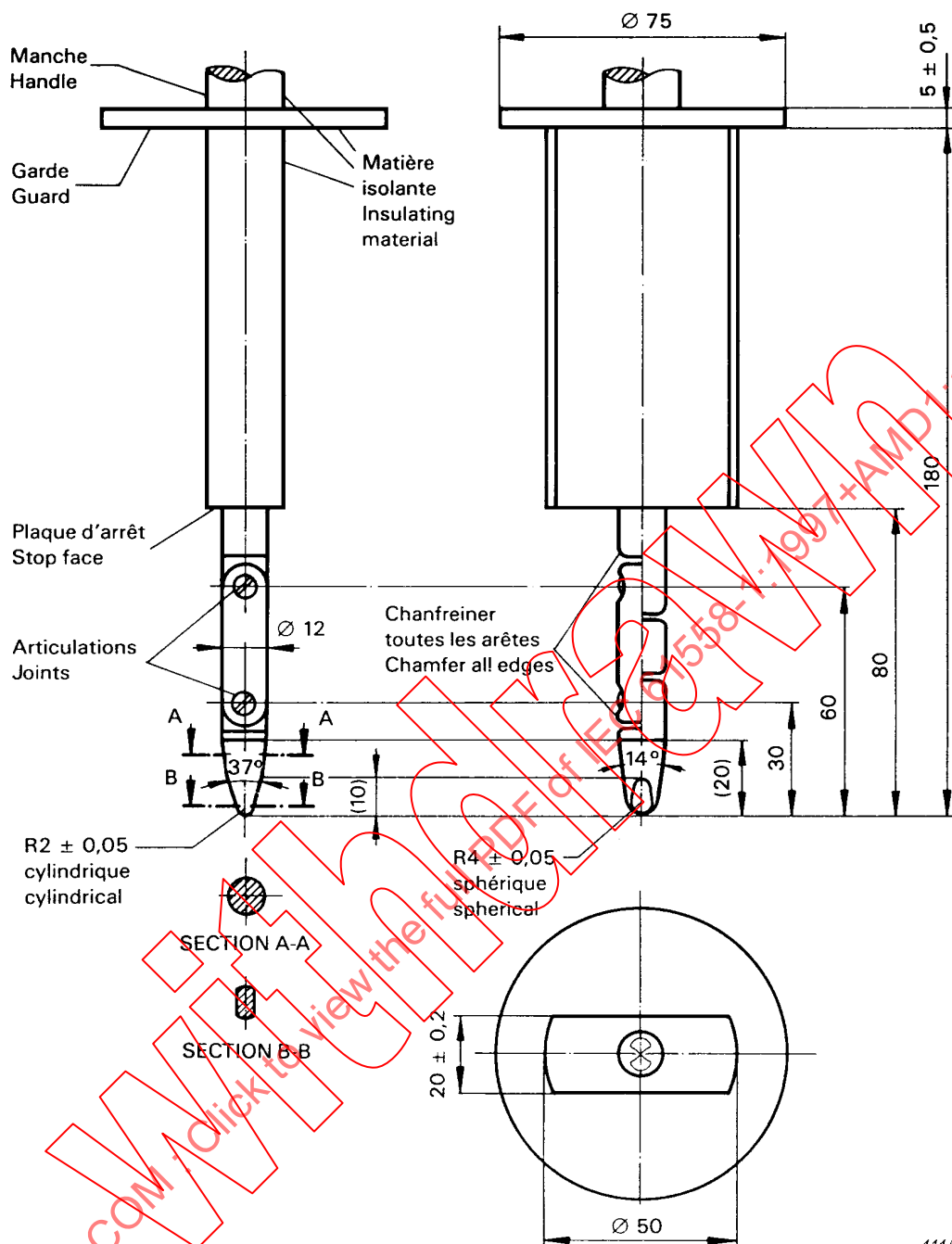


Figure 1 –

Mounting box for flush-type transformer (see 5.10)



444/89

Material: metal, except where otherwise specified

Linear dimensions in millimetres

Tolerances on dimensions without specific tolerance:

on angles: 0/-10°

on linear dimensions:

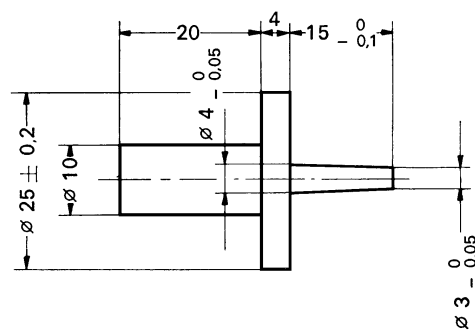
– up to 25 mm: $\begin{smallmatrix} 0 \\ -0,05 \end{smallmatrix}$

– over 25 mm: $\pm 0,2$

Both joints shall permit movement in the same plane and the same direction through an angle of 90° with a 0 to +10° tolerance.

Figure 2 –

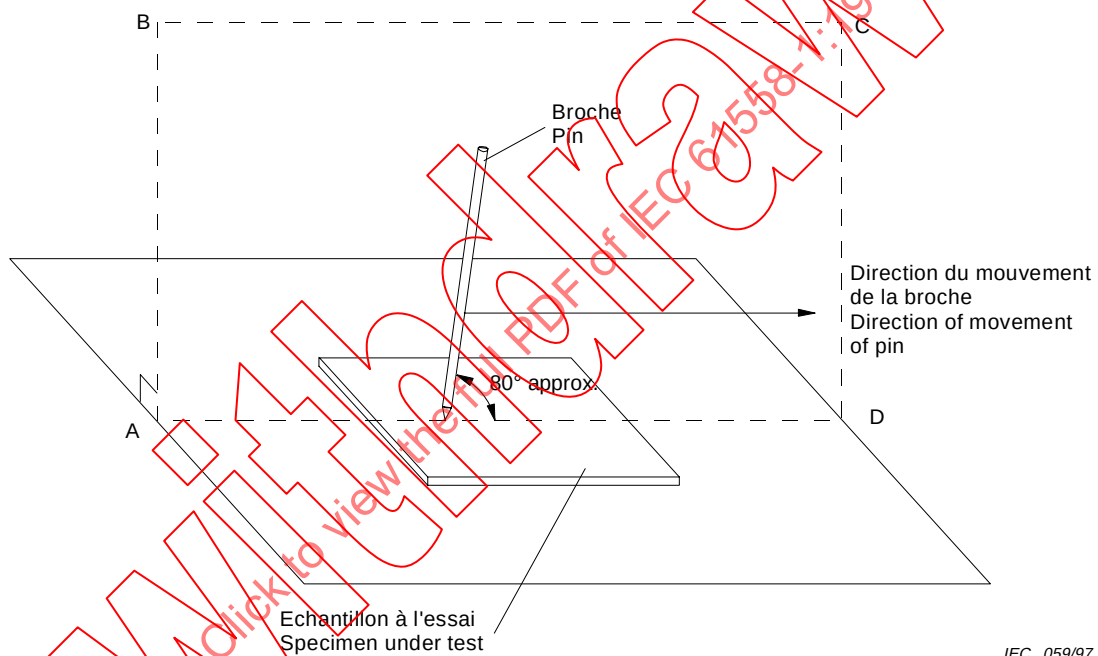
Standard test finger (see 9.2, 15.5.2 and IEC 61032 test probe B)



411/89

Dimensions in millimeters

Figure 3 –
Test pin (see 9.2 and IEC 61032 test probe 13)



IEC 059/97

NOTE –

The pin is in the plane ABCD which is perpendicular to the specimen under test.

