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Deuxième édition
Second edition
2005-09

PUBLICATION GROUPEE DE SÉCURITÉ
GROUP SAFETY PUBLICATION

**Sécurité des transformateurs, alimentations,
bobines d'inductance et produits analogues –**

**Partie 1:
Exigences générales et essais**

**Safety of power transformers, power supplies,
reactors and similar products –**

**Part 1:
General requirements and tests**



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

SAFETY OF POWER TRANSFORMERS, POWER SUPPLIES, REACTORS AND SIMILAR PRODUCTS –

Part 1: General requirements and tests

FOREWORD

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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 similar products

It has the status of a group safety publication in accordance with IEC Guide 104.

This second edition of IEC 61558-1 cancels and replaces the first edition (1997), amendment 1 (1998) and IS 01. This new edition represents a complete revision of the previous edition. The changes were necessitated by the introduction of new technology and implementation of requirements from equipment committees.

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

FDIS	Report on voting
96/224/FDIS	96/228/RVD

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

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

This second edition of Part 1 is only to be used in conjunction with parts 2 based on this edition. The parts 2 contain clauses to supplement or modify the corresponding clauses of this Part 1 in order to provide the relevant requirements for each type of transformer.

However, individual countries may wish to consider its application, to the extent reasonable, to transformers not mentioned in the parts 2, and to transformers designed on new principles.

NOTE Annex U contains the optional t_w system (marking, requirements and tests).

IEC 61558 consists of the following parts, under the general title *Safety of power transformers, power supplies, reactors and similar products*:¹⁾

- Part 1: General requirements and tests
- Part 2-1: Particular requirements for separating transformers for general use
- Part 2-2: Particular requirements for control transformers
- Part 2-3: Particular requirements for ignition transformers for gas and oil burners
- Part 2-4: Particular requirements for isolating transformers for general use
- Part 2-5: Particular requirements for shaver transformers and shaver supply units
- Part 2-6: Particular requirements for safety isolating transformers for general use
- Part 2-7: Particular requirements for transformers for toys
- Part 2-8: Particular requirements for bell and chime transformers
- Part 2-9: Particular requirements for transformers for class III handlamps for tungsten filament lamps
- Part 2-12: Particular requirements for constant voltage transformers
- Part 2-13: Particular requirements for auto-transformers for general use
- Part 2-14: Particular requirements for variable transformers (*in preparation*)
- Part 2-15: Particular requirements for isolating transformers for the supply of medical locations
- Part 2-16: Particular requirements for switch mode power supplies and transformers for switch mode power supplies (*in preparation*)

¹⁾ Some of the parts of this series published earlier appeared under the general title *Safety of power transformers, power supply units and similar* or *Safety of power transformers, power supply units and similar devices*. Future editions of these parts will be issued under the new general title indicated above.

Part 2-17: Particular requirements for transformers for switch mode power supplies

Part 2-19: Particular requirements for perturbation attenuation transformers

Part 2-20: Particular requirements for small reactors

Part 2-23: Particular requirements for transformers for construction sites

Other parts are under consideration.

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.

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

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

INTRODUCTION

This International Standard covers safety requirements for **transformers**. Where the term **transformer** is used, it covers **transformers**, **reactors** and **power supplies** where applicable.

During the development of this standard, to the extent possible, the requirements of IEC 60364 were taken into consideration, so that a **transformer** may be installed in accordance with the wiring rules contained in that standard. However, national wiring rules may differ.

This standard recognizes the internationally accepted levels of protection against the possible electrical, mechanical, and fire hazards caused by **transformers** operating under normal conditions in accordance with the manufacturer's instructions. It, also, covers abnormal conditions which may occur in practice.

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

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

The standard dealing with non-safety aspects of electromagnetic compatibility (EMC) of **transformers** is IEC 62041: *Power transformers, power supply units, reactors and similar products – EMC requirements*. However, that standard also includes tests which may subject the **transformer** to conditions involving the safety aspects.

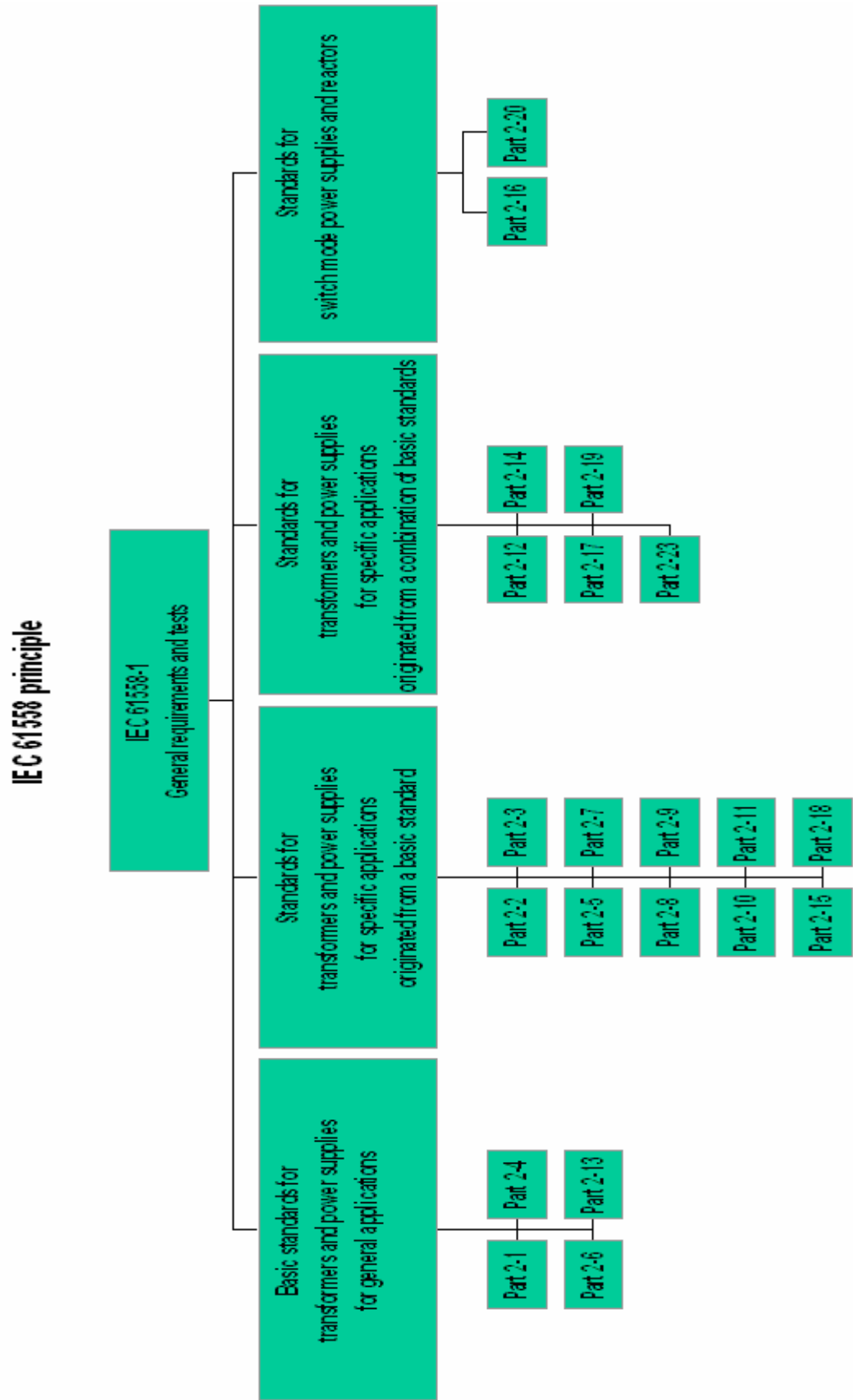
The objective of Part 1 of IEC 61558 is to provide a set of requirements and tests considered to be generally applicable to most types of **transformers**, and which can be called up as required by the relevant part 2 of IEC 61558. Part 1 is thus not to be regarded as a specification by itself for any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

Each part 2 in conjunction with Part 1 contains all the necessary requirements for the **transformer** being covered and does not contain references to other parts 2. For **transformers** with a protection index IP00 and associated **transformers**, it is possible to have circuits corresponding to different parts 2 within the same construction (e.g. SELV output circuit according to Part 2-6 and 230 V output circuit according to Part 2-4). However, if the **transformer** is covered by different parts 2 of IEC 61558, to the extent reasonable, the relevant part 2 is applied to each function/application separately. If applicable, the effect of one function on the other is taken into consideration.

If, 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 requirements of any of the clauses of a part 2 refer to Part 1 by the phrase "This clause of Part 1 is applicable", this phrase means all the requirements of that clause of Part 1 are applicable, except those requirements that are, clearly, not applicable to the particular type of **transformer** covered by that part 2.

The principle for preparation of the different parts 2 is as follows:



IEC 1269/05

Figure 0 – IEC 61558 principle

Relevant clauses of this standard (e.g. clauses dealing with thermal endurance test for windings) apply also to **transformers** forming an integral part of an appliance and which cannot be tested separately.

As an option, the thermal characteristics of **transformers** can be specified by the rated maximum operating temperature of the winding (symbol t_w) which shall not be exceeded to ensure a minimum lifetime as specified in Annex U. In addition, for **transformers** subjected to abnormal conditions as specified in Clause 15, the specified temperature limit shall not be exceeded when the **transformer** is built into an appliance or used as an independent **transformer**.

SAFETY OF POWER TRANSFORMERS, POWER SUPPLIES, REACTORS AND SIMILAR PRODUCTS –

Part 1: General requirements and tests

1 Scope

This International Standard deals with safety aspects of power **transformers**, power supplies, reactors and similar products such as electrical, thermal and mechanical safety.

This standard covers the following types of **dry-type transformers**, **power supplies**, including **switch mode power supplies**, and **reactors**, the windings of which may be encapsulated or non-encapsulated :

NOTE 1 The distinction between **transformers**, **power supplies** and **switch mode power supplies** is as follows:

- for **transformers**, there is no change in frequency .However, **transformers** (e.g. constant voltage **transformers**) may have an internal resonance frequency not exceeding 30 kHz;
- for **power supplies**, the **internal operational frequency** and waveform are different from the **supply frequency** and waveform, and the **internal operational frequency** does not exceed 500 Hz (see definition 3.1.19);
- for **switch mode power supplies**, the **internal operational frequency** and waveform are different from the **supply frequency** and waveform and the **internal operational frequency** exceeds 500 Hz and does not exceed 100 MHz.

The relevant parts 2 may be found in the introduction of this standard.

a) Stationary or portable, single-phase or poly-phase, air-cooled (natural or forced), **isolating** and **safety isolating transformers**, **independent** or **associated**, not forming a part of distribution networks and with the following characteristics:

- **rated supply voltage** not exceeding 1 000 V a.c.;
- **rated supply frequency** not exceeding 500 Hz;

and complying with the following values, unless otherwise specified in the relevant part 2:

- for **isolating transformers**:
 - **rated output** for single phase **transformers**, not exceeding 25 kVA, and for poly-phase **transformers** not exceeding 40 kVA.
 - **no-load output voltage** and the **rated output voltage** exceeding 50 V a.c., and not exceeding 500 V a.c, or 1 000 V a.c. to be in accordance with the National Wiring Rules or for a special application.
- for **safety isolating transformers**:
 - **rated output** for single phase **transformers** not exceeding 10 kVA, and for poly-phase **transformers** not exceeding 16 kVA.
 - **no-load output voltage** and the **rated output voltage** not exceeding 50 V a.c. between conductors, or between any conductor and protective earth.

NOTE 1 **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).

b) **Stationary or portable, single-phase or polyphase, air-cooled (natural or forced) separating transformers, auto-transformers, variable transformers and small reactors, independent or associated**, not forming a part of distribution networks and with the following characteristics:

- **rated supply voltage** not exceeding 1 000 V a.c.;
- **rated supply frequency** not exceeding 500 Hz;

and complying with the following values, unless otherwise specified in the relevant part 2:

- no-load output voltage or a rated output voltage for both independent and associated **transformers** not exceeding 15 kV a.c., and for independent **transformers**, a rated output voltage not less than 50 V a.c.;
- **rated output** not exceeding the following values:
 - 1 kVA for single-phase **transformers**;
 - 2 kVAR for single-phase **reactors**;
 - 5 kVA for poly-phase **transformers**;
 - 10 kVAR for poly-phase **reactors**.

NOTE 2 **Separating transformers** are used where **double** or **reinforced insulation** between circuits is not required by the installation rules or by the appliance specification.

NOTE 3 Normally, the **transformers** of type b) are intended to be associated with the equipment to provide voltages different from the supply voltage for the functional requirements of the equipment. The protection against electric shock 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 the protective earth.

c) **Stationary or portable, single-phase or polyphase, air-cooled (natural or forced), independent or associated power supplies and switch mode power supplies** incorporating one or more **transformer(s)** of type a) or b), not forming a part of distribution networks and with the following characteristics:

- **rated supply voltage** not exceeding 1 000 V a.c.;
- **rated supply frequency** not exceeding 500 Hz;
- internal operational frequency for power supplies not exceeding 500 Hz and for switch mode power supplies not exceeding 100 MHz;

and with the following values, unless otherwise specified in the relevant part 2:

- for power supplies and switch mode power supplies incorporating isolating **transformers**:
 - **rated output** for single- phase or polyphase **power supplies** or **switch mode power supplies** not exceeding 1 kVA;
 - **no-load output voltage** and the **rated output voltage** exceeding 50 V a.c. or 120 V ripple- free d.c., and not exceeding 500 V a.c. or 708 V ripple- free d.c., or 1 000 V a.c. or 1 415 V ripple- free d.c. to be in accordance with national wiring rules or for a special application;
- for **power supplies** and **switch mode power supplies** incorporating **safety isolating transformers**:
 - **rated output** for single- phase or polyphase **power supplies** and **switch mode power supplies** not exceeding 1 kVA;
 - **no-load output voltage** and **rated output voltage** not exceeding 50 V a.c. or 120 V ripple- free d.c. between conductors, or between any conductor and protective earth.

NOTE 4 **Power supplies** and **switch mode power supplies** incorporating **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).

- for **power supplies** and **switch mode power supplies** incorporating **separating transformers**, **auto-transformers**, and variable **transformers**:
 - **rated output** for single-phase or polyphase **power supplies** and **switch mode power supplies** not exceeding 1 kVA;
 - **no-load output voltage** and **rated output voltage** for both, **independent** and **associated transformers** not exceeding 15 kV a.c., and for **independent transformers**, a **rated output voltage** not less than 50 V a.c.;

NOTE 5 **Power supplies** and **switch mode power supplies** incorporating **separating transformers** are used where **double** or **reinforced insulation** between circuits is not required by the installation rules or by the appliance specification.

- d) This standard is also applicable to t_w -marked **transformers** with a rated output not exceeding 1 000 VA and where the t_w -temperature does not exceed 140 °C (t_w 140). However, t_w -marking of **transformers** is optional.

This standard also applies to **transformers**, **power supplies**, **switch mode power supplies**, and **reactors** incorporating electronic circuits.

This standard does not apply to external circuits and their components intended to be connected to the input and output terminals or socket-outlets of the **transformers**, **power supplies** and **switch mode power supplies**, and **reactors**.

NOTE 6 Attention is drawn to the following:

- for **transformers** intended to be used in vehicles, on board ships, and aircraft, additional requirements (from other applicable standards, National Rules, etc...) may be necessary;
- measures to protect the **enclosure** and the components inside the enclosure against external influences like fungus, vermin, termites, solar-radiation, and icing should also be considered;
- the different conditions for transportation, storage, and operation of the **transformers** should also be considered;
- additional requirements in accordance with other appropriate standards and national rules may be applicable to **transformers** intended for use in special environments, such as tropical environment

NOTE 7 Future technological development of **transformers** may necessitate a need to increase the upper limit of the frequencies; until then this standard may be used as a guidance document.

2 Normative references

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

IEC 60065:2001, *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, *Environmental testing – Part 2: Tests – Test FC: Vibration (sinusoidal)*

IEC 60068-2-32, *Environmental testing – Part 2: Tests – Test Ed: Free fall*

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

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

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

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

IEC 60112:2003, *Method for the determination of the proof and the comparative tracking indices of solid insulating materials*

IEC 60127-3, *Miniature fuses – Part 3: Sub-miniature fuse-links*

IEC 60216 (all parts), *Electrical insulating materials – Properties of thermal endurance*

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

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

IEC 60269 (all parts), *Low voltage fuses*

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

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

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

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

IEC 60317 (all parts), *Specifications for particular types of windings wires*

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

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

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IEC 60417-DB:2002²⁾, *Graphical symbols for use on equipment*

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

²⁾ "DB" refers to the IEC on-line database.