Figure 4 –
Abrasion resistance test for insulating coated layers

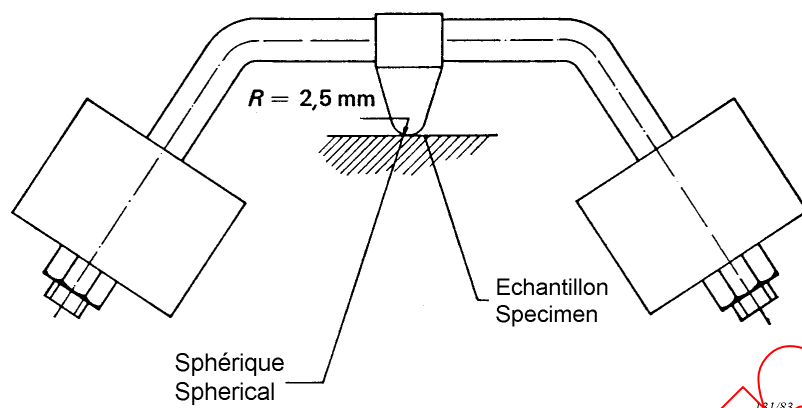


Figure 5 –
Ball-pressure apparatus (see 27.1)

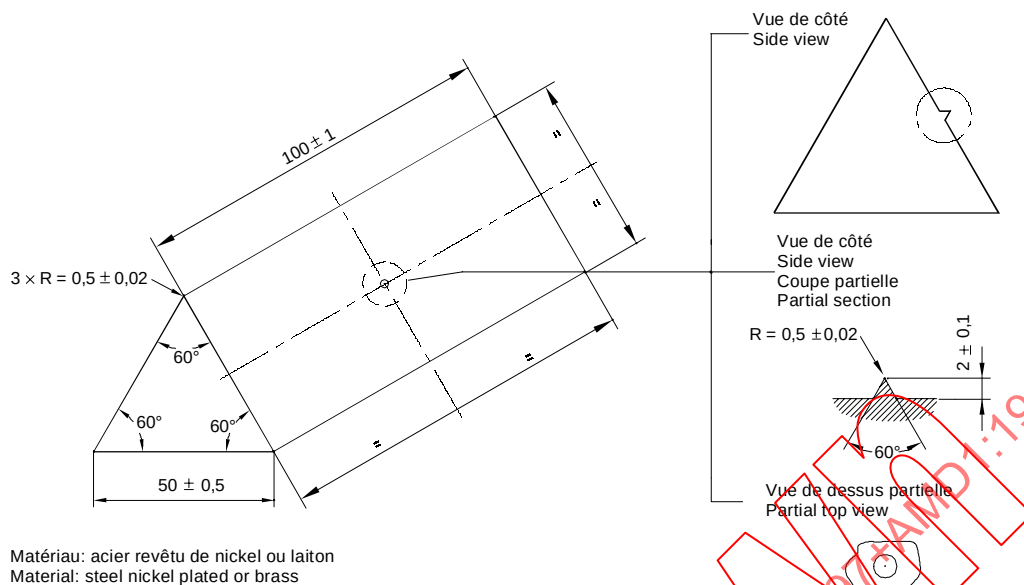


Figure 6a -
Mandrel

IEC 060/97

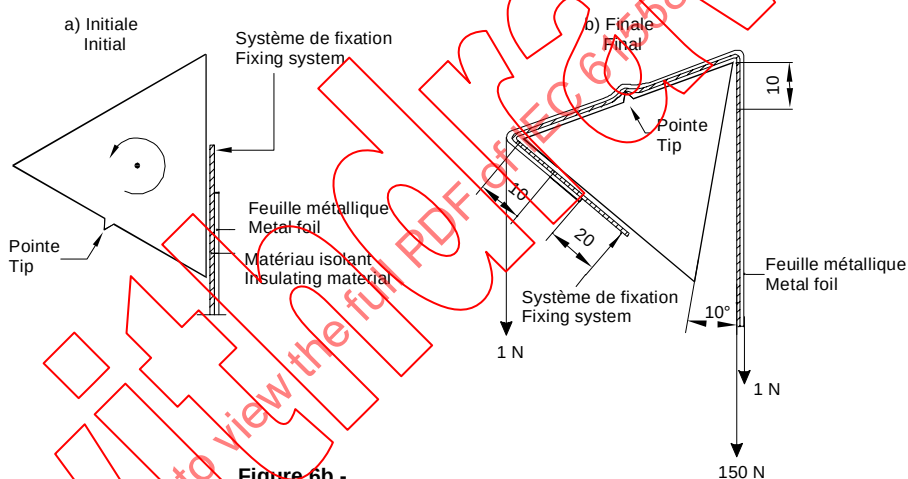
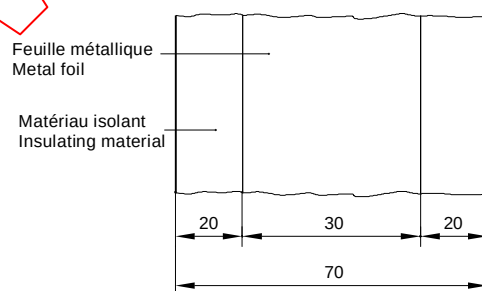


Figure 6b -
Position of mandrel

IEC 061/97



IEC 062/97

Figure 6c -
Position of metal foil on paper

Figure 6 -

Test arrangement for checking mechanical withstanding of insulating materials in thin sheet layers (see 26.3)

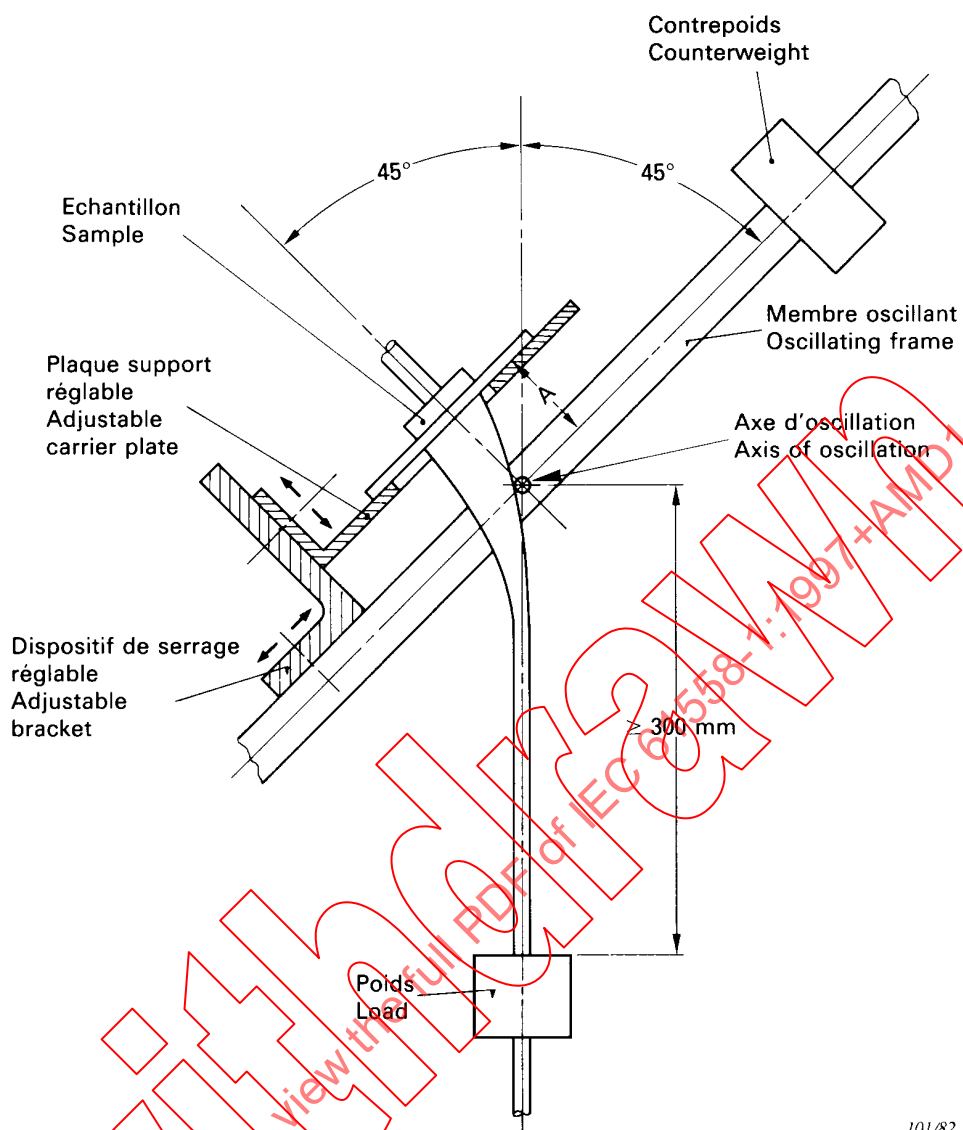


Figure 7 -

Flexing test apparatus (see 22.9.4)

Annex A (normative)

Measurement of creepage distances and clearances

The width X of grooves specified in examples 1 to 10 apply to all examples as a function of the **pollution degree** as follows:

Pollution degree	Width X of grooves: minimum values
1	0,25 mm
2	1,0 mm
3	1,5 mm

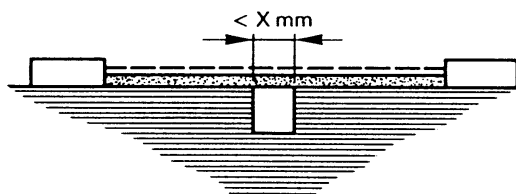
NOTE – If the associated **clearance** is less than 3 mm, the minimum groove width may be reduced to one-third of this distance.

The methods of measuring **creepage distances** and **clearances** are indicated in the examples 1 to 10. These cases do not differentiate between gaps and grooves or between types of insulation.

The following assumptions are made:

- any recess is assumed to be bridged with an insulating link having a length equal to the specified width X and being placed in the most unfavourable position (see example 3);
- where the distance across a groove is equal to or larger than the specified width X, the **creepage distance** is measured along the contours of the groove (see example 2);
- **creepage distances** and **clearances**, measured between parts which can assume different positions in relation to each other, are measured when these parts are in their most unfavourable position.

Example 1

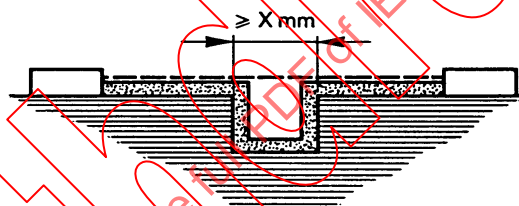


127/81

Condition: Path under consideration includes a parallel or converging sided groove of any depth with a width of less than X mm.

Rule: **Creepage distance** and **clearance** are measured directly across the groove as shown above.

Example 2



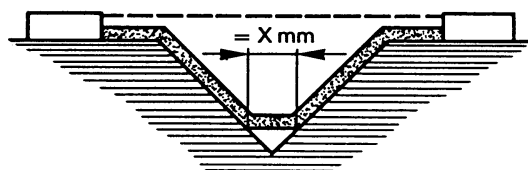
128/81

Condition: Path under consideration includes a parallel sided groove of any depth and equal to or more than X mm wide.

Rule: **Clearance** is the "line of sight" distance. Creepage path follows the contour of the groove.



Example 3

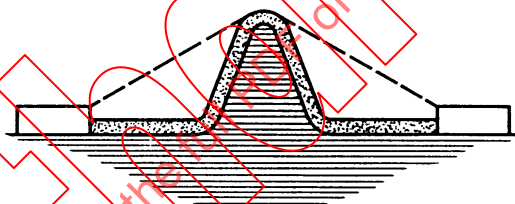


129/81

Condition: Path under consideration includes a V-shaped groove with an internal angle of less than 80° and a width greater than X mm.

Rule: **Clearance** is the "line of sight" distance. Creepage path follows the contour of the groove but "short-circuits" the bottom of the groove by a length of X mm.

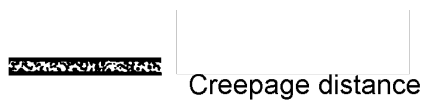
Example 4



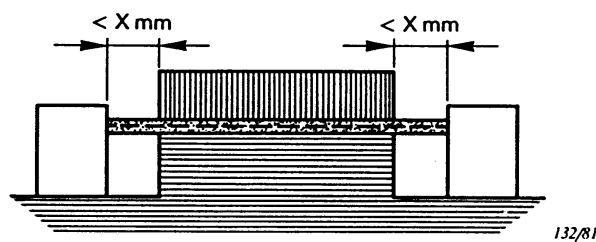
131/81

Condition: Path under consideration includes a rib.

Rule: **Clearance** is the shortest direct air path over the top of the rib. Creepage path follows the contour of the rib.



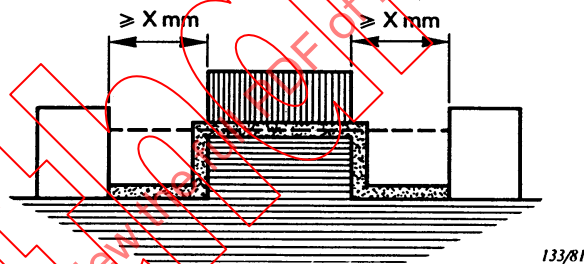
Example 5



Condition: Path under consideration includes an uncemented joint with grooves less than X mm wide on either side.

Rule: **Creepage distance** and **clearance** path is the "line of sight" distance shown.

Example 6

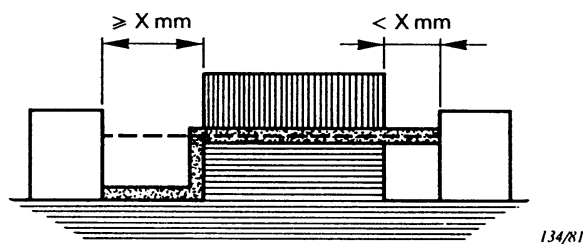


Condition: Path under consideration includes an uncemented joint with grooves equal to or more than X mm wide on each side.