IEC 60454 (all parts), *Specification for pressure-sensitive adhesive tapes for electrical purposes*

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IEC 60695-2-10, *Fire hazard testing – Part 2-10: Glowing/hot-wire based test methods – Glow-wire apparatus and common test procedure*

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IEC 60730 (all parts), *Automatic electrical controls for household and similar use*

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IEC 60851-3:1996, *Winding wires – Test methods: Part 3: Mechanical properties*

IEC 60851-5:1996, *Winding wires – Test methods: Part 5: Electrical properties*

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

IEC 60898 (all parts), *Electrical accessories – Circuit-breakers for overcurrent protection for household and similar installations³⁾*

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

IEC 60906-3, *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, *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*

³⁾ IEC 60898-2 is published under the general title *Circuit-breakers for overcurrent protection for household and similar installations* (i.e. without the element of “Electrical accessories” in the title).

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

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

IEC 60999-1, *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 61032:1997, *Protection of persons and equipment by enclosures - Probes for verification*

IEC 61058-1:2000, *Switches for appliances – Part 1: General requirements*

IEC 61140: *Protection against electric shock – Common aspects for installation and equipment*

ISO 4046-4:2002, *Paper, board, pulp and related terms – Vocabulary*

ISO 8820 (all parts), *Road vehicles – Fuse-links*

3 Terms and definitions

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

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.

Unless otherwise specified, the terms “voltage” and “current” imply the r.m.s. values of alternating voltage and current, and for direct voltage and current, they imply the corresponding arithmetic mean values.

“Ripple-free” is conventionally an r.m.s. ripple voltage not more than 10 % of the d.c. component.

An index of often used terms and definitions” is provided at the end of this document.

3.1 Transformers

3.1.1

(power) transformer

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 The term frequency also implies that the waveform remains the same.

3.1.2

isolating transformer

transformer with **protective separation** between the **input winding(s)** and **output winding(s)**

3.1.3**safety isolating transformer**

isolating transformer designed to deliver **SELV** (safety extra-low voltage) or **PELV** (protective extra-low voltage)

3.1.4**separating transformer**

transformer with **input winding(s)** separated from the **output winding(s)** by at least **basic insulation**

3.1.5

Void

3.1.6**associated transformer**

transformer designed to supply a specific appliance or equipment, or a part of them, and being either an **incorporated transformer** or a **transformer for specific use**

3.1.6.1**incorporated transformer**

associated transformer designed to be built into a specific appliance or equipment, or into a part of them, and the **enclosure** of which provides protection against electric shock

3.1.6.2**transformer for specific use**

associated transformer fixed to or delivered with the appliance or equipment, without being incorporated in this appliance or equipment and having its own **enclosure** which provides protection against electric shock

3.1.7**independent transformer**

transformer designed to supply unspecified appliances and intended to be used without any additional **enclosure** which provides protection against electric shock

NOTE Such a **transformer** can be either a portable **transformer** or a stationary **transformer**.

3.1.8

Void

3.1.9**short-circuit proof transformer**

transformer not exceeding the specified temperature limits when overloaded or short-circuited, and which continues to meet all the requirements of this standard after removal of the overload or short-circuit and is not required to operate continuously under short-circuit or overload condition

NOTE "Continues to meet all the requirements of this standard" does not imply that all types of short-circuit proof **transformers** continue to operate.

3.1.9.1**non-inherently short-circuit proof transformer**

short-circuit proof transformer equipped with a protective device or with an intentional weak part 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 continues to meet all the requirements of this standard after removal of the overload or short circuit

3.1.9.1.1**non-inherently short-circuit proof transformer with resettable, self-resetting or replaceable protective device**

short-circuit proof transformer equipped with a protective device which after resetting or replacing continues to operate

NOTE Examples of self-resetting or non self-resetting protective devices are fuses, **overload relays**, thermal fuses, thermal links, **thermal cut-outs** and PTC resistors and automatic break-off mechanical devices.

3.1.9.1.2**non-inherently short-circuit proof transformer with non-self-resetting or non-replaceable protective device**

short-circuit proof transformer equipped with a non-self-resetting or non-replaceable protective device or with a non-replaceable intentional weak part, which continues to meet all the requirements of this standard after removal of the overload or short circuit, but does not continue to operate after the overload or short-circuit is removed

3.1.9.2**inherently short-circuit proof transformer**

short-circuit proof transformer not equipped with any device for protection against overload or short circuit. The **transformer** by construction does not exceed the specified temperature limits, and 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**

transformer intended to be protected against excessive temperature by means of a protective device, not provided with but stated on the **transformer**, and which continues to meet all the requirements of this standard after the removal of the overload or short circuit and, if applicable, after resetting or replacing the protective device

3.1.11**fail-safe transformer**

transformer equipped with a protective device or with an intentional weak part, which permanently fails to function by the interruption of the **input circuit** when the **transformer** is overloaded or short-circuited, but presents no danger to the user or surroundings. It continues to meet all the requirements of this standard after removal of the overload or short circuit .

NOTE "Continues to meet all the requirements of this standard" does not imply that the fail-safe **transformer** continues to operate, After failing it fulfils the dielectric strength test based on 35 % of the original values (see 15.5).

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 or being a plug-in **transformer**

3.1.13**flush-type transformer**

transformer designed to be mounted in a flush-type mounting box

3.1.14**fixed transformer**

transformer intended to be used while fastened to a support in a position which may be specified by the manufacturer

3.1.15**stationary transformer**

either a **fixed transformer** or a **transformer** having a mass exceeding 18 kg and provided with no carrying handle(s)

3.1.16**hand-held transformer**

portable **transformer** intended to be held in the hand during normal use

3.1.17

void

3.1.18**dry-type transformer**

transformer incorporating non-liquid dielectric media, and the windings may be impregnated or encapsulated

3.1.19**power supply**

electronic device incorporating **transformer(s)** and electronic circuitry(ies), that converts electrical power into single or multiple power outputs. It may also isolate the **input circuit** from the **output circuit**, and regulate and/or convert the output voltage and current. The device may consist of one or more individual units with identical or different waveforms and frequencies including d.c. output, and the **internal operating frequency** and waveform are different from the supply frequency and waveform and the **internal operating frequency** does not exceed 500 Hz

3.1.20**switch mode power supply**

electronic device incorporating **transformer(s)** and electronic circuitry(ies), that converts electrical power into single or multiple power outputs. It may also isolate the **input circuit** from the **output circuit**, and regulate and/or convert the output voltage and current. The device may consist of one or more individual units with identical or different waveforms and frequencies including d.c. output, and the **internal operating frequency** and waveform are different from the supply frequency and waveform and the **internal operating frequency** does exceed 500 Hz, but not exceed 100 MHz

3.1.21**reactor**

arrangement comprising one or more windings with an impedance depending on the frequency, working in accordance with the principle of self-induction whereby a magnetising current generates a magnetic field through a magnetically effective core or through air

NOTE **Reactors** with toroidal core are also included in this definition

3.2 General terms**3.2.1****external flexible cable or cord**

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**

method of attachment enabling easy replacement of the ordinary or especially prepared cable or cord;

– **type Y attachment**

method of attachment intended to be replaced only 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**

method of attachment preventing replacement of the flexible cable or cord without breaking or destroying a part of the **transformer**.

3.2.2

power supply cord

external flexible cable or cord used to supply the **input circuit**

NOTE **Power supply cords** are:

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

3.2.3

connecting leads

lead connecting the end of a winding to the terminal of the **transformer**

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

3.2.4

body

accessible **conductive parts**, shafts, handles, knobs, grips and the like, accessible metal fixing screws and metal foil applied on accessible surfaces of insulating material

3.2.5

accessible part

parts which may be touched with the standard test finger after correct installation of the **transformer**

3.2.6

detachable part

part which can be removed without the aid of a **tool**

3.2.7

non-detachable part

part which can be removed only with the aid of a **tool**

3.2.8

tool

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

3.2.9

enclosure

part providing protection of the **transformer** against certain external influences and, in any direction, protection against direct contact

(IEV 826-03-12:1982)

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

3.2.10**intermediate conductive part**

non-accessible conductive part situated between **hazardous live parts** or the **body** and other hazardous live part

3.2.11**conductive part**

metal parts and non metal parts having a degree of conductivity equivalent to metal parts

3.2.12**electronic component**

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

NOTE Neon indicators are not considered to be electronic components

3.2.13**electronic circuit**

circuit incorporating at least one electronic component

3.2.14

void

3.2.15**electrical separation**

separation between conductive parts by means of air and/or solid insulation

3.3 Operations and protections**3.3.1****all pole disconnection**

disconnection of all supply conductors by a single switching action

NOTE 1 **protective earth 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**

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**

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**

thermal cut-out requiring manual resetting or replacement of a part to restore the current

3.3.5**thermal-link**

thermal cut-out which operates only once

3.3.6**overload relay**

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**intentional weak part**

part other than overload protective device (fuses, circuit-breaker, thermal cut-outs, ...) intended to rupture under conditions of abnormal operation to prevent the occurrence of a condition which could impair compliance with this standard. Such a part may be a replaceable component, such as a resistor or a capacitor or a non_replaceable part of a component such as an inaccessible weak point in a winding

3.3.8**working voltage**

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

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 On three phase systems the **working voltage** can be different from the nominal voltage

3.3.9**short-circuit voltage**

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**.

3.3.10**duty-type**

continuous or conventional periodic duty consisting of one or more sets of loads remaining constant for the durations specified

3.3.10.1**continuous duty**

operation for an unlimited period

3.3.10.2**short-time duty cycle**

operation for a specified period, starting from cold, the intervals between each period of operation being sufficient to allow the **transformer** to cool down to approximately ambient temperature

3.3.10.3**intermittent duty cycle**

operation in a series of specified identical cycles

3.3.11**protective earth conductor****PE**

conductor provided for purposes of safety, for example protection against electric shock

(IEV 195-02-09)

3.4 Circuits and windings

3.4.1

input circuit

circuit intended to be connected to the supply consisting of the **input winding** and the **internal circuits**

3.4.2

output circuit

circuit to which the distribution circuit, appliance or other equipment is to be connected, consisting of the **output winding** and the **internal circuits**

3.4.3

input winding

winding of the **input circuit**

3.4.4

output winding

winding of the **output circuit**

3.4.5

internal circuit

circuit which consists of components, interconnections and connections to the terminals and the windings, excluding protective earth circuit

3.4.6

insulated winding wire

wire with an insulation meeting the requirements of Annex K for use in windings

3.5 Ratings

3.5.1

rated supply voltage

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

supply voltage range assigned to the **transformer** by the manufacturer, expressed by its lower and upper limits

3.5.3

rated frequency

frequency assigned to the **transformer** by the manufacturer for the specified operating conditions of the **transformer**

3.5.3.1

rated supply frequency

frequency on the input of the **transformer** assigned by the manufacturer

NOTE The supply frequency is the frequency of the mains.

3.5.3.2

internal operational frequency

highest internal frequency assigned by the manufacturer as the operating frequency of a **transformer** or other components built into a **power supply**

3.5.4**rated output current**

output current at **rated supply voltage**, **rated supply frequency** and **rated output voltage**, at **rated power factor**, assigned to the **transformer** by the manufacturer for the specified operating conditions of the **transformer**

3.5.5**rated output voltage**

output voltage (for polyphase supply, the phase-to-phase voltage) at **rated supply voltage**, **rated supply 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**

power factor assigned to the **transformer** by the manufacturer for the specified operating conditions of the **transformer**

3.5.7**rated output**

product of the **rated output voltage** and the **rated output current** or, for three-phase **transformers**, $\sqrt{3}$ times the product of the **rated output voltage** and the **rated output current**. 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 **output circuits** intended to be loaded simultaneously

3.5.8**rated ambient temperature** t_a

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.

3.5.9**rated minimum ambient temperature** t_{amin}

minimum temperature at which the **transformer** may be operated continuously under normal conditions of use

3.5.10 t_w

rated maximum operating temperature of a **transformer** winding, the winding temperature being assigned by the manufacturer as the highest temperature at which the **transformer** may be expected to have a specified service life during **continuous operation**

3.6 No-load values**3.6.1****no-load input**

input of the **transformer** when connected to **rated supply voltage** at **rated supply frequency**, with no load on the output

3.6.2

no-load output voltage

output voltage when the **transformer** is connected to **rated supply voltage** at **rated supply frequency**, with no load on the output

3.7 Insulation

3.7.1

basic insulation

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

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

[IEC 61140, definition 3.10.1, modified]

3.7.2

supplementary insulation

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**

[IEC 61140, definition 3.10.2, modified]

3.7.3

double insulation

insulation comprising **basic insulation** plus **supplementary insulation**

[IEC 61140, definition 3.10.3, modified]

3.7.4

reinforced insulation

single insulation system applied to **hazardous live parts**, which provides a degree of protection against electric shock equivalent to **double insulation**

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**.

[IEC 61140, definition 3.10.4, modified]

3.7.5

class I transformer

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 a protective earth terminal, are provided for the connection of accessible **conductive parts** to the **protective earth 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

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 earth 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 **conductive parts**, with the exception of small **conductive 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 a protective earth terminal, it is deemed to be of **class I** construction.

NOTE 6 A **class II transformer** may be provided with functional earth circuit.

3.7.7

class III transformer

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

shortest distance in air between two **conductive parts**

(IEC 60664-1, definition 1.3.2)

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

shortest distance (through air) along the surface of an insulating material between two **conductive parts**

(IEC 60664-1, definition 1.3.3, modified)

NOTE For the purpose of determining a **creepage distance** from **transformer conductive parts** 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

(IEC 60664-1, definition 1.3.11)

3.7.11

micro-environment

immediate environment of the insulation, which particularly influences the dimensioning of the **creepage distances** or **clearances**

(IEC 60664-1, definition 1.3.12.2, modified)

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**

degrees of pollution in the **micro-environment** established for the purpose of evaluating **clearances** and **creepage distances**

3.7.12.1**pollution degree 1****P1**

pollution degree in which no **pollution** or only dry, non-conductive **pollution** occurs. The **pollution** has no influence

3.7.12.2**pollution degree 2****P2**

pollution degree in which only non-conductive **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**

pollution degree in which conductive **pollution** occurs, or dry non-conductive **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**) (based on definition 3.24 of IEC 61140)

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 earth conductor (based on definition 3.22 of IEC 61140)

3.7.15**ELV (extra-low voltage)**

voltage which does not exceed 50 V a.c. or 120 V ripple free d.c. between conductors, or between any conductor and earth (voltage band 1 of IEC 60449)

3.7.16**SELV (safety extra low voltage)**

ELV in a circuit which is isolated from the mains supply 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 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**

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 (protective extra low voltage)**

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 (functional extra low voltage)**

ELV circuit having the **ELV** voltage for functional reasons and not fulfilling the requirements for **SELV** or **PELV**

3.7.20**live part**

conductor or conductive part intended to be energised in normal operation, including a neutral conductor, but by convention not a PEN conductor or PEM conductor or PEL conductor

[IEV 195-02-19]

NOTE 1 This concept does not necessarily imply a risk of electric shock.

NOTE 2 For definitions of PEM and PEL see IEC 195-02-13 and 195-02-14

3.7.21**hazardous live part**

live part which, under certain conditions, can give a harmful electric shock

[IEV 195-06-05]

NOTE In case of high voltage, a hazardous voltage may be present on the surface of solid insulation. In such a case, the surface is considered to be a **hazardous live part**

[IEC 61140, definition 3.5].

3.7.22**functional insulation**

insulation between parts of different potential which, in general, is necessary only for the proper functioning of the **transformer**.

NOTE 1 For **transformers**, proper functioning may have influence on the safety. **Functional insulation** is checked by the requirements of this standard but additional requirements may exist in parts 2.

NOTE 2 **Functional insulation** is only applicable inside the windings between turns of the same winding.

3.8 Touch current and protective earth conductor current**3.8.1****touch current**

electric current passing through a human body or through an animal body when it touches one or more accessible parts of an installation or of equipment

(IEV 195-05-21)

3.8.2

protective earth conductor current

current which flows in a protective earth conductor

NOTE This current may have influence on the operation of RCD's (residual current protection devices) connected in the same circuit.

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 careless use as may occur in normal service.

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

4.2 When **associated transformers** 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.

*If a **transformer** is tested under the conditions present in the appliance or equipment for which it is intended, it shall comply with the following clauses or subclauses thereof of this 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 – except for the requirements in Table 1 starting with the first: "external enclosures"..., 14.2 – 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 8a – 18.4 – 19.1 – 19.12 – 20.9 – 26.1 – 26.2 – 26.3 – Annexes A, C, D, G, L, M, N, P.

Other clauses shall be taken from the relevant product standard. If the product standard does not fully cover the remaining clauses, the corresponding missing clauses of this **transformer** standard shall be used instead.