Rule: **Clearance** path is the "line of sight" distance. Creepage follows the contour of the groove.



Example 7

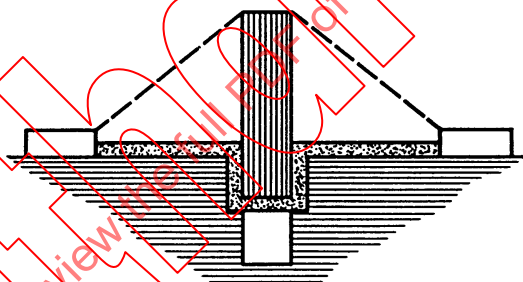


134/81

Condition: Path under consideration includes an uncemented joint with a groove on one side less than X mm wide and a groove on the other side equal to or more than X mm wide.

Rule: **Clearance** and creepage paths are as shown above.

Example 8



135/81

Condition: **Creepage distance** through the joint is less than **creepage distance** over the barrier.

Rule: **Clearance** is the shortest direct air path over the top of the rib. **Creepage distance** follows the contour of the barrier through the groove.

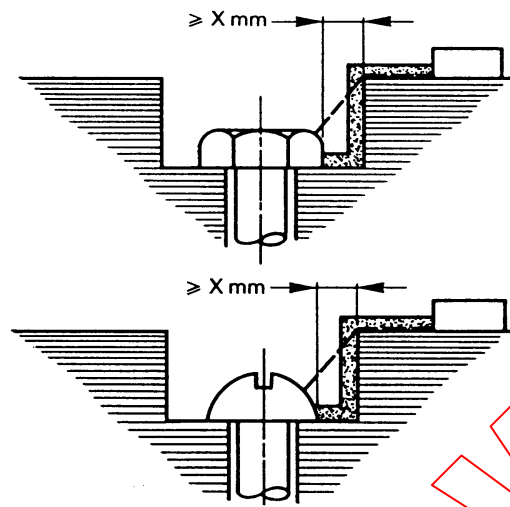


Clearance



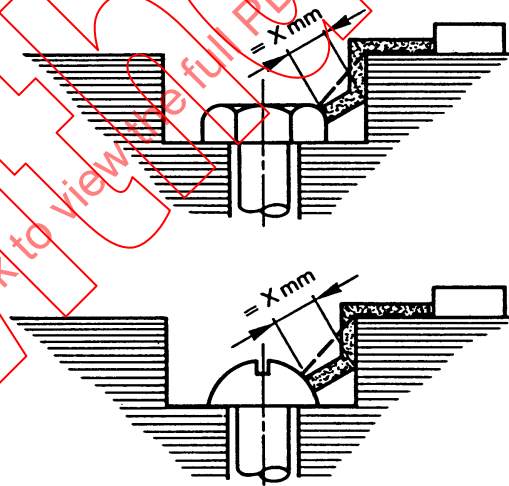
Creepage distance

Example 9



Gap between head of screw and wall of recess too narrow to be taken into account.

Example 10



Gap between head of screw and wall of recess wide enough to be taken into account.

----- Clearance

Creepage distance

Annex B (normative)

Testing a series of transformers

The prescriptions of this annex are intended to facilitate the testing of a series of transformers.

B.1 If a series of transformers is to be tested, the number of samples to be tested may be reduced.

Transformers can be considered as a series if:

- a) they are of the same family, this meaning that they are covered by the same section of part 2;
- b) they are of the same construction, implying that:
 - 1) they have lamination or core from the same pattern range and made of the same material,
 - 2) the same type of winding technology has been used (for example concentric or two chambers, same insulation system),
 - 3) the same assembling technology has been used (for example open type, enclosed type, encapsulated type, impregnated, potted, etc.),
 - 4) the same type of protection against overload has been used (for example fuses, **thermal cut-out**, etc.),
 - 5) they are of the same frequency range;
- c) they are designed for the same minimum and maximum ambient temperatures.

Variations in the following parameters are permitted, provided that the transformers comply in all other respects with the rules detailed above:

- 1) input voltage range;
- 2) output voltage range;
- 3) number of tapping and/or windings;
- 4) frequency in the declared frequency range;
- 5) **rated output**.

B.2 The number of samples needed in case of testing a series of transformers as defined above shall be:

- a) for parameters 1) 2) and 3): two samples minimum and not more than four, chosen in order to be sure that they represent the most unfavourable situation in the family to be tested;

NOTE 1 – The samples should be chosen according to the following rules:

- one of the lowest **rated output** with the highest voltages and the lowest number of tapplings;
- one of the highest **rated output** with the lowest voltages and the lowest number of tapplings;
- one of the lowest **rated output** with the highest number of tapplings with the highest voltage difference between adjacent windings;
- one of the medium **rated output** with medium voltages and medium number of tapplings;
- one of the highest **rated output** with the lowest voltages and the highest number of windings.

When only two samples are chosen the first two alternative should be used.

b) for parameter 4): one sample of the lowest frequency and, in case of doubt, one sample of the highest frequency within the range;

NOTE 2 – If possible, the sample may be the second sample chosen for parameters 1), 2) and 3).

c) for parameter 5): two samples minimum, taken from the extremities of the range.

NOTE 3 – The samples should be chosen according to the following rules:

- one of the lowest **rated output** with the highest difference in percentage between the value of the current of the transformer and the value of the current of the relevant protective device, if any;
- one of the highest **rated output** with the highest difference in percentage between the value of the current of the transformer and the value of the current of the relevant protective device, if any;
- one sample representing the most unfavourable condition of the temperature of winding and core;
- one sample representing the most unfavourable condition of the temperature rise of the **enclosure**.

To be sure that in any case the most unfavourable situation is covered, the manufacturer shall declare the type in the series having the maximum losses in normal condition; this type shall be chosen as one of the samples to be tested.

The conditions above may be covered by a minimum of two samples.

The number of specimens for each sample shall be in accordance with 5.2, except for:

- the test of 14.3 where only two samples of three specimens in total are needed for the series, the samples being the two first of parameter 5;
- the test of 15.5 where only two samples of three specimens in total are needed for the series, the samples being the two first of parameter 5;
- the test of 16.4 where only three specimens in total are needed for the series, the heaviest type being chosen.

B.3 At least one specimen of each lamination or core size shall be provided for constructional clearances, mechanical strength, etc.

NOTE – The samples required in B.3 shall include the samples used in B.2.

Annex C (normative)

Table C.1 – Creepage distances (cr), clearances (cl) and distances through insulation (dti)
Material group II ($400 \leq CTI < 600$)

P1 = pollution degree 1 P2 = pollution degree 2 P3 = pollution degree 3

	Type of insulation	Measurement				Working voltages ²⁾											
		Through winding enamel ¹⁾		Other than through winding enamel		V											
		P2	P3	P2	P3	≥25 ≤50		100		150		300		600		1 000	
						cl	cr	cl	cr	cl	cr	cl	cr	cl	cr	cl	cr
1) Insulation between input and output circuits (basic insulation)	a) Creepage distances and clearances between live parts of input circuits and live parts of output circuits	X	X	X	X	0,2 0,8 0,2 0,8	0,85 1,7 0,85 1,7	0,5 0,8 0,2 0,8	1,0 2,0 1,0 2,0	1,5 1,5 0,5 0,8	1,5 2,2 1,1 2,2	3,0 3,0 1,5 4,2	3,0 4,2 2,1 4,2	5,5 5,5 3,0 8,6	5,5 8,6 4,3 8,6	8,0 8,0 5,5 5,5	8,0 14,0 7,1 14,0
	Reduced values, 26.2 (P1)					–	0,18	–	0,25	–	0,3	–	0,7	–	1,7	–	3,2
						dti		dti		dti		dti		dti		dti	
	b) Distances through insulation between input or output circuits and an earthed metal screen	X	X	X	X	No requirements of thickness											
c) Distances through insulation between input and output circuits	X	X	X	X	No requirements of thickness												
2) Insulation between input and output circuits (double or reinforced insulation)	a) Creepage distances and clearances between live parts of input circuits and live parts of output circuits	X	X	X	X	0,5 0,8 0,2 0,8	1,0 2,0 1,0 2,0	1,5 1,5 0,5 0,8	1,5 2,8 1,4 2,8	3,0 3,0 1,5 1,5	3,0 4,2 2,0 4,2	5,5 5,5 3,0 8,6	5,5 8,6 4,3 8,6	8,0 8,0 5,5 17,2	8,6 17,2 8,6 17,2	14,0 14,0 8,0 8,0	14,0 28,0 14,0 28,0
	Reduced values, see 26.2 (P1)					–	0,25	–	0,4	–	0,7	–	1,7	–	4,0	–	7,5
						dti		dti		dti		dti		dti		dti	
	b) Distances through insulation between input or output circuits and an earthed metal screen, see 26.3	X	X	X	X	0,1 [0,05] ⁷⁾		0,2 [0,07] ⁷⁾		0,25 [0,08] ⁷⁾		0,5 [0,16] ⁷⁾		0,7 [0,19] ⁷⁾		1,0 [0,25] ⁷⁾	
	c) Distances through insulation between input and output circuits, see 26.3	X	X	X	X	0,2 ⁴⁾ [0,1] ⁵⁾ – ⁶⁾		0,3 ⁴⁾ [0,1] ⁵⁾ – ⁶⁾		0,5 ⁴⁾ [0,15] ⁵⁾ – ⁶⁾		1,0 ⁴⁾ [0,3] ⁵⁾ – ⁶⁾		1,5 ⁴⁾ [0,4] ⁵⁾ – ⁶⁾		2,0 ⁴⁾ [0,5] ⁵⁾ – ⁶⁾	

For notes, see page 187

Dimensions in millimetres

Table C.1 (continued)

Type of insulation	Measurement		Working voltages ²⁾															
			V															
	Through winding enamel ¹⁾	Other than through winding enamel	≥25 ≤50		100		150		300		600		1 000					
	P2	P3	P2	P3	cl	cr	cl	cr	cl	cr	cl	cr	cl	cr	cl	cr	cl	cr
3) Insulation between adjacent input circuits or insulation between adjacent output circuits ³⁾	X	X	X	X	0,2 0,8	0,85 1,7	0,2 0,8	1,0 2,0	0,2 0,8	1,1 2,2	0,5 0,8	2,1 4,2	1,5 1,5	4,3 8,6	3,0 3,0	7,1 14,0		
Reduced values see 26.2 (P1)					–	0,18	–	0,25	–	0,3	–	0,7	–	1,7	–	3,2		
4) Creepage distances and clearances between terminals for the connection of external cables and cords excluding those between screw terminals for input and for output circuits																		
a) Up to and including 6 A	X	X	X	X	3,0		3,6		4,0		6,0		9,0		12,5			
b) Over 6 A up to and including 16 A	X	X	X	X	5,0		6,0		7,0		10,0		13,0		16,0			
c) Over 16 A	X	X	X	X	10,0		11,0		12,0		14,0		17,0		20,0			
5) Basic or supplementary insulation																		
Between:																		
a) live parts of different polarity			X		0,2 0,8	0,9 1,7	0,5 0,8	1,0 2,0	1,5 1,5	1,5 2,2	3,0 3,0	3,0 4,2	5,5 5,5	5,5 8,6	8,0 8,0	8,0 14,0		
b) live parts and the body if intended to be connected to protective earth				X	0,2 0,8	0,9 1,7	0,2 0,8	1,0 2,0	0,5 0,8	1,1 2,2	1,5 1,5	2,1 4,2	3,0 3,0	4,3 8,6	5,5 5,5	7,1 14,0		
c) accessible metal parts and metal rod of the same diameter as the flexible cable or cord (or metal foil wrapped around the cord) inserted inside inlet bushing, anchorage and the like	X	X			0,2 0,8	0,9 1,7	0,2 0,8	1,0 2,0	0,5 0,8	1,1 2,2	1,5 1,5	2,1 4,2	3,0 3,0	4,3 8,6	5,5 5,5	7,1 14,0		
d) live parts and an intermediate metal part																		
e) an intermediate metal part and the body																		
Reduced values, see 26.2 (P1)					–	0,03	–	0,1	–	0,24	–	0,7	–	1,7	–	3,2		

For notes, see page 187

Dimensions in millimetres

Table C.1 (concluded)

	Type of insulation	Measurement		Working voltages ²⁾													
				V													
		Through winding enamel ¹⁾	Other than through winding enamel	≥25 ≤50	100	150	300	600	1 000								
		P2	P3	P2	P3	cl	cr	cl	cr	cl	cr	cl	cr	cl	cr	cl	cr
6) Reinforced or double insulation	Between the body and live parts			X		0,5 0,8 0,2 0,8	1,0 2,0 1,0 2,0	1,5 1,5 0,5 0,8	1,5 3,0 1,5 3,0	3,0 3,0 1,5 1,5	3,0 4,2 2,1 4,2	5,5 5,5 3,0 8,6	5,5 8,6 4,3 8,6	8,0 8,0 5,5 17,2	8,6 17,2 8,6 17,2	14,0 14,0 8,0 8,0	14,0 28,0 14,0 28,0
	Between body and live parts of the output circuit if protected by additional provisions against transient voltages	X	X	X	X	0,2 0,8	1,0 2,0	0,2 0,8	1,5 3,0	0,5 0,8	2,1 4,2	1,5 1,5	4,3 8,6	3,0 3,0	8,6 17,2	5,5 5,5	14,0 28,0
	Reduced values, see 26.2 (P1)					–	0,25	–	0,4	–	0,7	–	1,7	–	4,0	–	7,5
7) Distance through insulation (excluding insulation between input and output circuit)	a) Basic ⁸⁾	X	X	X	X	No requirement of thickness											
	b) Supplementary ⁸⁾	X	X	X	X	dti 0,1 ⁴⁾ [0,05] ⁵⁾ – ⁶⁾	dti 0,15 ⁴⁾ [0,05] ⁵⁾ – ⁶⁾	dti 0,25 ⁴⁾ [0,08] ⁵⁾ – ⁶⁾	dti 0,5 ⁴⁾ [0,15] ⁵⁾ – ⁶⁾	dti 0,75 ⁴⁾ [0,20] ⁵⁾ – ⁶⁾	dti 1,0 ⁴⁾ [0,25] ⁵⁾ – ⁶⁾						
	c) Reinforced	X	X	X	X	0,2 ⁴⁾ [0,1] ⁵⁾ – ⁶⁾	0,3 ⁴⁾ [0,1] ⁵⁾ – ⁶⁾	0,5 ⁴⁾ [0,15] ⁵⁾ – ⁶⁾	1,0 ⁴⁾ [0,3] ⁵⁾ – ⁶⁾	1,5 ⁴⁾ [0,4] ⁵⁾ – ⁶⁾	2,0 ⁴⁾ [0,5] ⁵⁾ – ⁶⁾						