5 General notes on tests

5.1 Tests according to this standard are:

- type tests (defined from 8.15, and Clause 9 through Clause 28);
- routine tests (defined 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, 16.4 and 26.2, the number of specimens is one for all **rated outputs**.

If the tests of 14.3 need to be performed, three additional specimens shall be used. Three more specimens are required if the tests need to be repeated.

If the tests of 15.5 need to be performed, three additional specimens shall be used. These specimens are used only for the tests of 15.5.

If the tests of 16.4 need to be performed, they are carried out on four additional specimens.

If the tests of 26.2 need to be performed, they are carried out on three additional specimens.

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

*For testing a series of **transformers**, see Annex B.*

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

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

NOTE 2 In case of non-replaceable and non-resettable protective devices the compliance is checked on a specially prepared specimen.

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 sinusoidal wave form, and, if not otherwise specified, have a frequency of 50 Hz or 60 Hz.

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

5.7 As far as possible, measurements are made with instruments which do not appreciably affect the values to be measured; if necessary, corrections shall be 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 conductive parts which are not connected to a protective earth terminal or protective earth contact, and are not separated from **hazardous live parts** by an **intermediate conductive part** which is connected to a protective earth terminal or protective earth 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-mount 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 painted dull black, and 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 Void

5.13 **IP00 transformers** with unknown end application, are tested without adding an **enclosure**.

For these **transformers**, the requirements of Clauses 9 and 17 are not applicable.

5.14 **IP00 transformers**, with known end application, are mounted and tested in accordance with the manufacturer's instructions.

5.15 The tests in Clauses 18 and 26 are based on an elevation of 2 000 m above sea level. If tested in elevations in excess of 2 000 m above sea level, Annex A of IEC 60664-1 applies.

6 Ratings

Ratings are indicated in the relevant part 2 for different types of **transformers** and in Annex U for **t_w** marked **transformers**.

7 Classification

7.1 Transformers are classified:

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 code) except IP1X

NOTE 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 duty type:

- **continuous duty;**
- **short-time duty cycle;**
- **intermittent duty cycle.**

7.6 According to the intended use:

7.6.1 Associated

- **incorporated;**
- **for specific use.**

7.6.2 Independent

7.7 Optionally (only for t_w marked **transformers**), according to the rated maximum operating temperature of the winding, t_w , and corresponding estimated life expectancy under specified conditions

- t_{w5} for 5 years continuous operation
- t_{w10} for 10 years continuous operation
- t_{wn} where n stands for number of years other than the above

7.8 According to the environmental conditions where they are intended to be used:

- normal environment
- special environments (e.g. arctic, etc.)

8 Marking and other information

8.1 Transformers shall be marked with the:

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

Transformers having a range of rated values and able to operate 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 between 115 V and 230 V.

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 1: 115 V / 230 V: the **transformer** is only suitable for 115 V or 230 V (e.g. a **transformer** with a selector switch or different sets of terminals).

NOTE 3 Example 2: 230 V/400 V: The **transformer** is only suitable for 230 V or 400 V where 230 V is for single-phase operation and 400 V for three-phase operation (e.g., 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, or the output voltage before the rectifier shall be expressed as an r.m.s. value.

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 volt-amperes reactive or kilovolt-amperes reactive for reactors;

NOTE 5 For **transformers** incorporating a rectifier, the **rated 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 supply frequency(ies) in hertz;

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

- g) symbol or abbreviation AC for alternating current or DC for direct current output;

- h) symbol indicating the kind of **transformer** as indicated in the relevant part 2; if an IP00 **transformer** or and **associated transformers** have circuits corresponding to different parts 2 in the same construction (e.g. **SELV output circuit** according to Part 2-6 and 230 V **output circuit** according to Part 2-4) the relevant symbols have to be used.

- 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

- 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) **rated minimum ambient temperature** t_{amin} , if lower than + 10 °C and if a temperature sensitive device is used.

NOTE 7 It is recommended that the values of t_{amin} are given in steps of 5 °C.

- q) **duty cycle**, if any, 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 duty cycle** or **intermittent duty cycle** shall correspond to normal use. The operating time for **transformers** with short-time duty shall be expressed in seconds (s) or minutes (min); the operating time and the resting time of **transformers** with intermittent duty cycle shall be expressed in seconds (s) or minutes (min), separated by an oblique stroke;
- r) declared values of the rated maximum operating temperature of the winding, increase in multiples of 5 °C and indication of the rated life expectancy, for t_w -marked **transformers** only
- s) **transformers** to be used with forced air cooling where the fan is not a part of the **transformer** shall be marked with “AF” followed by the air speed, expressed in m/s.
- t) 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 8 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 9 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 provided in the data sheets of the **transformer** or in the manufacturer's instruction sheet..

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

This information shall enable replacement of the original **transformer** with an equivalent **transformer**.

NOTE 2 Equivalent implies electrically, mechanically, dimensionally and functionally interchangeable.

8.3 If the **transformer** can be adjusted for different **rated supply voltages**, the adjusted voltage 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; if the **rated output** for all tapings or windings is the same, at least one tapping or winding shall be marked.

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

8.5 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 protective device, and/or the ratings of the protective device.

NOTE 1 In addition, a symbol in accordance with Annex V can be used.

NOTE 2 **Non-inherently short-circuit proof transformers** with non-replaceable protective devices need no additional marking regarding the protective device.

The marking shall contain sufficient information to ensure proper replacement of the protective device.

When replaceable protective devices other than fuses are used, appropriate information about their replacement shall be provided in an instruction sheet or the equivalent accompanying the **transformer**.

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

Protective earth terminals shall be identified 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 Transformer 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 following information or the equivalent:








- 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** shall be scrapped".



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

8.10 Class II transformers shall be marked with the graphical symbol IEC 60417-5172 (DB:2002-10) placed adjacent to the supply information (e.g. on the rating plate), such that it is obvious the symbol is part of the technical information and can in no way be confused with the manufacturer's name or any other identification (see 7.2.3 of IEC 61140).

Class II transformer with parts to be mounted, shall be delivered with all parts which make them class II after mounting according to the mounting instruction of the manufacturer and shall be marked with the class II symbol. Moreover, if the **transformer** can be mounted without the covers (e.g. on a distribution box), the marking for class II shall be placed on a part which, effectively, provides the class II characteristics (e.g., on a cover for terminal to connect to the supply).

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

Symbol or graphical symbol	Explanation or title	Identification
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	IEC 60417-5031 (DB:2002-10)
N	Neutral	
	Alternating current	IEC 60417-5032 (DB:2002-10)
3~	Three-phase alternating current	IEC 60417-5032-1 (DB:2002-10)
3/N~	Three-phase alternating current with neutral conductor	IEC 60417-5032-2 (DB:2002-10)
cos φ	Power factor	
	Class II equipment	IEC 60417-5172 (DB:2003-02)
	Class III equipment	IEC 60417-5180 (DB:2003-02)
	Fuse (add symbol for time-current characteristics)	IEC 60417-5016 (DB:2002-10)
t_a	Rated maximum ambient temperature	
	Frame or chassis (or core terminal)	IEC 60417-5020 (DB:2002-10)
	Protective earth (ground)	IEC 60417-5019 (DB:2002-10)
IPXX	IP number**	

Symbol or graphical symbol	Explanation or title	Identification
	Earth (ground or functional earth)	IEC 60417-5017 (DB:2002-10)
	indoor use only	IEC 60417-5957 (DB:2004-12)
$t_{w5} \text{ } yyy,$	For t_w marked transformer only with 5 years life expectancy yyy= Rated maximum operating temperature	
$t_{w10} \text{ } yyy,$	For t_w marked transformer only with 10 years life expectancy yyy= Rated maximum operating temperature	
$t_{wx} \text{ } yyy,$	For t_w marked transformer only where x= life expectancy yyy= Rated maximum operating temperature	
<p>* Multiple or submultiples are allowed (e.g. kV, mA...).</p> <p>** 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.</p>		

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 numbers 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 the 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 the 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 the 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.

8.14 Information shall be provided when it is necessary to take special precautions for installation or use (in the catalogue, data sheet or instruction sheet):

- **non-inherently short-circuit proof transformer with non-self-resetting or non-replaceable protective device** and non-replaceable intentional weak parts shall have an information explaining the protective devices cannot be resetted or replaced after a short-circuit or an overload;

- for **transformers** generating a **protective earth conductor current** greater than 10 mA and are intended for permanent connection, the **protective earth conductor current** shall be clearly stated in the instruction and indication shall be given that the installation shall be made according to the wiring rules;
- for **associated transformers** and IP00 **transformers**, an informative note shall indicate that a 10 % over or under voltage may appear in the supply and the **rated output** of the **transformer** shall be selected accordingly;
- 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**;
- the limiting temperature of the winding under abnormal conditions which shall be respected when the **transformer** is built into an appliance as information for appliance design;
- for t_w **transformers**, the specified constant S other than 4 500, the symbol S together with its appropriate value in thousands, (e.g., "S6", if S has a value of 6 000);
NOTE Preferred values of S are: 4 500, 5 000, 6 000, 8 000, 11 000 and 16 000;
- for **transformers** not designed for series and/or parallel connection with more than one output winding, that the **transformer** is not intended for series/parallel connection.

Compliance with the requirements of 8.1 to 8.14 is checked by inspection.

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 an aromatic content of 0,1 % maximum, by 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 electric shock

Transformers shall be enclosed and provided with adequate protection against contact with **hazardous live parts** and shall have no risk of an electric shock from stored charge on capacitors.

Compliance is checked by inspection and by the tests of 9.1.1, 9.1.2 and 9.2.

9.1 Protection against contact with hazardous live parts

9.1.1 Determination of hazardous live parts

A **live part** is not a **hazardous live part** if it is separated from the supply by **double** or **reinforced insulation** and the requirements of 9.1.1.1 or 9.1.1.2 are met when **the transformer** is supplied at **rated supply voltage**.

9.1.1.1 The voltage shall not exceed 35 V a.c. peak or 60 V ripple free d.c.

Compliance is checked by measurements carried out between any two conductive parts.

9.1.1.2 Where the voltage exceeds 35 V (peak) a.c. or 60 V ripple free d.c., the touch-current shall not exceed:

- for a.c.: 0,7 mA (peak)
- for d.c.: 2,0 mA.

Compliance is checked by measuring the touch current as stated in Annex J.

*In addition, when a capacitor is connected to the **live parts**:*

9.1.1.2.1 The discharge shall not exceed 45 μC for stored voltages between 60 V and 15 kV, or

9.1.1.2.2 The energy of discharge shall not exceed 350 mJ for stored voltages exceeding 15 kV.

Compliance of 9.1.1.2.1 and 9.1.1.2.2 is checked by measurements carried out with a load of 2 000 Ω .

9.1.2 Accessibility to hazardous live parts

Transformers shall be constructed to provide adequate protection against accessibility to **hazardous live parts**.

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

For **class I transformers**, accessible parts shall be separated from **hazardous live parts** by at least **basic insulation**.

Class II transformers shall be so constructed and enclosed that there is adequate protection against accessibility to **basic insulation** and to **conductive parts** separated from **hazardous live parts** by **basic insulation** only. Only parts separated from **hazardous live parts** by **double** or **reinforced insulation** may be accessible.

Hazardous live parts shall not be accessible after removal of detachable parts except for:

- lamps having caps larger than B9 and E10
- type D fuse-holders.

NOTE 1 IP00 **transformers** shall comply with the end product standard after incorporation in the end product.

The insulating properties of lacquer, enamel, paper, cotton, oxide film on conductive parts and sealing compound shall not be considered as giving the required protection against accidental contact with **hazardous live parts**.

NOTE 2 Self-hardening resins can be relied upon to give the required protection against accidental contact with **hazardous live parts**.

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

Compliance is checked by inspection and by the relevant tests of IEC 60529.

*In addition, openings in **class II transformers**, and openings in **class I transformers** other than those in **conductive parts** connected to a protective earth 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 conductive parts separated from **hazardous live parts** by **basic insulation** only with the test finger.*

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

NOTE 3 This requirement does not apply to lamp caps or socket-outlets.

NOTE 4 In case of doubt, an electrical contact indicator, with a voltage not less than 40 V, is used with a test pin.

9.1.3 Accessibility to non hazardous live parts

Non **hazardous live parts** of the **output circuit** isolated from the **input circuit** by **double** or **reinforced insulation** may be accessible under the following conditions:

- for **no-load output voltages** not exceeding 35 V peak a.c. or 60 V ripple-free d.c., both poles may be accessible.
- for **no-load output voltages** exceeding 35 V peak a.c. or 60 V ripple-free d.c. and not exceeding 250 V a.c., only one of the poles may be accessible.

9.2 Protection against hazardous electrical discharge

For **transformers** with a primary supply plug, the pins of the plug shall not be **hazardous live** measured 1s after withdrawal of the plug.

For **transformers** without a primary supply plug, the terminals provided for connecting the **transformer** to the supply source shall not be **hazardous live** measured 5 s after disconnection of the supply source.

NOTE 1 For the purpose of this subclause, plug connectors and appliance inlets are regarded as mains plugs.

Compliance is checked by the following test:

If the nominal capacitance across the pins does not exceed 0,1 μ F, no test is conducted.

*The primary supply switch of the **transformer**, if any, is in the off-position, unless it is more unfavourable in the on-position.*

The test shall be carried out 10 times or with a device used to switch off at the most unfavourable electrical angle of the supply voltage.

The voltage is measured between the input terminals or between the supply leads or between the pins of the supply plug used for the connection to the supply source after 1 s or 5 s.

If the voltage exceeds 60 V ripple free d.c., the discharge is measured in the same conditions and shall not exceed 45 μ C.

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**.

NOTE As an example, the requirement concerning the voltage setting is met if a **tool** is needed to remove a cover before the voltage setting can be changed.

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

Plug connected **transformers** provided with a device to select the input connections (e.g. by tapings) to adjust supply voltages within a range of not more than 10 % of the value corresponding with the midpoint of that range, are not considered to be **transformers** with more than one supply voltage.

Plug connected **safety isolating transformers** shall have only one **rated supply voltage** unless the **transformer** is not capable of producing an output voltage in excess of the limits allowed in the scope if the higher marked voltage is connected to the lower voltage winding.

Compliance is checked by measurement and inspection.

11 Output voltage and output current under load

11.1 When the **transformer** is connected to the **rated supply voltage**, at the **rated supply frequency**, and loaded with an impedance resulting in the **rated output** at the **rated output voltage** and, for a.c. current, at the **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, with the **transformer** connected to the **rated supply voltage**, at the **rated supply frequency**, and loaded with an impedance resulting in the **rated output**, at the **rated output voltage** and the **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 the **rated output**, the **rated output voltage**, the **rated output current**, and the **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 requirements for the **no-load output voltage** limitation are given in the parts 2 for the different types of **transformers**.

*For **transformers** incorporating a rectifier, the output voltages are measured at the input and output terminals 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 **short-circuit voltage** marking, the **short-circuit voltage** measured shall not deviate by more than 20 % from the value marked.

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

14 Heating

14.1 General requirements

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

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 conducted at $t_a \pm 5$ °C.*

NOTE 1 The heating test is carried out taking into consideration only the t_a (and not t_{amin}).

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 2 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 supplied at the **rated supply voltage** and loaded with an impedance producing the **rated output**, at the **rated output voltage** and, for a.c. current, at the **rated power factor**. The value of the output current is measured when steady state is established. Then the supply voltage is increased by 10 % and the output current is adjusted to the same value measured before. The output current is not adjusted for **independent transformer**. After this 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 as indicated in the relevant specifications. **Transformers** with intermittent ratings shall be tested at the intermittent ratings, until steady state conditions are established.

The temperatures of windings are determined by the change of resistance method.

NOTE 3 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 equals $\Delta t + t_2$;

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 the 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 ambient temperature shall not vary by more than 10 °C during the test. For **t_a transformers** the test temperature equals $\Delta t + t_a$.*

*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 **conductive parts**, or a reduction of **creepage distances** or **clearances** below the values specified in Clause 26. In addition, thermocouples shall be placed at the hottest points of the insulating material to avoid a risk of fire.*

*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 ^a	Temperature °C
Windings, if the insulation system (i.e., bobbins and any other insulating materials that are in contact with the windings) is:	
– of class A ^b	100
– of class E ^b	115
– of class B ^b	120
– of class F ^b	140
– of class H ^b	165
– of other classes ^c	–
External enclosures ^d (which can be touched with the standard test finger) of stationary transformers , if of:	
– metal	70
– other material	80
External enclosures ^d (which cannot be touched with the standard test finger) of stationary transformers	85
External enclosures ^d , 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 ^e :	
– of rubber	65
– of polyvinyl chloride	70
Parts the deterioration of which could affect safety ^e :	
– 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 circuit boards ^e):	
– bonded with phenol-formaldehyde, melamine-formaldehyde, phenol-furfural or polyester	105
– bonded with epoxy	140

Table 1 (continued)

- ^a If other materials are used, they shall not be exposed to temperatures in excess of those which have been proved permissible for these materials.
- ^b The 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.
- ^c If other insulating materials than those covered by IEC 60085 and IEC 60216 are used, the insulation system shall withstand the test of 14.3.
- ^d 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**.
- ^e The grades of rubber and polyvinyl chloride insulation are those covered by IEC 60245 and IEC 60227, respectively.