NOTES

Dimensions in millimetres

- 1) Measurement through winding wire enamel if the winding wire complies at least with grade 1 of IEC 60317.
- 2) Values of **creepage distances** and **clearances** and distances through insulation may be found for intermediate values of **working voltages** by interpolation between the values in the table. No values are required for **working voltages** below 25 V as the voltage test of table 8 is considered sufficient.
- 3) These values do not apply:
 - inside each winding or between groups of windings intended to be permanently connected together, provided that the termination of windings to be connected together are at the same potential,
 - where the **working voltage** does not exceed 300 V and the winding wires comply at least with grade 1 of IEC 60317, even if the windings are intended to be connected in a series or parallel arrangement (e.g. input voltage 110/220 V).
- 4) For solid insulation.
- 5) In the case of insulation consisting of three layers.
- 6) In the case of insulation consisting of two separate layers (no glued layers are allowed in this case) and each layer passes the mandrel test of 26.3 at a voltage of 5,5 kV.
- 7) In the case of insulation consisting of two layers.
- 8) When **double insulation** is required between **input** and **output windings**, the total thickness through insulation shall be the same as shown in box 2 c) whether measured directly or via metal parts.
- 9) When the layers of insulation are made of turns of insulating tape, the winding of the tape should be such that at every place there is at least the required number of layers.
- 10) When a number is replaced by a dash in a column of the table it means that no value is required.

Annex D (normative)

Table D.1 – Creepage distances (cr), clearances (cl) and distances through insulation (dti)
Material group I (CTI ≥ 600)

P1 = pollution degree 1 P2 = pollution degree 2 P3 = pollution degree 3

Type of insulation	Measurement	Working voltages ²⁾															
		Through winding enamel ¹⁾		Other than through winding enamel		≥25 ≤50		100		150		300		600		1 000	
		P2	P3	P2	P3	cl	cr	cl	cr	cl	cr	cl	cr	cl	cr	cl	cr
1) Insulation between input and output circuits (basic insulation)	a) Creepage distances and clearances between live parts of input circuits and live parts of output circuits			X		0,2	0,6	0,5	0,7	1,5	1,5	3,0	3,0	5,5	5,5	8,0	8,0
		X	X		X	0,8	1,5	0,8	1,8	1,5	2,0	3,0	3,9	5,5	7,7	8,0	12,5
					0,2	0,6	0,2	0,7	0,5	0,8	1,5	1,5	3,0	3,0	5,5	5,5	
			X		0,8	1,5	0,8	1,8	0,8	2,0	1,5	3,9	3,0	7,7	5	12,5	
	Reduced values, 26.2 (P1)					–	0,18	–	0,25	–	0,3	–	0,7	–	1,7	–	3,2
b) Distances through insulation between input or output circuits and an earthed metal screen	X	X	X	X	No requirements of thickness												
	X	X	X	X	No requirements of thickness												
	X	X	X	X	No requirements of thickness												
2) Insulation between input and output circuits (double or reinforced insulation)	a) Creepage distances and clearances between live parts of input circuits and live parts of output circuits			X		0,5	0,7	1,5	1,5	3,0	3,0	5,5	5,5	8,0	8,0	14,0	14,0
		X	X		X	0,8	1,8	1,5	2,5	3,0	3,9	5,5	7,7	8,0	16,0	14,0	25,0
					0,2	0,7	0,5	1,0	1,5	1,5	3,0	3,0	5,5	6,0	8,0	10,0	
			X		0,8	1,8	0,8	2,5	1,5	3,9	3,0	7,7	5,5	16,0	8,0	25,0	
	Reduced values, see 26.2 (P1)					–	0,25	–	0,4	–	0,7	–	1,7	–	4,0	–	7,5
b) Distances through insulation between input or output circuits and an earthed metal screen, see 26.3	X	X	X	X	dti		dti		dti		dti		dti		dti		
	X	X	X	X	0,1 [0,05] ⁷⁾		0,2 [0,07] ⁷⁾		0,25 [0,08] ⁷⁾		0,5 [0,16] ⁷⁾		0,7 [0,19] ⁷⁾		1,0 [0,25] ⁷⁾		
c) Distances through insulation between input and output circuits, see 26.3	X	X	X	X	0,2 ⁴⁾ [0,1] ⁵⁾ – ⁶⁾		0,3 ⁴⁾ [0,1] ⁵⁾ – ⁶⁾		0,5 ⁴⁾ [0,15] ⁵⁾ – ⁶⁾		1,0 ⁴⁾ [0,3] ⁵⁾ – ⁶⁾		1,5 ⁴⁾ [0,4] ⁵⁾ – ⁶⁾		2,0 ⁴⁾ [0,5] ⁵⁾ – ⁶⁾		

For notes, see page 193

Dimensions in millimetres

Table D.1 (continued)

	Type of insulation	Measurement				Working voltages ²⁾											
						V											
		Through winding enamel ¹⁾		Other than through winding enamel		≥25 ≤50		100		150		300		600		1 000	
		P2	P3	P2	P3	cl	cr	cl	cr	cl	cr	cl	cr	cl	cr	cl	cr
3) Insulation between adjacent input circuits or insulation between adjacent output circuits ³⁾	Creepage distances and clearances	X	X	X	X	0,2 0,8	0,6 1,5	0,2 0,8	0,7 1,8	0,2 0,8	0,8 2,0	0,5 0,8	1,5 3,9	1,5 1,5	3,0 7,7	3,0 3,0	5,0 12,5
	Reduced values see 26.2 (P1)					–	0,18	–	0,25	–	0,3	–	0,7	–	1,7	–	3,2
4) Creepage distances and clearances between terminals for the connection of external cables and cords excluding those between screw terminals for input and for output circuits	a) Up to and including 6 A	X	X	X	X	3,0		3,6		4,0		6,0		9,0		12,5	
	b) Over 6 A up to and including 16 A	X	X	X	X	5,0		6,0		7,0		10,0		13,0		16,0	
	c) Over 16 A	X	X	X	X	10,0		11,0		12,0		14,0		17,0		20,0	
5) Basic or supplementary insulation	Between:																
	a) live parts of different polarity			X		0,2	0,6	0,5	0,7	1,5	1,5	3,0	3,0	5,5	5,5	8,0	8,0
	b) live parts and the body if intended to be connected to protective earth	X			X	0,8	1,5	0,8	1,8	1,5	2,0	3,0	3,9	5,5	7,7	8,0	12,5
	c) accessible metal parts and metal rod of the same diameter as the flexible cable or cord (or metal foil wrapped around the cord) inserted inside inlet bushing, anchorage and the like		X			0,2	0,6	0,2	0,7	0,5	0,8	1,5	1,5	3,0	3,0	5,5	5,5
	d) live parts and an intermediate metal part					0,8	1,5	0,8	1,8	0,8	2,0	1,5	3,9	3,0	7,7	5,5	12,5
	e) an intermediate metal part and the body																
	Reduced values, see 26.2 (P1)					–	0,03	–	0,1	–	0,24	–	0,7	–	1,7	–	3,2