The temperature rise on the heating elements of protective devices touching insulating material shall also be measured.

*Immediately after the test, the specimen shall withstand a dielectric strength test as specified in 18.3, the values are specified in Table 8a and the test voltage being applied between **input** and **output circuits** only.*

*During and after the test, the electrical connections shall not be loose, **creepage distances** and **clearances** shall not be reduced to less than the values specified in Clause 26, sealing compound shall not melt, and overload protective devices shall not operate.*

14.2 Application of 14.1 or 14.3 according to the insulation system

The following apply to the windings.

14.2.1 *If the manufacturer has stated which class of insulation system has been used, the measured temperature of the winding shall not exceed the relevant value given in Table 1 (considering t_a if stated).*

14.2.2 *If the manufacturer has not stated which class of insulation system has been used the measured temperature of the winding shall not exceed the value given in Table 1 for class A insulation system (considering t_a if stated).*

14.2.3 *If the manufacturer has not stated which class of insulation system has been used and the measured temperature of the winding exceeds the value given in Table 1 for class A insulation system (considering t_a if stated), the **live parts** of **transformers** (core and windings) are subjected 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.*

14.3 Accelerated ageing test for undeclared class of insulation system

*When applicable (see 14.2, 19.12.3 and 26.3), the **live parts** of the transformer (core and windings) are subjected to the following ageing test, each cycle consisting of a heat run, vibration, and a moisture treatment. Measurements are made according to 14.3.4.*

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 system, the specimens are kept in a heating cabinet for the combinations of time and temperature recommended by the manufacturer in accordance with 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	Testing time for the thermal class of the insulation system (days)				
	100 °C	115 °C	120 °C	140 °C	165 °C
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

After the heat tests, the specimens are allowed to cool down to ambient temperature before the vibration is conducted.

14.3.2 Vibration

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.

14.3.3 Moisture treatment

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

14.3.4 Measurements

All the following measurements and tests are made and conducted before the cycling and after each complete cycle:

- the no-load input current or its ohmic value.

The no-load input current or the ohmic component of the no-load input current shall not be more than 30 % greater than the corresponding value obtained during the initial measurement;

- *the insulation resistance is measured according to 18.1 and 18.2;*
- *a dielectric strength test according to 18.3 and 18.4. However, the values of the test voltages are reduced to 35 % of the specified values and the testing time is doubled;*
- *the following test only for **transformers** with a **rated supply frequency** of 50 Hz or 60 Hz. After the dielectric strength test, one **input circuit** is supplied by a test voltage of at least 1,2 times the **rated supply voltage** at double the **rated supply 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 than the double supply frequency may be used; the duration of the period of connection, in minutes, being equal to 10 times the **rated supply frequency** divided by the test frequency, but not less than 2 min.*

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

*If, after the completion of all 10 cycles, one or more specimens fail, the **transformer** is considered as not having complied with the accelerated ageing test.*

15 Short circuit and overload protection

15.1 General

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 14.1 at the same ambient temperature, and without changing the position of the **transformer**, at 1,1 times the **rated supply voltage**, or, for **non-inherently short-circuit proof transformers**, at any value of the supply voltage between 0,9 times and 1,1 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 carried out twice, once with the short circuit applied on the input terminals of the rectifier, and again with the short circuit applied on the output terminals 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 intended to be loaded at the same time are loaded at the **rated output** and then the selected **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
Winding protected inherently	Maximum temperature				
	°C				
Subclause 15.2	150	165	175	190	210
Winding protected by protective device:					
a) Subclauses 15.3.2 – 15.3.3 – 15.3.4 – during the time required or the time <i>T</i> given in Table 4 ^a	200	215	225	240	260
b) Subclause 15.3.1 – during the first hour, peak value – after the first hour, peak value – after the first hour, arithmetic mean value ^b	200	215	225	240	260
	175	190	200	215	235
	150	165	175	190	210
c) Subclause 15.3.5	175	190	200	215	235
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				

^a The maximum temperature to be considered is the maximum temperature reached during and after the test due to the thermal inertia of the **transformer**.

^b The arithmetic mean value is determined as follows:

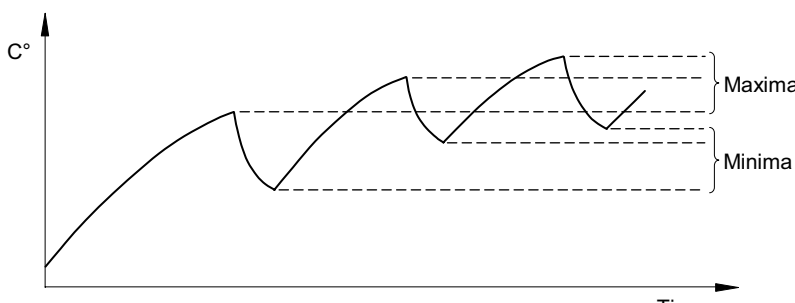
The graph of temperature versus time, while the power to the **transformer** is cycling on and off, is plotted for a period of test under consideration. The arithmetic average temperature (*t_A*) is determined by the formula:

$$t_A = (t_{\max} + t_{\min})/2$$

where:

t_{max} is the average of the maxima

t_{min} is the average of the minima



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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 system, 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

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

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

15.3.1 The output terminals are short-circuited. The incorporated overload protective device shall operate before the temperature exceeds the values shown in Table 3 for any value of the supply voltage between 0,9 times and 1,1 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 protective fuse-link, where k and T have the values shown in Table 4. The current in the fuse shall be kept constant during the test. The fuse-link is replaced by a link of negligible impedance

Table 4 – Values of T and k for fuses

Values marked as rated current I_n of protective 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 fuse-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 vehicle 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. The current in the fuse shall be kept constant during the test. The fuse-link is replaced by a link of negligible impedance.*

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

*If the **transformer** is protected by miniature fuses in accordance to IEC 60127, an additional overload test shall be performed at 1,5 times the rated fuse current until steady state condition.*

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. The current in the fuse shall be kept constant during the test. The circuit breaker is replaced by a link of negligible impedance.*

15.3.5 *If protected by:*

- *an overload protective device other than a fuse according to IEC 60127 or IEC 60269, or a circuit-breaker or*
- *an intentional weak part*

*the **transformer** is loaded by a current equal to 0,95 times the value of the lowest current which causes the protective device to operate, until steady-state conditions are reached. The lowest current causing the protective device to operate is determined by initially operating the transformer at 100 % of the **rated output**, and gradually increasing the output current in steps of 2 %, (each step is maintained until steady state condition is achieved) until the protective device operates.*

*If the protective device is an **intentional weak part**, the above test is repeated on two new samples. During the test on the first sample, the weak part shall operate in the same manner and place as above. During the test on the second sample, the temperatures shall not exceed the values in Table 3 in the steady state condition.*

15.4 Non-short-circuit proof transformers

Non-short-circuit proof transformers are tested as indicated in 15.3. with the appropriate protective device specified by the manufacturer installed in the relevant **input** or **output circuit**.

Associated **non-short-circuit proof transformers** are tested under the most unfavourable conditions of normal use with the appropriate protective device specified by the manufacturer installed 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 new specimens are used only for the following test.

During this test when the **transformer** fails, the interruption shall be in the **input circuit**.

Each of the three specimens is mounted as in normal use on a 20 mm thick dull black painted plywood surface and heated in accordance with 14.2 until the temperatures stabilise. Each **transformer** is then operated at 1,1 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. For this part of the test, each specimen shall fail within the time duration being no longer than the time necessary to reach steady state conditions, but not exceeding 5 h.

The **transformer** 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 **transformer** which can be touched with the standard test finger shall not exceed 175 °C;
- the temperature of the plywood support shall nowhere exceed 125 °C;
- the **transformer** 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 **transformer** shall withstand a dielectric strength test, the test voltage being 35 % of the values according to Clause 18, Table 8b. 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 have no holes allowing the standard test finger (Figure 2) to touch **hazardous live parts**. In case of doubt, contact with **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 above test.

16 Mechanical strength

16.1 General

Transformers shall have adequate mechanical strength, and be so constructed as to withstand 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 in accordance with the requirements of this standard. In particular, **hazardous live parts** shall not become accessible, when checked as described in 9.1.2. Insulating barriers shall not be damaged, and handles, levers, knobs and the like shall not move 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, in regard to the test of 16.4, bending of the pins during the test is ignored.

16.2 Stationary transformers

*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 test Eh of IEC 60068-2-75 with an 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 (except portable transformers with integral pins for introduction in socket-outlet in the fixed wiring)

***Portable transformers** except those **portable transformers** with integral pins for introduction in socket-outlets of the fixed wiring 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(s) or cord(s)**, they are cut to a length of 100 mm.*

16.4 Portable transformers provided with integral pins for introduction in socket-outlets of the fixed wiring

Portable transformers with integral pins for introduction into fixed socket-outlets shall have adequate mechanical strength.

Compliance is checked by carrying out the tests a), b) and c). The test a) is carried out on three specimens that all shall withstand the tests. Both the test of b) and c) shall be carried out on a new specimen.

- a) The test is carried out 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 brake 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 27.1 of IEC 60884-1 are neglected.

- 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, and 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 be displaced in the body of the device by more than 1 mm.

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

17.1 Degrees of protection provided by enclosures (IP code)

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**, except IP1X which shall be marked and tested as IP00.

NOTE An explanation of the IP code 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 the **rated output** conditions and brought to a stable operating temperature at the 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, using the most unfavourable type and cross-sectional area.*

*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** with enclosure 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 inside enclosures for 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** except SELV parts below 15 V ac or 25 V dc 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 inside the enclosures of drip-proof, spray-proof, splash-proof and jet-proof **transformers**, which may impair safety;
- e) no water or trace of water entered inside the enclosure of a watertight **transformer**;
- f) no entry into the **transformer** enclosure by the relevant test probe for solid-object-proof **transformers**.

17.1.1 Tests on transformers with enclosure

- 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.
- 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 be 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 1 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.

NOTE 2 This treatment of test condition corresponds to category 1 of IEC 60529.

- 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 Drip-proof **transformers** (second characteristic IP numeral 2) are tilted in any angle up to 15° and subjected for 10 min to a 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**.

- G Spray-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 as stated in IEC 60529.

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 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 × 360°) being about 12 s. The **transformer** shall be turned about its vertical axis as stated in IEC 60529.

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 an additional 10 min.

- I Jet-proof **transformers**) are switched off and immediately afterwards are 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 rate of the water flow shall be 12,5 l/min.

- J Powerful jet-proof **transformers** are switched off and immediately afterwards are subjected to a water jet for 3 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 12 mm. The nozzle shall be held 3 m away from the sample.

The rate of the water flow shall be 100 l/min.

- K 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.

- L 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 Humidity treatment

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 several knock-outs are provided and positioned on different parts of the enclosure, the knock-out which produces the most unfavourable condition will be 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 **transformers** with protection index IP20, or lower;*
- *seven days (168 h) for **transformers** with other protection index.*

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, dielectric strength and leakage current

18.1 General

The insulation resistance, the dielectric strength and the leakage current of **transformers** shall be adequate.

Compliance is checked by the tests of 18.2 to 18.5 which are carried out immediately after the test of 17.2, in the humidity cabinet or in the room where the specimen was brought to the prescribed temperature, after reassembling those parts which may have been removed.

18.2 Insulation resistance

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

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.

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 conductive parts of class II transformers which are separated from hazardous live parts by basic insulation only	2
Between conductive 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 of class II transformers	7

18.3 Dielectric strength test

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

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

Table 8a – Table of dielectric strength test voltages

Application of dielectric strength test voltage ^a	Working voltage V ^b				
	<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: – inside the same winding: no test (functional insulation only); – other than winding: test applies; 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 ; f) each input circuit and all other input circuits connected together .	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
^a For the construction according to 19.12.3 b) and 26.2.4.1, test b) the voltage is multiplied by the factor 1,25. For the construction according to 26.2.4.2 the voltage is multiplied by the factor 1,35. ^b Values of dielectric strength test voltage for intermediate values of working voltage are found by interpolation between tabulated values.					

No flashover or breakdown of the insulating materials and/or system 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.

Details of the test method to be used are given in IEC 61180-1 and IEC 61180-2.

*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.*

Care shall be taken that the dielectric voltage applied between **input** and **output circuits** does not overstress 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 dielectric test voltage of item 3 of Table 8a. 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 dielectric test voltage applied to the **reinforced insulation** does not over-stress the **basic** or **supplementary insulation**.

18.4 Insulation between and within windings

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 supply frequency** for 5 min. No load is connected to the **transformer**. During the test polyfilar windings, if any, are connected in series. This test is only applicable for **transformers** with **rated supply frequency** lower than 500 Hz.

A higher test frequency than the double supply frequency may be used; the duration of the period of connection, in minutes, then being equal to 10 times the **rated supply 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.

18.5 Touch current and protective earth conductor current

The **touch** and **protective earth conductor current** are measured as described under 18.5.1 and 18.5.2 below.

For variable **transformers** or **transformers** with tapping, the most unfavourable setting shall be chosen. For **transformers** with more than one **input** or **output winding**, the most unfavourable combination shall be chosen.

The method of measurement described here is based on the assumption that the **transformer** is used in a star TN or TT system, i.e. the **transformer** is connected between line (L) and Neutral (N). For other systems, see relevant parts of the IEC 60990.

In case of multi phase connections the same procedure is used, but the measurement(s) are made on one phase at the time. The same limits apply for each phase.

The **touch current** and **protective earth conductor current** are measured with the **transformer** loaded as described in Clause 14 and the measurements are made at steady state condition.

NOTE To avoid unnecessary testing it is recommended that this measurement be carried out in connection with the heating test in Clause 14.

18.5.1 Touch current

In case of **enclosures** fabricated of insulating material, a metal foil 10 cm x 20 cm in size is placed in contact with the accessible surfaces and the measurement is made to this foil. In case of class II insulated parts on a **class I transformer** the **touch current** shall be measured simultaneously on the two parts.

*During the measurements, a test circuit according to Figure 8 shall be used. The test circuit shall include an **isolating transformer** and the "neutral" conductor connected to the measuring network shall be reliably earthed for safety reasons. For **class II transformers** the protective earth conductor is ignored. The measuring network indicated is the network described in Figure J.1 in Annex J. However, if frequencies above 30 kHz are involved, measurement of **touch current** shall include measurement with regard to electric burn effects in addition to the measurements of Figure J.1. For the burn effects, the unweighted r.m.s. value of the **touch current** is relevant. Unweighted **touch current** is calculated from the r.m.s. voltage U_1 , measured across the 500 Ω resistor of Figure J1 Annex J.*

The terminal A electrode shall be applied to each accessible part in turn.

For each application of the terminal A electrode, the terminal B electrode shall be applied to earth, then applied to each of the other accessible part in turn.

Measurements:

*The **touch-current** is measured with the switch p in both position and the following combination of switches e and n:*

- switches n and e in the on position;*
- switch n in the off position and switch e in the on position;*
- switch n in the on position and switch e in the off position.*

*For each application of the terminal A and B electrodes and for each combination of the switches p, e and n, the **touch current** measured shall be equal to or less than in Table 8b.*

18.5.2 Protective earth conductor current

*The **protective earth conductor current** is measured with the **transformer** connected as described in Clause 14. In addition an ammeter of negligible impedance (less than 0,5 Ω) is connected between the earth terminal of the **transformer** and the protective earth conductor.*

*The **protective earth conductor current** (s) shall not exceed the following values:*

Table 8b – Limits for currents

Type of leakage Current	Rated current	Max limit (r.m.s)
Touch current: All class I and class II transformers equipped with a plug according to IEC 60083	–	0,5 mA
Protective conductor current:		
– Class I transformers fitted with a single or multiphase plug rated up to and including 32 A	≤ 4 A > 4 A but ≤ 10 A > 10 A	2 mA 0,5 mA/A 5 mA
– Class I transformers intended for permanent connection	≤ 7 A > 7 A but ≤ 20 A > 20 A	3,5 mA 0,5 mA/A 10 mA

The value to be observed during the measurement is a peak value. The peak value can be transformed into true r.m.s using a good quality oscilloscope.

NOTE Further explanations regarding the measurement of **touch current** and **protective conductor current** can be found in IEC 60990 and IEC 61140 (subclause 7.5).