For notes, see page 193

Dimensions in millimetres

Table D.1 (concluded)

	Type of insulation	Measurement				Working voltages ²⁾											
						V											
		Through winding enamel ¹⁾		Other than through winding enamel		≥25 ≤50		100		150		300		600		1 000	
		P2	P3	P2	P3	cl	cr	cl	cr	cl	cr	cl	cr	cl	cr	cl	cr
6) Reinforced or double insulation	Between the body and live parts			X	X	0,5 0,8 0,2 0,8	0,7 1,8 0,7 1,8	1,5 1,5 0,5 0,8	1,5 2,5 1,0 2,5	3,0 3,0 1,5 1,5	3,0 3,9 1,5 3,9	5,5 5,5 3,0 7,7	5,5 7,7 3,0 7,7	8,0 8,0 5,5 5,5	8,0 16,0 6,0 16,0	14,0 14,0 8,0 8,0	14,0 25,0 10,0 25,0
	Between body and live parts of the output circuit if protected by additional provisions against transient voltages	X	X	X	X	0,2 0,8	0,7 1,8	0,2 0,8	1,0 2,5	0,5 0,5	1,5 3,9	1,5 1,5	3,0 7,7	3,0 3,0	6,0 16,0	5,5 5,5	10,0 25,0
	Reduced values, see 26.2 (P1)					–	0,25	–	0,4	–	0,7	–	1,7	–	4,0	–	7,5
7) Distance through insulation (excluding insulation between input and output circuit)	a) Basic ⁸⁾	X	X	X	X	No requirement of thickness											
	b) Supplementary ⁸⁾	X	X	X	X	dti 0,1 ⁴⁾ [0,05] ⁵⁾ – ⁶⁾	dti 0,15 ⁴⁾ [0,05] ⁵⁾ – ⁶⁾	dti 0,25 ⁴⁾ [0,08] ⁵⁾ – ⁶⁾	dti 0,5 ⁴⁾ [0,15] ⁵⁾ – ⁶⁾	dti 0,75 ⁴⁾ [0,20] ⁵⁾ – ⁶⁾	dti 1,0 ⁴⁾ [0,3] ⁵⁾ – ⁶⁾	dti 1,5 ⁴⁾ [0,4] ⁵⁾ – ⁶⁾	dti 2,0 ⁴⁾ [0,5] ⁵⁾ – ⁶⁾	dti 2,5 ⁴⁾ [0,6] ⁵⁾ – ⁶⁾	dti 3,0 ⁴⁾ [0,7] ⁵⁾ – ⁶⁾	dti 3,5 ⁴⁾ [0,8] ⁵⁾ – ⁶⁾	dti 4,0 ⁴⁾ [0,9] ⁵⁾ – ⁶⁾
	c) Reinforced	X	X	X	X	0,2 ⁴⁾ [0,1] ⁵⁾ – ⁶⁾	0,3 ⁴⁾ [0,1] ⁵⁾ – ⁶⁾	0,5 ⁴⁾ [0,15] ⁵⁾ – ⁶⁾	1,0 ⁴⁾ [0,3] ⁵⁾ – ⁶⁾	1,5 ⁴⁾ [0,4] ⁵⁾ – ⁶⁾	2,0 ⁴⁾ [0,5] ⁵⁾ – ⁶⁾	2,5 ⁴⁾ [0,6] ⁵⁾ – ⁶⁾	3,0 ⁴⁾ [0,7] ⁵⁾ – ⁶⁾	3,5 ⁴⁾ [0,8] ⁵⁾ – ⁶⁾	4,0 ⁴⁾ [0,9] ⁵⁾ – ⁶⁾	4,5 ⁴⁾ [1,0] ⁵⁾ – ⁶⁾	5,0 ⁴⁾ [1,1] ⁵⁾ – ⁶⁾

NOTES

Dimensions in millimetres

- 1) Measurement through winding wire enamel if the winding wire complies at least with grade 1 of IEC 60317.
- 2) Values of **creepage distances** and **clearances** and distances through insulation may be found for intermediate values of **working voltages** by interpolation between the values in the table. No values are required for **working voltages** below 25 V as the voltage test of table 8 is considered sufficient.
- 3) These values do not apply:
 - inside each winding or between groups of windings intended to be permanently connected together, provided that the termination of windings to be connected together are at the same potential,
 - where the **working voltage** does not exceed 300 V and the winding wires comply at least with grade 1 of IEC 60317, even if the windings are intended to be connected in a series or parallel arrangement (e.g. input voltage 110/220 V).
- 4) For solid insulation.
- 5) In the case of insulation consisting of three layers.
- 6) In the case of insulation consisting of two separate layers (no glued layers are allowed in this case) and each layer passes the mandrel test of 26.3 at a voltage of 5,5 kV.
- 7) In the case of insulation consisting of two layers.
- 8) When **double insulation** is required between **input** and **output windings**, the total thickness through insulation shall be the same as shown in box 2 c) whether measured directly or via metal parts.
- 9) When the layers of insulation are made of turns of insulating tape, the winding of the tape should be such that at every place there is at least the required number of layers.
- 10) When a number is replaced by a dash in a column of the table it means that no value is required.

Annex E (normative)

Glow-wire test

The glow-wire test is carried out in accordance with IEC 60695-2-1/0.

For the purpose of this standard, the following applies with reference to the relevant clauses and subclauses of IEC 60695-2-1/1.

5 Severity

The temperature of the tip of the glow-wire shall be 650 °C.

7 Conditioning

Preconditioning is required.

9 Test procedure

Add to 9.1 the following paragraph:

If possible, the tip of the glow-wire is applied to flat surfaces and not to grooves, knock-outs, narrow recesses or sharp edges.

Annex F (normative)

Requirements for switches complying with IEC 61058

F.1 Manually operated mechanical switches shall meet one of the following requirements, a) or b)

a) The switch, tested as a separate component, shall comply with the requirements and tests of IEC 61058-1, whereby the following applies:

- the number of operating cycles shall be 10 000 (see 7.1.4.4 of IEC 61058-1);
- the switch shall be suitable for use in the relevant **pollution degree** situation (see 7.1.6.2 of IEC 61058-1);
- the switch shall be of category D regarding the resistance to heat and fire (see 7.1.9.3 of IEC 61058-1).

The characteristics of the switch with regard to:

- 1) the rating of the switch (see clause 6 of IEC 61058-1);
- 2) the classification of the switch according to:
 - nature of supply (see 7.1.1 of IEC 61058-1),
 - type of load to be controlled by the switch (see 7.1.2 of IEC 61058-1),
 - ambient air temperature (see 7.1.3 of IEC 61058-1)

shall be appropriate for the function of the switch under normal operating conditions.

If the switch is a mains switch which controls mains socket-outlet(s), the rated current I and the rated peak surge current of the socket-outlet(s) as specified in clause F.2 shall be taken into account.

Compliance is checked according to test specifications of IEC 61058-1, by inspection and by measurements,

b) The switch, tested as part of the apparatus working under normal operating conditions, shall meet the requirements of F.2, F.3 and F.4.