19 Construction

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

19.2 Materials known to be highly flammable, 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 impregnators 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 27.3 at 550 °C.

NOTE Insulating material is considered impregnated if the space between the fibres of the material are substantially filled with a suitable insulating coating (i.e., epoxy resin, varnish, etc.).

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 There shall be provisions to prevent contact between accessible **conductive 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** serving as **supplementary insulation** or **reinforced insulation** which might be omitted during reassembly after servicing, shall either:

- be fixed in such a way that they cannot be removed without being seriously damaged; or
- be so designed that they cannot be replaced in an incorrect position and that, if they are omitted, the **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 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 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, independent 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 Conductive parts connected to accessible conductive parts by resistors or capacitors shall be separated from the **hazardous live parts** by **double insulation** or **reinforced insulation**.

*Compliance is checked by all relevant requirements and tests for **double insulation** or **reinforced insulation**.*

19.8 Conductive parts separated by **double** or **reinforced insulation** e.g. **live parts** and the **body** or **primary** and **secondary circuits**, may be bridged (conductive bridge) by resistors or Y2 capacitors provided that they consist of at least two separate components whose impedance is unlikely to change significantly during the lifetime of the **transformer**.

If the resistors are used they shall comply with the requirements of test (a) in 14.1 of IEC 60065. If capacitors are used they shall comply with the relevant requirements of IEC 60384-14.

Where two capacitors are used in series, they shall each be rated for the total working voltage across the pair and shall have the same nominal capacitance value. If any one of such two components is short-circuited or open-circuited, the values specified in Clause 9 shall not be exceeded.

In addition, if the **working voltage** does not exceed 250 V, **conductive parts** separated by **double** or **reinforced insulation** (e.g. live parts and the body or primary and secondary circuits), may be bridged by a single Y1 capacitor complying with the relevant requirements of IEC 60384-14.

NOTE A Y1 capacitor is considered to have **reinforced insulation**.

Compliance is checked by inspection and by measurement.

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, if any cracks 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, an alternative method has to be used (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 up 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 using a spring-operated impact hammer according to IEC 60068-2-75 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 not loosen or 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 coating.

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

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

*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 **transformers**, 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 (bobbins without flange) 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, in an insulation system providing **basic** or **reinforced insulation**, shall meet the following requirements.

- a) Where the insulation on the winding wire is used to provide **basic 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 one **insulated winding wire** shall consist of at least two layers;
- b) Where the insulation on the winding wire is used to provide **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 one **insulated winding wire** shall consist of at least three layers;
 - the insulation is subjected to the relevant dielectric strength test of 18.3 which is conducted at a voltage multiplied by the factor 1,25.

Where the insulated winding wire is wound:

- upon metal or ferrite cores or
- upon enamelled wire or;
- under enamelled wire;

an additional insulation complying with dti in Table 13 for **supplementary insulation** shall be provided between the insulated wires and the core or between the insulated wires and the enamelled wires.

NOTE This requirement takes into consideration the mechanical production stress applied to the **insulated winding wires**.

The manufacturer of the **transformer** shall demonstrate that the winding wire has been subjected to 100 % routine dielectric strength test as in K.3.

No requirements for creepage distances and clearances are applicable for the insulated winding wires.

For windings providing **reinforced insulation**, no value is required in box 2) c) of Table 13, Table C.1 and Table D.1,

Compliance is checked by inspection of the part and the declaration of the wire manufacturer.

19.13 Handles, operating levers and similar parts 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 have a protection index IP20 or higher. For **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 its windings and core and all uninsulated live parts, are completely embedded in an appropriate potting material.

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

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

If a **class I stationary transformer** is equipped with a **non-detachable** flexible cable or cord, the cable or cord shall have a protective earth conductor and the plug shall have a protective earth 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. Taking the relevant **working voltage** into account the following requirements shall be met:

- **SELV output circuits** shall be electrically separated from all circuits other than **SELV** and **PELV** by **double** or **reinforced insulation**.
- **SELV output circuits** shall be electrically separated from other **SELV** and **PELV circuits** by **basic insulation**.

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

*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 protective earth, to **live parts**, or protective earth conductors forming part of other circuits.

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

- protective earth, or to
- protective earth conductors or exposed **conductive parts** of another circuit.

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 8a.

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 8a.

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 protective 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 **class II transformer** intended for looping-in may have an internal terminal for maintaining the electrical continuity of an protective earth conductor not terminating in the **transformer**, provided that the terminal is insulated from the accessible **conductive 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

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.

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.

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.

20.1 Appliance couplers for mains supply shall comply with the IEC 60320 series for IPX0 **transformers** and IEC 60320-2-3 or IEC 60309 for other **transformers**.

20.2 Automatic controls shall comply with IEC 60730 series and the appropriate parts 2 unless they are tested with the **transformer**.

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

20.4 Switches forming part of the **transformer** assembly shall comply with Annex F.

In addition, switches intended to disconnect the **transformer** from the supply shall disconnect all poles and shall provide full disconnection under the relevant overvoltage category. The requirements with regard to all-pole disconnection and full disconnection do not apply to **transformers** 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.

20.5 There shall be no unsafe compatibility between the socket-outlets in the **output circuit** 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** systems shall comply with the requirements of IEC 60906-3 and 60884-2-4. However, plugs and socket-outlets for **SELV** systems with both a rated current ≤ 3 A and a maximum voltage of 24 V a.c. or 60 V d.c. with a power not exceeding 72 W are allowed to comply only with the following requirements:

- it shall not be possible for plugs to enter socket-outlets of other standardised voltage systems;
- socket-outlets shall not accommodate plugs for other standardised voltage;
- socket-outlets shall not have a protective earth contact.

NOTE As IEC 60906-3 covers only 6 V, 12 V, 24 V and 48 V, **transformers** with intermediate supply voltage should be able to withstand the nearest upper voltage. Other plugs and socket-outlet systems are allowed for **associated transformers** only.

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

- it shall not be possible for plugs to enter socket-outlets of other standardized voltage systems;
- socket-outlets shall not accommodate plugs of other standardized voltage systems;
- socket-outlets shall not have a protective earth contact.

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:

- It shall not be possible for plugs to enter socket-outlets of other standardized voltage systems; and
- socket-outlets shall not accommodate plugs of other standardised voltage systems.

Compliance is checked by inspection and by manual test.

20.6 Thermal cut-outs, thermal links, **overload relays**, fuses and other overload protective devices shall have adequate breaking capacity.

*Compliance of the breaking capacity of **Thermal cut-outs** is checked by the relevant tests of 20.7 and 20.8.*

*Compliance of the breaking capacity of **Thermal links** is checked by the relevant test of 20.8*

The breaking capacity of the fuse shall be in accordance with the relevant fuse standard.

20.6.1 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.

20.7 Thermal cut-outs shall meet the requirements of 20.7.1.1 and 20.7.2, or 20.7.1.2 and 20.7.2.

20.7.1 Requirements according to IEC 60730-1

20.7.1.1 Thermal cut-outs when tested as separate components shall comply with the appropriate requirements and tests of IEC 60730-1.

For the purpose of this standard the following applies.

- a) **Thermal cut-outs** shall be of type 1 or type 2 (see 6.4 of IEC 60730-1)
- b) **Thermal cut-outs** shall have at least micro-interruption (type 1C or 2C) (see 6.4.3.3 and 6.9.3 of IEC 60730-1), or micro-disconnection (type 1B or 2B) (see 6.4.3.2 and 6.9.2 of IEC 60730-1).
- c) **Thermal cut-outs** with manual reset shall have a trip free mechanism with contacts that cannot be prevented from opening against continuation of a fault (type 1E and 2E) (see 6.4.3.5 of IEC 60730-1).
- d) The number of cycles of automatic action shall be:
 - 3 000 cycles for **self-resetting thermal cut-outs**,
 - 300 cycles for **non-self-resetting thermal cut-outs** which can be reset by hand without the use of a **tool** (see 6.11.10 of IEC 60730-1),
 - 300 cycles for **non-self-resetting thermal cut-outs** which can be reset when the **transformer** is disconnected (see 6.11.10 of IEC 60730-1),
 - 30 cycles for **non-self-resetting thermal cut-outs** which can only be reset by the use of a **tool** (see 6.11.11 of IEC 60730-1).
- e) **Thermal cut-outs** shall be designed to withstand electrical stresses across their insulating parts for a long period of time and shall be tested accordingly (see 6.14.2 of IEC 60730-1).
- f) The characteristics of **thermal cut-outs** with regard to:
 - their ratings (see Clause 5 of IEC 60730-1) ;

- their classification 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 degree** (see 6.5.3 of IEC 60730-1),
 - 6) their comparative tracking index (see 6.13 of IEC 60730-1), and
 - 7) their maximum ambient temperature limit (see 6.7 of IEC 60730-1),

shall be appropriate for the application in the **transformer** under normal operating conditions and under fault conditions (e.g. short-circuit of the output terminals).

20.7.1.2 A **thermal cut-out** when tested as part of a **transformer** shall:

- have at least micro-interruption (type 1C or type 2C) or micro-disconnection (type 1B or 2B) according to IEC 60730-1 ;
- 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 operation as specified under 20.7.1.1 for **thermal cut-outs** tested as a separate component, by establishing the relevant fault condition(s).

The tests are carried out on three samples.

NOTE A sample consists of a **transformer** with an incorporated **thermal cut-out**.

Compliance is checked by inspection and by the specified tests.

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

*After the tests, there shall be no damage to the **thermal cut-out** and the **transformer** in the sense of this standard, in particular, the **enclosure** shall not deteriorate, there shall be no reduction of **clearances** and **creepage distances**, and no loosening of electrical connections or mechanical securing means .*

20.7.2 **Thermal cut-outs** shall have adequate breaking capacity.

20.7.2.1 A **transformer** with a **non-self-resetting thermal cut-out** is supplied at 1.1 times **rated input voltage** and the output terminals are short-circuited until the **thermal cut-out** operates. Then the supply voltage is switched off until the **transformer** cools down to approximately the room temperature. The supply voltage is then switched on (the output terminals still short circuited).

This cycle of operation is carried out:

- 3 times at a room temperature of 25 °C \pm 10 °C for **transformers** without a t_{amin} marking;
- 3 times at min. ambient temperature t_{amin} for **transformers** with a t_{amin} marking.

After the cycling test, the **transformer** is supplied at 1,1 times the **rated supply voltage** for 48 h with the output terminals short-circuited.

20.7.2.2 A **transformer** with a **self-resetting thermal cut-out** is supplied at 1,1 times the **rated input voltage** with the output terminals short-circuited.

This operation is carried out:

- 48 hours at an ambient temperature of $25\text{ °C} \pm 10\text{ °C}$ for **transformers** without a t_{amin} marking ;
- 24 hours at an ambient temperature of $25\text{ °C} \pm 10\text{ °C}$ and 24 h at min. ambient temperature t_{amin} for transformers with a t_{amin} marking.

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

During these tests, no sustained arcing shall occur.

After the test, the **transformer** shall:

- withstand the test of Clause 18,
- show no damage in the sense of this standard, and
- be operational.

20.7.3 A PTC resistor of indirect heating type is considered to be a **non-self-resetting thermal cut-out by this standard**.

Compliance is checked by the following test:

The **transformer** is supplied at 1,1 times the rated input voltage for 48 h (two days) 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 by the **transformer manufacturer**.
- The same test cycles shall be repeated, except at 0,9 times the rated input voltage and the minimum ambient temperature declared by the **transformer manufacturer**.

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 be operational.

20.8 Thermal-links shall be tested in one of the following two ways.

20.8.1 The **thermal-links**, when tested as separate components, shall comply with the requirements and tests of IEC 60691 .

When a **thermal link** is tested according to IEC 60691, the following applies:

- the electrical conditions (see 6.1 of IEC 60691);
- the thermal conditions (see 6.2 of IEC 60691);
- the ratings of the **thermal-link** (see 8 b) of IEC 60691); and
- suitability of the sealing compounds, and impregnating fluids or cleaning solvents (see 8 c) of IEC 60691)

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

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

20.8.2 The thermal-links when tested as part of a 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, when relevant, $t_a + 10$ °C;
- shall be subjected to the **transformer** fault conditions which cause the **thermal-link** to operate. There shall be no sustained arcing during the tests, and no damage in the sense of this standard; and
- shall be capable of withstanding two times the rated voltage across the disconnection, and have an insulation resistance of at least 0,2 MΩ when measured with a d.c. voltage equal to two times the rated voltage across the disconnection.

The test is conducted 3 times; no failure is allowed. This test is not applicable to **fail safe transformers**.

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

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

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

20.9 Self-resetting thermal protective devices shall not be used unless no mechanical, electrical, or other hazards occur from their operation during and after the tests of this standard.

Compliance is checked by inspection.

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

Compliance is checked by inspection.

20.11 Overload protective devices shall not operate when the supply voltage is switched on.

Compliance is checked by the following test.

*The **transformer**, with no load, is supplied from a voltage source equal to 1,1 times the **rated supply voltage**. The supply voltage is then switched on and off 20 times at intervals of approximately 10 s or at a point on the voltage wave such that the inrush current is maximized.*

NOTE The switching -on and -off may be carried out only twice if a device is used to switch on at the most unfavourable electrical angle of the supply voltage.

The supply source shall be such that the voltage drop does not exceed 2 % as a result of the 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 Uninsulated conductors shall be so fixed that their 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 loosen up 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 subject to temperatures exceeding the limitations in 14.2 under normal use shall be provided with heat-resistant and non-hygroscopic insulating materials.

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 this clause 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, 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 For **portable transformers** provided with **power supply cords**, the length of the cord shall:

- not exceed 2 m for cross-sectional area of 0,5 mm²
- exceed 2 m for cross-sectional areas greater than 0,5 mm².

Compliance is checked by inspection.

22.5 Power supply cords of both **transformers** with protection index of IPX0 and **transformers** for “indoor use only” with protection index higher than IPX0, shall be as follows:

- for **transformers** with a mass not exceeding 3 kg, not lighter than light polyvinyl chloride sheathed flexible cable or cords (60227 IEC 52) or ordinary tough rubber sheathed flexible cable or cords (60245 IEC 53);
- for **transformers** with a mass exceeding 3 kg, not lighter than ordinary polyvinyl chloride sheathed flexible cable or cords (60227 IEC 53) or ordinary tough rubber sheathed flexible cable or cords (60245 IEC 53)

Power supply cords of **transformers** with protection index higher than IPX0, except for **transformers** for “indoor use only”, shall be polychloroprene sheathed cord and shall not be lighter than ordinary polychloroprene sheathed cord (60245 IEC 57),

22.6 Power supply cords may be cord sets fitted with appliance couplers in accordance with IEC 60320, provided the **transformers** are single-phase **portable transformers** with input current not exceeding 16 A at the **rated output**.

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

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

Input or output current at rated output A	Nominal cross-sectional areas mm ²
Up to and including 3 ^a	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
NOTE In Japan, cords having a nominal cross-sectional area of 0,5 mm ² are not allowed for external power supply cord .	
^a 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.	

Compliance is checked by inspection and by measurement.

22.8 Each **Power supply cord** of **class I transformers** shall have a green/yellow coloured cord connected to the protective earth terminal of the **transformer** and to the protective earth 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 plugs complying with IEC 60083 or IEC 60906-1. Other **portable transformers** may be provided with plugs complying with IEC 60309.

Compliance is checked by inspection.

22.9 **External flexible cables 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 designed and shaped, or be provided with an inlet bushing such 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**; and
- 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 **basic insulation**.

NOTE 2 A lining or a bushing of insulating material in a metallic enclosure is only regarded as **supplementary insulation** if it complies with the relevant requirements.

NOTE 3 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**; and
- 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 conducted 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; and
- 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** shall be 20 000, and for other attachments 10 000. The rate of flexing shall be 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 under test, and at the rated voltage.

NOTE 2 Current is not passed through the protective earth 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; and*
- *broken strands piercing the insulation and becoming accessible.*

NOTE 3 Conductors include protective earth 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 **external flexible cables or cords** and **portable transformers** shall be provided with cord anchorages for strain relief including twisting where they are connected within the **transformer**, and for protection of the insulation of the conductors against abrasion.

For **type X attachments**, glands shall not be used as cord anchorages in **portable transformers** unless they have provisions for clamping all types and sizes of cables and cords which might be used as **external flexible cables 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 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 easily possible;
- it is clear how strain relief and prevention of twisting are to be obtained;
- it is suitable for connection of different types of cords, unless the **transformer** is designed to accommodate only a specific type of cord;
- the entire 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; and
- the cord cannot touch the clamping screws of the cord anchorage if these screws are accessible or in contact with accessible **conductive parts**.

For **type X** with a special cord, and **type Y** and **Z attachments**, the cores of the **external flexible cable or cord** shall be insulated from accessible **conductive parts** by insulation complying with the requirements for **basic insulation** for **class I transformers**, and 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 entire 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; and
- the cord cannot touch the clamping screws of the cord anchorage if these screws are accessible or in contact with accessible conductive parts;

Compliance is checked by inspection and by the following tests.

*For **type X attachments**, except with a special cord, the **transformer** shall be fitted with a suitable **external flexible cable or cord**. The conductors shall be introduced into the terminals, and the terminal screws, if any, shall be tightened sufficiently to prevent the conductors from shifting position. The cord anchorage shall be used in the normal way, its clamping screws tightened with a torque equal to two-thirds of that specified in Table 11.*

*The tests are first conducted 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 designed to accommodate only a specific type of cord.*

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

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

The cord shall then be subjected 25 times to a pull force of the value shown in Table 10. The pull force shall be applied in the most unfavourable direction without a jerking motion, each time for 1 s.

Immediately after the pull tests, 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 cables or cords fixed to stationary and portable transformers

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 be longitudinally displaced by more than 2 mm, and the conductors shall not shift 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 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 under the pull force.

22.9.6 The space for the supply cables or the **external flexible cable or cord** provided inside for the connection:

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

- permit checking the proper connection and positioning of the conductors prior to fitting of cover, if any;
- ensure the covers, if any, can be fitted without risk of damage to the conductors or their insulation;
- prevent, for **portable transformers**, the un-insulated end of the conductor, should it pull free from the terminal, from coming into contact with accessible **conductive parts**, unless, for **type X** and **Y attachments**, the cord is provided with terminations that are unlikely to pull free from the conductor; and

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

- adequate to allow the conductors to be easily introduced and connected; and
- designed such 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 **Z attachments** shall be provided with terminals in which connection is made by means of screws, nuts or equally effective devices.

*Terminals that are an integral part of the **transformer** shall 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 60947-7-1, 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 soldering alone to maintain the conductor in position, unless barriers are provided so that **creepage distances** and **clearances** between **hazardous live parts** and other conductive 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 **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 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 **conductive 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 method for retaining the conductor of a flexible cable or cord in position, provided the hole through which the conductor is passed is not unduly large.

23.2 Terminals for **type X** attachment with a special cord, and **types 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 force 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 loosen up, 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, and the torque applied shall be equal to two-thirds of the torque specified in Clause 25.

NOTE Securing with sealing compounds without other means of clamping is not considered sufficient. However, self-hardening resins may be used to secure terminals that are not subject to torsion in normal use.

23.5 Terminals provided for connection to fixed wiring, and terminals with **type X attachment** shall be located near their associated terminals of different polarities and the protective earth 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 strand of wire from a stranded conductor pull out when the conductors are fitted, there shall be no risk of accidental connection between **live parts** and accessible **conductive parts**, and in case of **class II transformers**, between **live parts** and **conductive parts** separated from accessible **conductive parts** by **supplementary insulation** only.

Compliance is checked by inspection 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 strand of wire from the stranded conductor is left free, and the other strands are fully inserted into the terminal and clamped in.

The free strand of wire is bent in every possible direction without making sharp bends round barriers and without tearing the insulation back. The free strand of wire connected to a live terminal shall not touch any accessible conductive parts. For **class II transformers**, it shall also not touch any conductive part separated from accessible conductive parts by basic or **supplementary insulation** only. The free strand of wire from a conductor connected to an earthing terminal shall not touch any **hazardous live part**.

23.8 Terminals without pressure plate shall be provided with at least two clamping screws if the current exceeds 25 A.

Compliance is checked by inspection.

23.9 Terminal screws, other than screws of terminals for the connection of protective earth conductors shall not come into contact with any accessible **conductive parts**. For **class II transformers**, they shall also not touch any conductive parts separated from accessible conductive parts by **basic** or **supplementary insulation** only when the screws are loosened up as far as possible.

Compliance is checked by inspection during the test of 23.2.

24 Provisions for protective earthing

24.1 Accessible conductive parts of **class I transformers** which may become live in the event of an insulation break down shall be permanently and reliably connected to a protective earth terminal within the **transformer**.

Class II transformers shall have no provisions for earthing the **transformer** except for functional purposes.

Compliance is checked by inspection.

NOTE If accessible **conductive parts** are separated from **hazardous live parts** by a conductive screen connected to the protective earth 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 break down.

24.2 Protective earth terminals for connection to fixed wiring, and protective earth 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 Some terminals, especially, the pillar types, may require special provisions, such as an adequately resilient part not likely to be removed inadvertently.

24.3 All parts of the protective earth terminal shall be such that there is no risk of corrosion resulting from contact between these parts and the copper of the protective earth conductor, or any other metal that is in contact with these parts.

If the **body** of the protective earth 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 earth 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 earth 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 earth terminal and each of the **accessible conductive 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 phases.

*The voltage drop between the protective earth terminal and the **accessible conductive part** is measured and the resistance calculated from the current and this voltage drop.*

In no case shall the resistance exceed 0,1Ω.

In case of doubt, after 1 min, the test shall be conducted until steady state conditions are established.

NOTE 2 Care is taken that the contact resistance between the tip of the measuring probe and the conductive part under test does not affect 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 cables 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 are stretched before the protective earth conductor if the cord pulls 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 soft metal 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**, and the screws which may be removed when replacing a **power supply cord** shall not 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 the threads of insulating material, and*
- *five times for nuts and other screws.*

Screws in engagement with the threads 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 and it is repositioned before each tightening.

The test is conducted by means of a suitable test screwdriver, spanner or key, applying a torque as shown in Table 11, the appropriate column shall be:

- 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 further use of the screwed connections shall occur.

NOTE 1 Screws or nuts likely to be tightened by the user include screws intended to be operated when replacing **power supply cords** with **type X attachment**.

NOTE 2 The blade of the test screwdriver shall fit the head of the screw to be tested. The screws and nuts should be tightened without jerking motion.

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.

Proper 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, and the torque applied shall be increased to 1,2 times the torque specified.

NOTE The requirement for the proper introduction is met if introduction of the screw in a slanting manner is prevented (e.g., by guiding the screw using 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 suitable locking means .

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 making mechanical connections between different parts of the **transformer** shall be locked against loosening if the connection carries current or forms part of the protective earth 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 compounds softening due to heat provide 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, and the force shown in Table 12 shall be 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 not be less than the values shown in Table 13 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.

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 layers of serration coincided with one another.

NOTE 4 Diagrams showing some examples of the methods of measurement of **creepage distances** and **clearances** are 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 over voltage category II for **basic insulation** and over voltage category III for **double** or **reinforced insulation**.

Values for printed wiring boards 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 board complies with the requirements of IEC 60664-3.

If the **pollution** results in high and persistent conductivity caused, for instance, by conductive dust, 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 and clearances (cr)

The **creepage distance** and clearance values are shown in Tables 13, C.1 and D.1.

26.2.1 Windings covered with adhesive tape

For windings covered with an adhesive bonding tape adhering to the flanges of a coil former, the values of creepage path are considered along the bonded surface of the adhesive bonding tape. Reduced values are those stated for **pollution degree 1 (P1)**, provided:

- all insulating materials are classified according to IEC 60085 and IEC 60216;
- the impulse voltage dielectric test of 4.1.1.2.1 of IEC 60664-1 is fulfilled; and
- the test A of 26.2.3 is fulfilled.

Clearance values are not required.

26.2.2 Uncemented insulating parts

Where an insulation barrier consisting of an uncemented snap-on partition wall is used, **creepage distances** and **clearance** are measured through the joint. If the joint is covered by 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.

The materials used shall be classified according to IEC 60085 and IEC 60216.

The values stated for **pollution degree 1 (P1)** do not apply.

26.2.3 Cemented insulating parts

For **transformers** with cemented parts or parts adhered together, no minimum **creepage distance** and **clearance** are required through the joint. Only the values for distance through insulation (d.t.i.) apply. In this case, the impulse voltage dielectric test of 4.1.1.2.1 of IEC 60664-1 shall also be fulfilled.

The materials used shall be classified according to IEC 60085 and IEC 60216.

In order to check whether the parts are adequately cemented or adhered, the following tests are performed as appropriate:

- **Test A**

*Three specially prepared specimens with winding wires replaced by uninsulated wires without any impregnation or potting are required. The windings shall be constructed such that there is no possible flashover between **input** and **output windings** anywhere other than in the cemented joint to be tested.*

The specimens shall be 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 shall then be subjected to the humidity treatment of 17.2 (48 h treatment) and the relevant dielectric strength test of 18.3, except the test voltage is multiplied by 1,35.

One of the three specimens shall be subjected to the relevant dielectric strength test of 18.3 immediately after the last period at the highest temperature during the thermal cycling test, except the test voltage is multiplied by 1,35.

NOTE The test voltage applied to the specimens for cemented parts is higher than the normal test voltage in order to ensure that if the surfaces are not cemented together a breakdown occurs.

26.2.4 Enclosed parts (e.g. by impregnation or potting)

26.2.4.1 For **transformers** with parts enclosed or hermetically sealed against ingress of dust and moisture, and satisfying the following tests, the minimum required **creepage distances** may be the reduced values as stated for pollution degree 1 (P1). In this case, the impulse voltage dielectric test of 4.1.1.2.1 of IEC 60664-1 shall also be fulfilled.

No clearance values are required.

The materials used shall be classified according to IEC 60085 and IEC 60216.

In order to check whether the parts are adequately potted or impregnated, the following tests are performed as appropriate:

• Test B

To test the potting or the impregnation, three prepared specimens shall be used as follows. For components where potting or impregnation is used, the reliability of the joint is checked by subjecting the samples to the dielectric strength test applied only directly to the joint.

The specimens shall be 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 or 60 Hz shall be applied to the specimens between the windings where the reduced values apply.*

Two of the three specimens shall then be subjected to the humidity treatment of 17.2 (48 h treatment) and the relevant dielectric strength test of 18.3 conducted at a voltage multiplied by 1,25.

One of the three specimens shall be subjected to the relevant dielectric strength test of 18.3 immediately at the end of the last period at the highest temperature during the thermal cycling test conducted at a voltage multiplied by 1,25.

26.2.4.2 For **transformers** with parts enclosed or hermetically sealed against ingress of dust and moisture, and satisfying the following tests, no minimum **creepage distances** and **clearances** are required. Only the values for distance through insulation (d.t.i) apply. In this case, the impulse voltage dielectric test of 4.1.1.2.1 of IEC 60664-1 shall also be fulfilled.

In order to check whether the parts are adequately potted or impregnated, the following tests shall be performed as appropriate:

- **Test C**

To test the potting or the impregnation three specimens shall be used.

*For components where insulating compound forms solid insulation between **conductive parts**, finished components shall be tested. There shall be neither cracks nor voids in the insulating compounds.*

The specimens shall be 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 or 60 Hz shall be 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 conducted at a voltage multiplied by 1,35.

One of the three specimens shall be subjected to the relevant dielectric strength test of 18.3 immediately at the end of the last period at highest temperature during the thermal cycling test conducted at a voltage multiplied by 1,35.

26.3 Distance through insulation (dti)

The distances through insulation (dti) are required for **supplementary**, **double** or **reinforced** insulation only as shown in boxes 2b,2c and 7 of Tables 13, C.1 and D.1.

The insulation shall fulfil either the material classification as given in IEC 60085 and IEC 60216 or the test of 14.3.

NOTE The material is considered as having adequate mechanical strength and resistance to ageing if it fulfils the test of 14.3.

The requirements concerning distance through insulation do not imply that the prescribed distance shall be through solid or thin sheet insulation only. It may consist of the thickness of solid or thin sheet insulation plus a specified clearance distance.

26.3.1 In case of solid insulation, the required values in the tables are marked by the index ^d. For classified materials in accordance to IEC 60085 and IEC 60216, distances through insulation multiplied by 0,4 with a minimum of 0,2 mm for **reinforced insulation** and of 0,1 mm for **supplementary insulation for working voltage** above 25 V may be used if the test of 14.3 is fulfilled.

26.3.2 In case of insulation constructed of thin sheets of insulated material, the insulation shall be such that at every place, there is at least the required number of layers and the d.t.i as follows:

- if the layers are non separable (glued together):
 - 3 layers are required;
 - the entire composite sheet shall fulfil the mandrel test of 26.3.3 (pull force of 150 N);
 - the required values for d.t.i of Tables 13, C.1 and D.1 are marked by the index ^e;
- if the layers are separated:
 - 2 layers are required; for separated serrated layers, one additional layer is required (serrated tape) plus one layer without serration fixed (e.g. adhesive);
 - each layer shall fulfil the mandrel test of 26.3.3 (pull force of 50 N);
 - the required values for d.t.i of Tables 13, C.1 and D.1 are marked by the index ^e;
- if the layers are separated (alternative):
 - at least 3 layers are required; for separated serrated layers, one additional layer is required (serrated tape) plus one layer without serration fixed (e.g. adhesive);
 - two-thirds of the number of layers shall fulfil the mandrel test of 26.3.3 (pull force of 100 N);
 - the required values for d.t.i of Tables 13, C.1 and D.1 are marked by the index ^e.

NOTE Additional layers are required in case of use of serrated layers because it is assumed that different layers of serration can coincide with one another.

For classified materials in accordance to IEC 60085 and IEC 60216, no requirements for distances through insulation are required if the test of 14.3 is fulfilled.

The figures within square brackets in boxes 2 and 7 of Table 13, Annex C Table C.1 and Annex D Table D.1 shall be 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.

26.3.3 For the mandrel test, three separate test specimens of thin sheets 70 mm in width shall be supplied by the manufacturer.

The test shall be performed by fixing the specimens of thin sheets on a mandrel made of nickel plated steel or brass with smooth surface finish as shown on Figure 6.

A metal foil (aluminium or copper) 0,035 mm ± 0,005 mm thick shall be placed closely to the surface of the specimen and subjected to a pull force 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 held in place at its free end by an appropriate clamping device and subjected to:

- a pull force of 150 N for a specimen consisting of several non separable layers;*
- a pull force of 100 N for a specimen consisting of 2/3 the number of separated layers (serrated or not);and*
- a pull force of 50 N for a specimen consisting of a single layer (serrated or not).*

The mandrel shall be slowly rotated forwards and backwards three times for 230° without jerking motion. If the specimen breaks at the clamping device during the rotation, the test shall be 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 a minute following the final positioning, a dielectric strength test voltage shall be applied for 1 minute as described in 18.3 between the mandrel and the metal foil as follows:

- a test voltage of at least 5 kV or the applicable test voltage of Clause 18.3 multiplied by 1,35 for a specimen consisting of several non separable layers (at least 3 layers) whichever is the greater;*
- a test voltage of at least 5 kV or the applicable test voltage of 18.3 multiplied by 1,25 for a specimen consisting of 2/3 of the number of at least 3 separated layers whichever is the greater;*
- a test voltage of at least 5 kV or the applicable test voltage of 18.3 multiplied by 1,25 for a specimen consisting of one layer of the number of 2 separated layers whichever is the greater.*

No flashover or breakdown shall occur during the test, and corona effects and similar phenomena shall be disregarded.

Table 13 – Creepage distances (cr), clearances (cl) and distances through insulation (dti) – Material group IIIa (175 ≤ CTI < 400)

NOTE The following table extends over several pages. For notes and footnotes, please see the final page of the table.