F.2 The switch shall withstand without excessive wear or other harmful effects the electrical, thermal and mechanical stresses that occur in normal use, and shall have a mechanism complying with 13.3 of IEC 61058-1 for both d.c. switches and a.c. mains switches.

Compliance is checked according to 13.1 of IEC 61058-1 and by the following endurance test:

The switch is subjected to 10 000 cycles of operation with a sequence according to 17.1.2 of IEC 61058-1, except the increased voltage test at accelerated speed specified in 17.2.4 of IEC 61058-1, and under electrical and thermal conditions given by the normal operating conditions of the apparatus.

The test is carried out on three specimens, no failure is allowed.

F.3 If the switch is a mains switch which controls mains socket-outlet(s), the endurance test is carried out with an additional load connected to the socket-outlet(s), consisting of the circuit shown in figure 9 of IEC 61058-1, taking into account figure 10.

The rated current I of the additional load shall correspond to the marking of the socket-outlet(s) (see item e) of 5.2). The peak surge current of the additional load shall have a value as shown in table F.1.

Table F.1

Rated current of the socket-outlet(s) A	Peak surge current A
$I \leq 0,5$	20
$0,5 < I \leq 1,0$	50
$1,0 < I$	100

If the socket-outlet(s) is/are marked with the current which may be drawn, this/these value(s) is/are chosen for the rated current I of the socket-outlet(s).

If the socket-outlet(s) is/are marked with the power which may be drawn, the rated current I of the socket-outlet(s) is calculated from this/these value(s).

After the test, the switch shall show no damage in the sense of this standard. In particular, it shall show no deterioration of its **enclosure**, no reduction of **clearances** and **creepage distances** and no loosening of electrical connections with mechanical fixing.

Compliance is checked by inspection and by the tests specified in clauses F.4 and F.5, respectively, in the given order.

F.4 The switch shall be so constructed that it does not attain excessive temperatures in normal use. The materials used shall be such that the performance of the switch is not adversely affected by the operation in normal use in the conditions given by the apparatus. In particular, the material and design of the contacts and terminals shall be such that the operation and the performance of the switch are not adversely affected by its oxidation or other deterioration.

Compliance is checked in the "ON" position under normal operating conditions and according to 16.2.2 d) - j) and m) of IEC 61058-1, taking into account the rated current I of mains socket-outlet(s), if any, including the peak surge current according to clause F.3.

F.5 The switch shall have adequate dielectric strength.

Compliance is checked by the following tests:

The switch shall withstand a dielectric strength test as specified in 18.3, without being previously subjected to the humidity treatment, the test voltage being decreased to 75 % of the corresponding test voltage specified in that subclause, but not less than 500 V r.m.s. (700 V peak).

- The test voltage is applied in the "ON" position between **hazardous live parts** and accessible conductive parts, and, in addition, between the poles in case of a multipole switch.*
- The test voltage is applied in the "OFF" position across each contact gap. During the test, resistors and capacitors in parallel to a contact gap may be disconnected.*

Annex G (normative)

Tracking test

For the purpose of this standard, materials are separated into three groups by their comparative tracking index (CTI) values, as follows:

material group I	$600 < (\text{CTI})$
material group II	$400 < (\text{CTI}) < 600$
material group IIIa	$175 < (\text{CTI}) < 400$

Separation of the material groups is determined by compliance with the comparative tracking index test made in accordance with IEC 60112.

The test is made on three separate specimens or on three pieces cut from the relevant component, care being taken that the electrodes are clean, correctly shaped and correctly positioned before each test is started. In case of doubt, the test is repeated, if necessary, on a new specimen.

For the purpose of this standard, the following applies with reference to the clauses and subclauses of IEC 60112.

3 Test specimen

The last sentence of the first paragraph does not apply.

5 Test apparatus

The note in 5.1 does not apply.

Note 4 in 5.3 does not apply.

The test solution A as described in 5.4 is used.

6 Procedure

For the CTI test of 6.2, notes 2 and 3 of clause 3 also apply.

Subclause 6.3 does not apply.

Annex H (normative)

Electronic circuits

H.1 Scope

For circuits comprising at least one electronic component the standard applies with the following modifications.

H.3 Definitions

Additional definitions:

H.3.8 Electronic circuits and components

H.3.8.1 electronic component: Part in which conduction is achieved principally by electrons moving through a vacuum, gas or semiconductor.

NOTE – Neon indicators are not considered to be electronic components.

H.3.8.2 electronic circuit: Circuit incorporating at least one electronic component.

H.5 General notes on tests

Additions:

H.5.1 All clauses of part 1, as modified in this annex, and in the parts 2 for the specific transformers, apply to electronic circuits.

H.5.2 The accumulation of stress resulting from successive tests is to be avoided. It may be necessary to replace components or to use additional samples.

NOTE – The number of additional samples should be kept to a minimum by an evaluation of the relevant circuits.

H.15 Short circuit and overload protection

Additions:

H.15.6 Electronic circuits shall be so designed and applied that a fault condition will not render the transformer unsafe with regard to electric shock, fire hazard or dangerous malfunction.

Compliance is checked by evaluation of the fault conditions specified in H.15.8 for all circuits or parts of circuits, unless they comply with the conditions specified in H.15.7.

If the safety of the transformer under any of the fault conditions depends on the operation of a fuse-link, the test of H.15.9 is made.

During and after each test, the temperatures shall not exceed the values specified in table 3 of 15.1 and the transformer shall comply with the conditions specified in 15.1.

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

- the printed circuit board complies with the requirements of FV1 or better according to IEC 60707;
- the interrupted conductors have not peeled by more than 2 mm on each side;
- the interruption is in a low-power circuit as described in H.15.7, and in addition the voltage over the interruption shall not exceed 50 V;
- the transformer complies with the requirements of this subclause with the interrupted conductors bridged;
- no other conductor has been loosened over a length of more than 5 mm;
- any peeled or loosened conductor does not reduce the **creepage distances** and **clearances** between **hazardous live parts** and **accessible parts** below the values specified in clause 26.

NOTE 1 – Unless it is necessary to replace components after any of the tests, the dielectric strength test of 18.3 need only be carried out after the final test on the electronic circuit.

NOTE 2 – In general, examination of the transformer and its circuit diagram will reveal the fault conditions which have to be simulated, so that testing can be limited to those cases which may be expected to give the most unfavourable result.

H.15.7 Fault conditions a) to f) specified in H.15.8 are not applied to circuits or parts of circuits where both of the following conditions are met:

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

A low-power circuit is determined as follows (an example is given in figure H.1):

The transformer is operated 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. Any point nearest to the supply at which the maximum power delivered to this resistor does not exceed 15 W at the end of 5 s is called a low-power point. The part of the circuit which is further from the supply source than a low-power point is considered to be a low-power circuit.

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

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

NOTE 2 – The power consumed by the variable resistor is measured by a wattmeter.

H.15.8 The following fault conditions are considered and, if necessary, applied one at a time. Consequential faults are taken into consideration.

- a) Short circuit of **creepage distances** and **clearances** between **live parts** of different polarity, if these distances are less than those specified in clause 26.
- b) Open circuit at the terminals of any component.
- c) Short circuit of capacitors, unless they comply with IEC 60384-14.