Dimensions in millimetres																	
	Type of insulation	Measurement				Working voltages ^b V											
		Through winding enamel ^a		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	X	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	
					0,8	1,9	0,8	2,2	1,5	2,5	3,0	4,7	5,5	9,5	8,0	16,0	
					0,2	1,2	0,2	1,4	0,5	1,6	1,5	3,0	3,0	6,0	5,5	10,0	
					0,8	1,9	0,8	2,2	0,8	2,5	1,5	4,7	3,0	9,5	5,5	16,0	
	-Reduced values, see 26.2 (P1)				-	0,18	-	0,25	-	0,3	-	0,7	-	1,7	-	3,2	
					dti		dti		dti		dti		dti		dti		
		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
		No requirements of thickness															
2) Insulation between input and output circuits (double or reinforced insulation)	c) Distances through insulation between input and output circuits	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
		X	X	X	0,5	1,4	1,5	2,0	3,0	3,0	3,0	5,5	6,0	8,0	12,0	14,0	20,0
					0,8	2,2	1,5	3,2	3,0	4,7	5,5	9,5	8,0	19,2	14,0	32,0	
					0,5	1,4	0,5	2,0	1,5	3,0	3,0	6,0	5,5	12,0	8,0	20,0	
	- Reduced values, see 26.2 (P1)				-	0,25	-	0,4	-	0,7	-	1,7	-	4,0	-	7,5	
		X	X	X	dti		dti		dti		dti		dti		dti		
					0,1 ^d	[0,05] ^e	0,2 ^d	[0,07] ^e	0,25 ^d	[0,08] ^e	0,5 ^d	[0,16] ^e	0,7 ^d	[0,19] ^e	1,0 ^d	[0,25] ^e	
			c) Distances through insulation between input and output circuits , see 26.3.	X	X	X	0,2 ^d	[0,1] ^e	0,3 ^d	[0,1] ^e	0,5 ^d	[0,15] ^e	1,0 ^d	[0,3] ^e	1,5 ^d	[0,4] ^e	2,0 ^d

Table 13 (continued)

	Type of insulation	Measurement				Working voltages ^b V											
		Through winding enamel ^a		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 adjacent output circuits ^{c, g}	Creepage distances and clearances -Reduced values see 26.2 (P1)	X		X		0,2	1,2	0,2	1,4	0,2	1,6	0,5	3,0	1,5	6,0	3,0	10
			X			0,8	1,9	0,8	2,2	0,8	3,1	0,8	4,7	1,5	9,5	3,0	16
						-	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 circuits and for output circuits	a) Up to and including 6 A b) Over 6 A up to and including 16 A c) Over 16 A	X	X	X	X	3,0		3,6		4,0		6,0		9,0		12,5	
		X	X	X	X	5,0		6,0		7,0		10,0		13,0		16,0	
		X	X	X	X	10,0		11,0		12,0		14,0		17,0		20,0	
5) Basic or supplementary insulation ^h	Where it is required by the standard and for example 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 metal foil wrapped around the cord) inserted inside inlet bushing, anchorage and the like. d) live parts and an intermediate conductive part e) an intermediate conductive part and the body - Reduced values, see 26.2 (P1)			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
					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
		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
			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
						-	0,18	-	0,25	-	0,3	-	0,7	-	1,7	-	3,2

Table 13 (continued)

Dimensions in millimetres

		Measurement		Working voltages ^b V												1 000			
				Through winding enamel ^a		Other than through winding enamel		≥25 ≤ 50		100		150		300				600	
6) Reinforced or double insulation	Type of insulation	P2	P3	P2	P3	cl	cr	cl	cr	cl	cr	cl	cr	cl	cr	cl	cr		
				X		0,5	1,4	1,5	2,0	3,0	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	2,0	1,5	3,0	3,0	6,0	5,5	12,0	8,0	20,0		
7) Distance through insulation	Type of insulation					0,8	2,2	0,8	3,2	1,5	4,7	3,0	9,5	5,5	19,2	8,0	32,0		
		X		X		0,2	1,4	0,2	2,0	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		
						-	0,25	-	0,4	-	0,7	-	1,7	-	4,0	-	7,5		
		X		X		No requirement of thickness													
						dti		dti		dti		dti		dti		dti			
		X		X		0,1 ^d [0,05] ^e		0,15 ^d [0,05] ^e		0,25 ^d [0,08] ^e		0,5 ^d [0,15] ^e		0,75 ^d [0,20] ^e		1,0 ^d [0,25] ^e			
		X		X		0,2 ^d [0,1] ^e		0,3 ^d [0,1] ^e		0,5 ^d [0,15] ^e		1,0 ^d [0,3] ^e		1,5 ^d [0,4] ^e		2,0 ^d [0,5] ^e			

NOTE 1 For Material Group II see Annex C and Material Group I see Annex D.

NOTE 2 P1 = **pollution degree 1** P2 = **pollution degree 2** P3 = **pollution degree 3**.

NOTE 3 When a numeric figure is replaced by a dash in a column of the Table it means that no value is required

NOTE 4 The minimum values of clearance in this table are applicable in air up to 2000 m above sea level.

^a Measurement through winding wire enamel if at least one winding is constructed with wire complying with at least grade 1 of IEC 60317.^b 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 8a is considered sufficient.^c 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, if only the windings are intended to be connected in a series or parallel arrangement (e.g. input voltage 110/220 V).

^d For solid insulation^e In case of insulation consisting of thin sheets^f 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 metals parts, with the exception of insulated wires (see 19.12).^g For insulation between **SELV circuits** and adjacent **circuits** other than **SELV** or **PELV**, the values of this box shall be replaced by the values of boxes 6 and 7 (according to 19.1).^h In case of a physical breakdown of the **basic insulation** or **supplementary insulation**, the thickness of the insulation is added to the clearance.

27 Resistance to heat, fire and tracking

For components previously tested in accordance with their relevant IEC standards, the requirements and tests having the same level of severity as the requirements and tests of this standard, the following tests may be omitted.

27.1 Resistance to heat

All parts of the **transformer** made of insulating material shall be resistant to heat.

The following tests do not apply to parts made of natural or synthetic rubber which shall be tested according to 19.9. Additionally the tests do not apply to parts made of ceramic material.

Compliance is checked by subjecting parts made of insulating materials to a ball-pressure test according to 27.1.1 and 27.1.2 as appropriate by means of the apparatus shown in Figure 4.

The test is not carried out for cables and small connectors with a rated current ≤ 3 A and a rated voltage ≤ 24 V a.c. or ≤ 60 V d.c. and a power not exceeding 72 W.

The test shall be performed in a heating cabinet at a temperature specified below.

NOTE 1 Details of the ball pressure test procedure are described in IEC 60695-10-2.

The surface of the part to be tested shall be placed in a horizontal position and a steel ball of 5 mm diameter shall be pressed against the surface with a force of 20 N.

After 1 h, the ball is removed from the specimen, and the specimen is 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.

27.1.1 External accessible parts

External accessible parts of insulating materials shall be resistant to heat.

Compliance is checked by the following test.

The test is carried out at a temperature of (70 ± 2) °C, or at a temperature of $(T + 15 \pm 2)$ °C where T is the temperature of the relevant part during the test of 14.2, whichever is higher.

*The temperature of the relevant part shall be measured at the hottest point, normally, occurring inside the **enclosure**.*

NOTE 1 The constant 15 °C is the safety margin.

27.1.2 Internal parts

Internal parts of insulating material retaining current carrying parts in position shall be resistant to heat.

Compliance is checked by the following test.

The test shall be performed at a temperature of $(125 \pm 2) ^\circ\text{C}$, or at a temperature of $(T + 15 \pm 2) ^\circ\text{C}$ where T is the temperature of the relevant part during the test of 14.2, whichever is higher.

NOTE 1 The constant $15 ^\circ\text{C}$ is the safety margin.

NOTE 2 The test is not conducted on parts of ceramic material, bobbins, or glass.

27.2 Resistance to abnormal heat under fault conditions

The insulation system of the **transformers** under fault conditions shall not act as a source of ignition, result in breakdown of the insulation between the windings, and for **transformers** with protection index IP 20 or higher, hazardous life parts shall not be accessible.

*Compliance is checked by the tests of 27.2.1 and 27.2.2. This test is not required on **fail safe transformers** as they are covered by 15.5.*

For this test, one or two additional specially prepared specimens is (are) required. A short-circuit in the winding(s) shall either be built in, or made possible by short-circuiting the leads connected to the winding(s) provided by the manufacturer.

If the **transformer** is provided with a thermal protective device in the **input circuit**, the short-circuit shall be introduced in the **output winding** and vice versa.

If the **transformer** is provided with a thermal protective device in both the **input** and **output circuits**, the short-circuit shall be introduced in each winding in two separate specimens.

The short-circuit shall be made in the middle of the winding. In case of more than two windings, the short-circuit shall be introduced in the winding being thermally farthest away from the thermal control.

The percentage of turns to be short-circuited shall be approximately equal to the **short-circuit voltage** expressed as a percentage of the **rated supply voltage**. The specimen with the short-circuit shall then be checked as follows. The unloaded **transformer** shall be supplied at 1,1 times the **rated input voltage** at ambient temperature and the input power (watt) measured shall be equal to the value of the **rated output** with a tolerance of $\pm 20\%$. During the measurement, no adjustments shall be made.

27.2.1 Portable transformers shall be placed on a dull black painted plywood support as described in 14.2.

Stationary transformers, not designed to be built in, shall be mounted 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 this test, the **input circuit** shall be protected by a 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 when applicable, shall be 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.

For **transformers** with self-resettable protective devices, all the protective devices are short-circuited.

If the non-self-resettable or replaceable protective device, if any, interrupts the circuit, the supply shall be switched off and the **transformer** shall be left to cool down for 2 h. Then the protective device shall be reset or replaced, and the supply shall be switched on until the device interrupts the circuit or an interruption in the **transformer** occurs. If no interruption in the **transformer** occurs, 30 cycles shall be conducted in the case of resettable protective 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.

27.2.2 After the test of 27.2.1 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 8a of Clause 18.
- b) **Transformers** where no definitive interruption has occurred after the cycling test shall withstand the test voltages according to Table 8a of Clause 18.

Transformers with protection index IP 20 and higher shall not allow 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.

27.3 Resistance to fire

All parts of the **transformer** made of insulating material shall be resistant to ignition and spread of fire.

This requirement does not apply to decorative trims, knobs and other parts not likely to be ignited or to propagate flames originating from inside the **transformer**.

Compliance is checked by subjecting parts made of insulating materials to the glow-wire test, specified in IEC 60695-2-10 and amended in Annex E of this standard.

The test shall be performed on a complete **transformer**. If this is not possible, a suitable specimen of the part to be tested shall be used.

If necessary, parts of an **enclosure** can be removed or a suitable specimen can be cut off to perform the test. However, care shall be 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. Burning or molten drops, if any, shall not ignite the tissue paper, as specified in 4.187 of ISO 4046-4, spread out horizontally as a single layer (200 ± 5) mm below the specimen.

Only one specimen shall be tested. In case of inconclusive results, the test is repeated on two additional specimens and both shall pass the test.

27.3.1 External accessible parts

External parts of insulating materials 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 with the temperature of the glow wire as follows:*

- 650 °C for **enclosures**
- 650 °C for parts retaining current carrying (keeping in position) parts in position and terminals for external conductors which carry a current up to 0,2 A during normal operation
- 750 °C for parts retaining (keeping in position) current carrying parts in position and terminals for external conductors with fixed connection (e.g., soldering) which carry a current exceeding 0,2 A during normal operation
- 850 °C for parts retaining (keeping in position) current carrying parts in position and terminals for external conductors with non-fixed connection which carry a current exceeding 0,2 A during normal operation

No glow wire tests are required for foils in thin sheet form with a thickness of up to 0,2 mm.

27.3.2 Internal parts

Parts of insulating materials retaining (keeping in position) current carrying parts in position shall be resistant to ignition and spread of fire.

Compliance is checked by subjecting the parts of insulating materials to the glow-wire test with the temperature of the glow wire as follows:

- 550 °C for internal insulating material not retaining (not keeping in position) current carrying parts in position
- 650 °C for coil formers (bobbins)
- 650 °C for parts retaining (keeping in position) current carrying parts in position and terminals for external conductors which carry a current up to 0,2 A during normal operation
- 750 °C for parts retaining (keeping in position) current carrying parts in position and terminals for external conductors with fixed connection (e.g., soldering) which carry a current exceeding 0,2 A during normal operation
- 850 °C for parts retaining (keeping in position) current carrying parts in position and terminals for external conductors with non fixed connection which carry a current exceeding 0,2 A during normal operation

No glow wire tests are required for foils in thin sheet form with a thickness of up to 0,2 mm.

27.4 Resistance to tracking

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 pollution degree 3.

For materials 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 1 This requirement applies to the outer surfaces of iron cores, in which 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 shall be removed from the parts to be tested by immersion in trichloroethane for 10 min. The parts shall then be 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 shall be 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 2 Traces of rust on sharp edges and any yellowish film removable by rubbing are ignored.

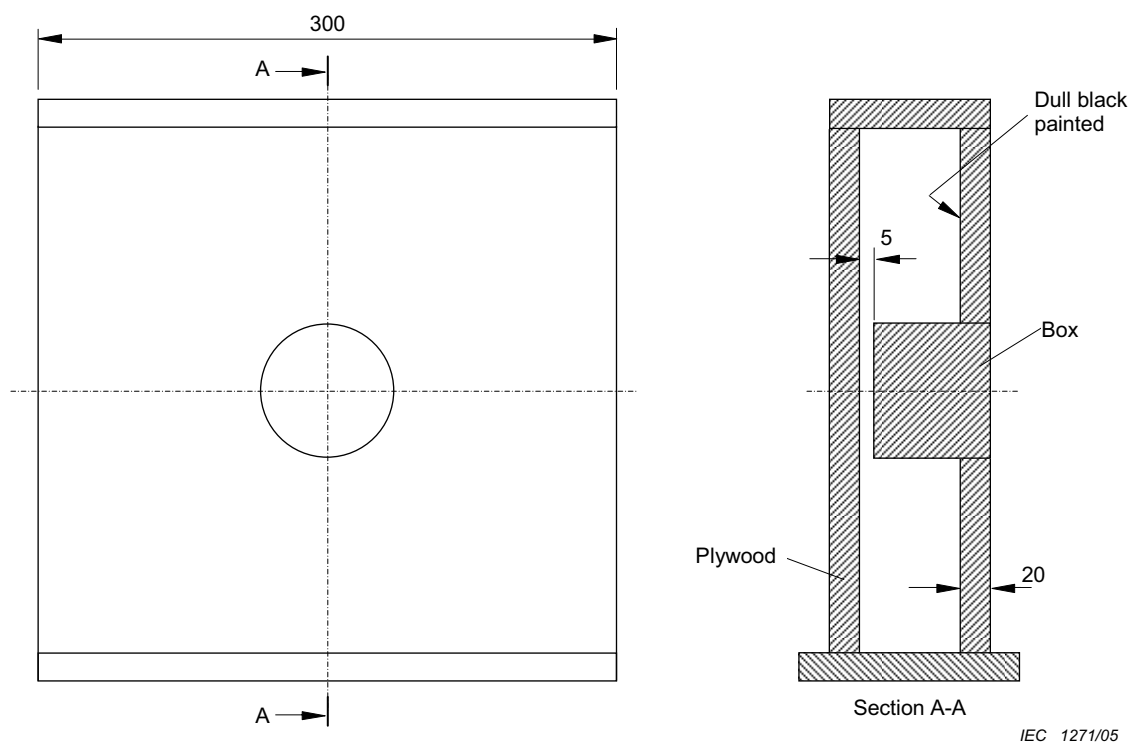
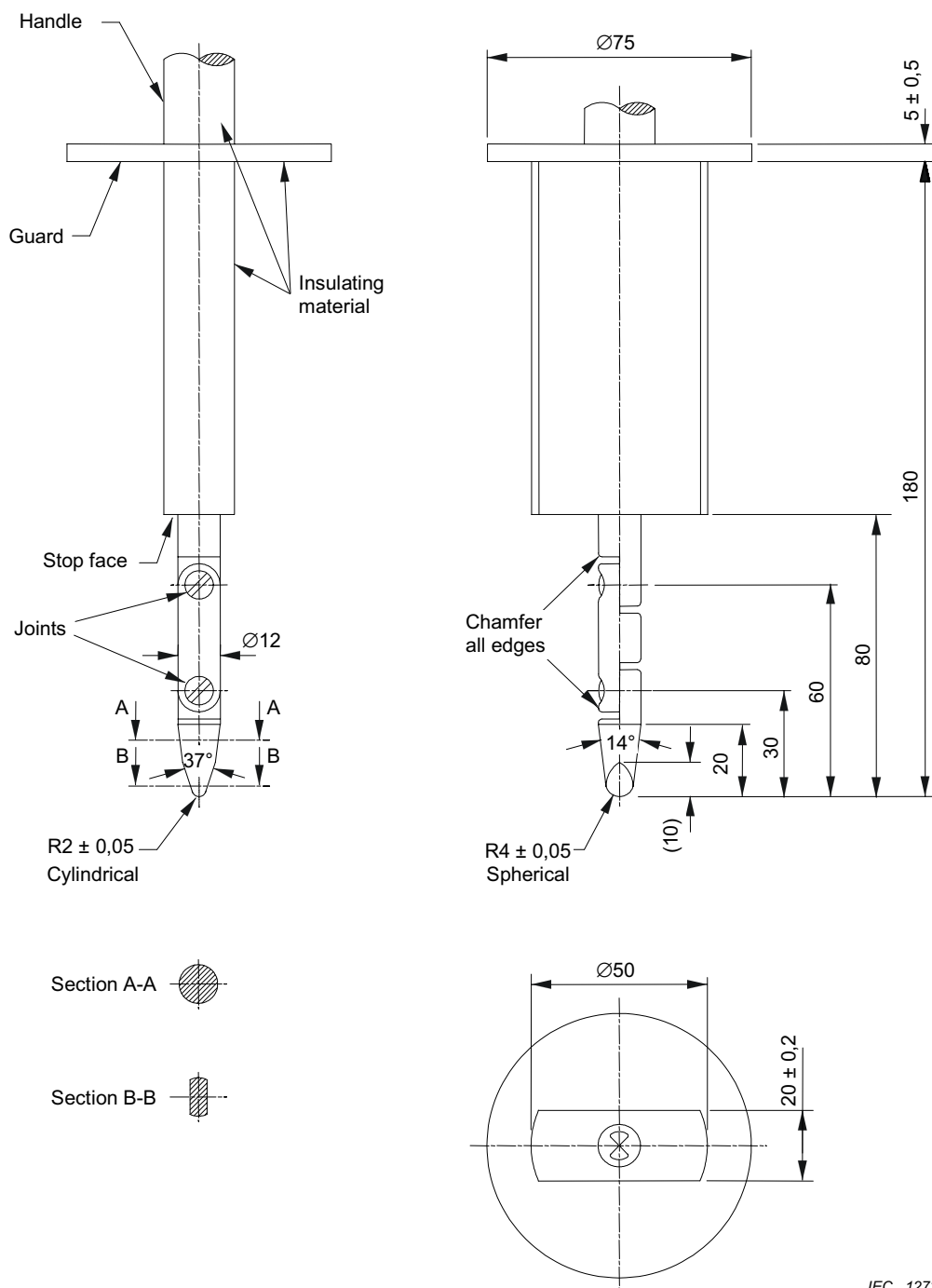


Figure 1 – Mounting box for flush-type transformer (see 5.10)



IEC 1272/05

Material: metal, except where otherwise specified

Linear dimensions in millimetres

Tolerances on dimensions without specific tolerance:

on angles: $0/-10^\circ$

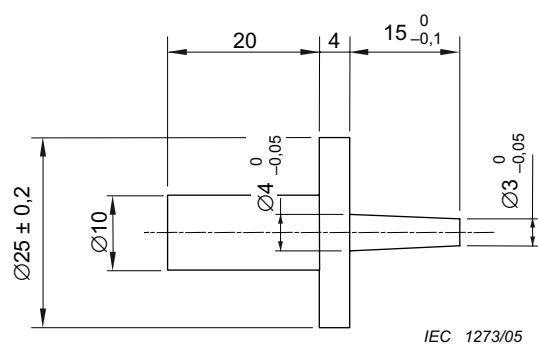
on linear dimensions:

– up to 25 mm: $\begin{matrix} 0 \\ -0,05 \end{matrix}$

– over 25 mm: $\pm 0,2$

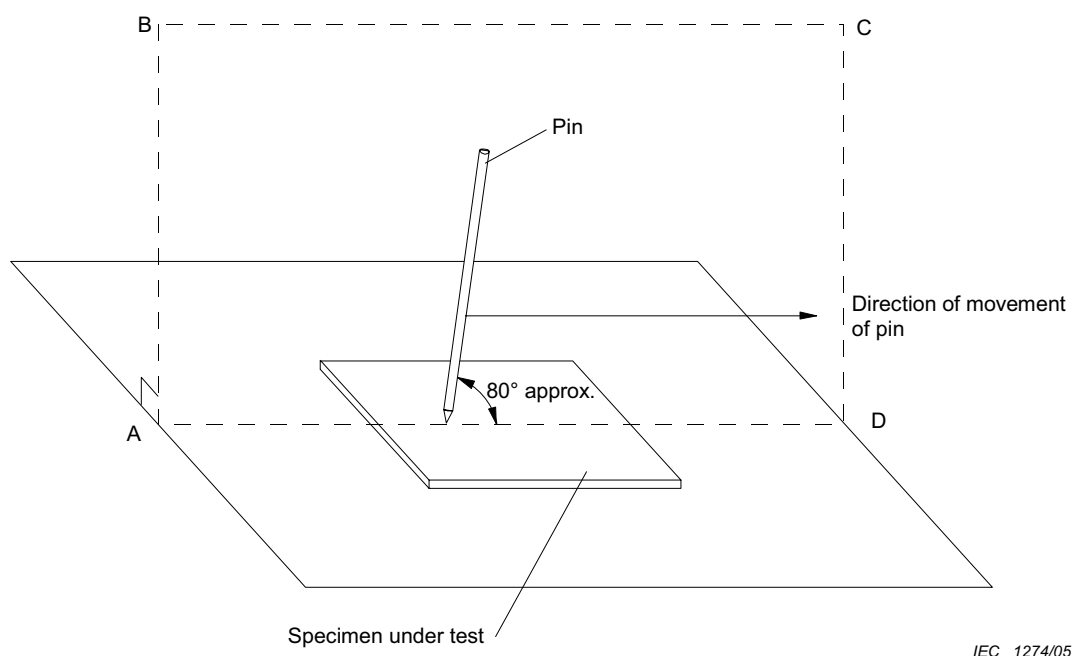
Both joints shall permit movement in the same plane and the same direction through an angle of 90° with a 0° to $+10^\circ$ tolerance.

Figure 2 – Standard test finger (see 9.1.2, 15.5.2 and IEC 61032, test probe B)



Dimensions in millimeters

Figure 3 – Test pin (see 9.2 and IEC 61032, test probe 13)



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

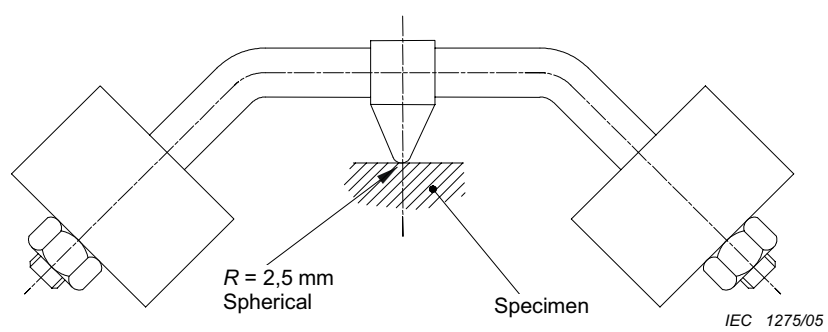


Figure 5 – Ball-pressure apparatus (see 27.1)

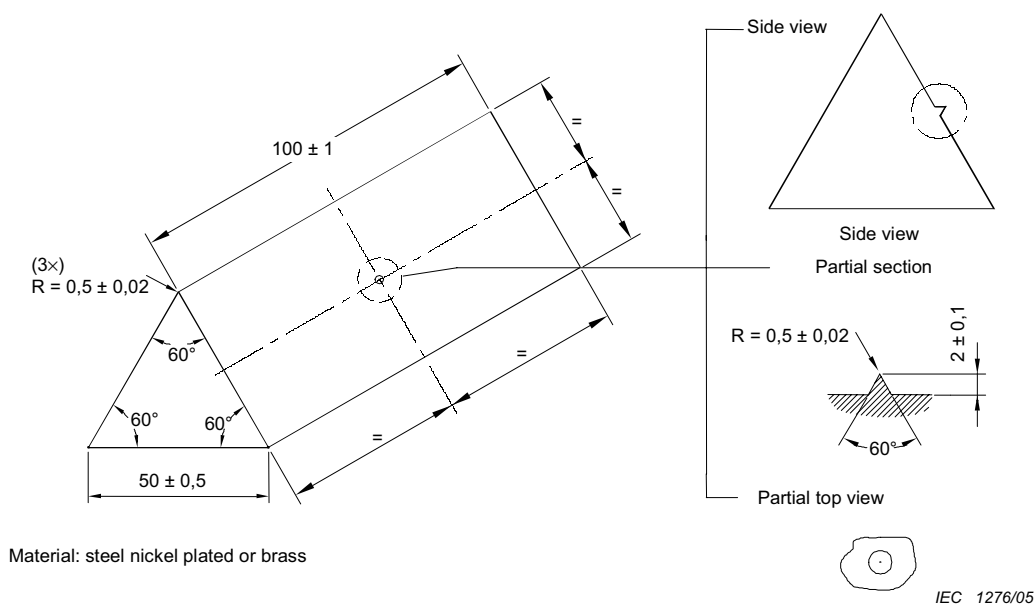


Figure 6a – Mandrel

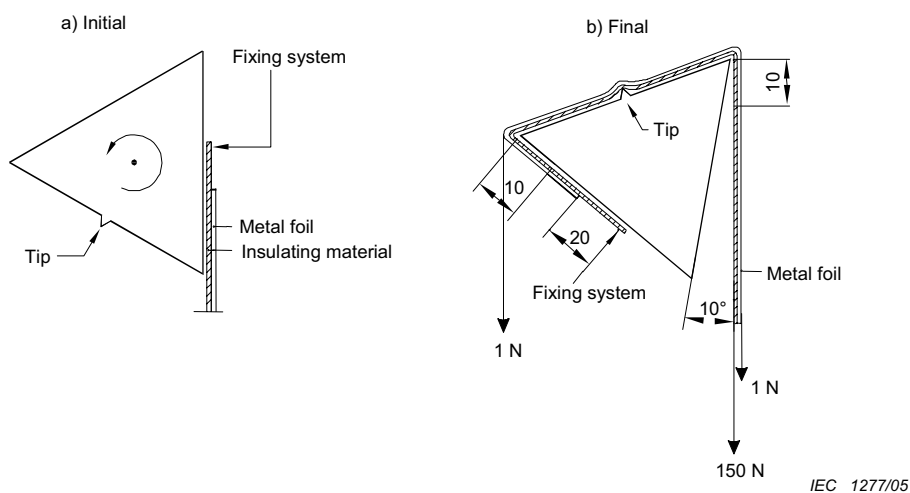


Figure 6b – Position of mandrel

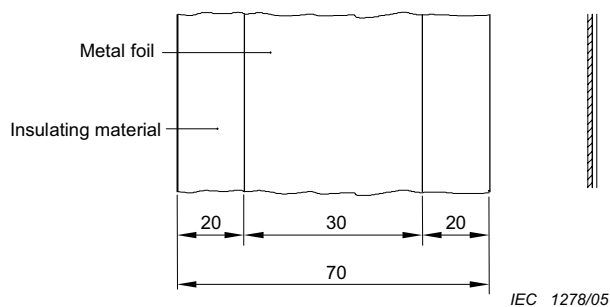
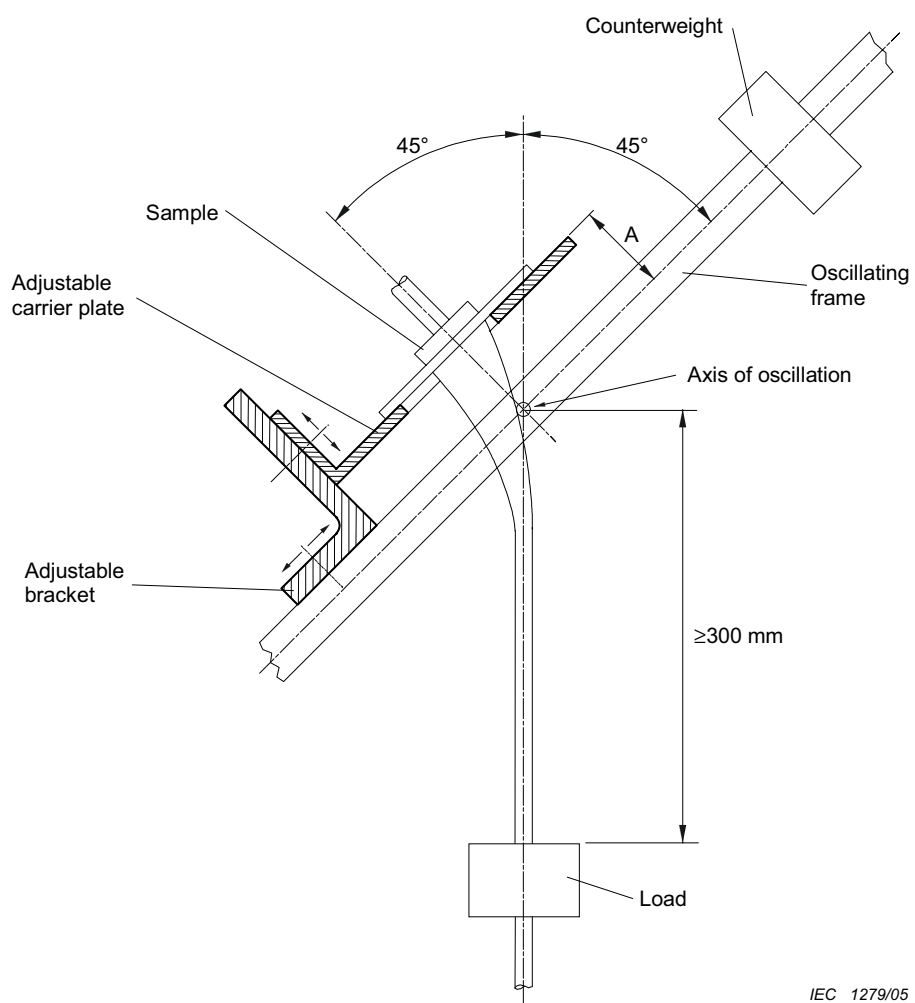


Figure 6c – Position of metal foil on paper

Figure 6 – Test arrangement for checking mechanical withstanding of insulating materials in thin sheet layers (see 26.3)



IEC 1279/05

Figure 7 – Flexing test apparatus (see 22.9.4)

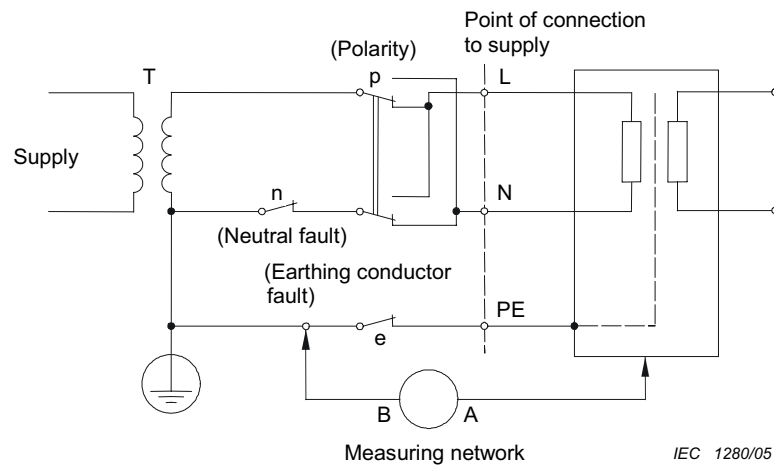


Figure 8 – Test configuration: single-phase equipment on star TN or TT system

Annex A (normative)

Measurement of creepage distances and clearances

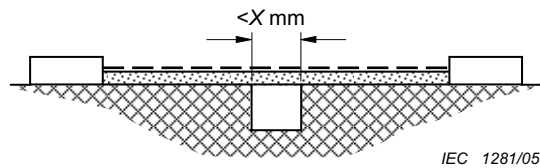
The widths *X* of grooves specified in Examples 1 to 10 below apply to all examples as a function of the **pollution degree** as follows:

Pollution degree	Width <i>X</i> of grooves Minimum values mm
1	0,25
2	1,0
3	1,5
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 Examples 1 to 10. These cases do not differentiate between gaps and grooves or between types of insulation.

The following assumptions are made:

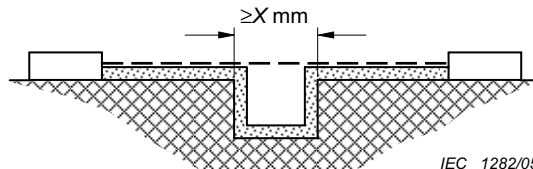
- *any recess is assumed to be bridged with an insulating link having a length equal to the specified width *X* and being placed in the most unfavourable position (see Example 3);*
- *where the distance across a groove is equal to or larger than the specified width *X*, the **creepage distance** is measured 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

IEC 1281/05

Condition: Path under consideration includes a parallel or converging sided groove of any depth with a width of less than X mm.

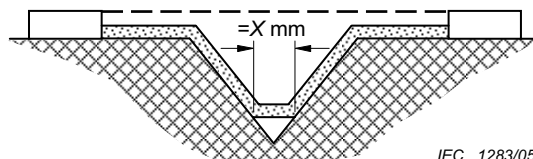
Rule: **Creepage distance** and **clearance** are measured directly across the groove as shown above.

Example 2

IEC 1282/05

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

IEC 1283/05

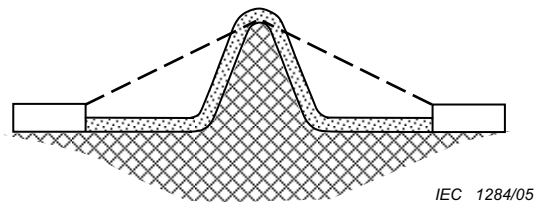
Condition: Path under consideration includes a V-shaped groove with an internal angle of less than 80° and a width greater than X mm.

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.

— — — — — Clearance

===== Creepage distance

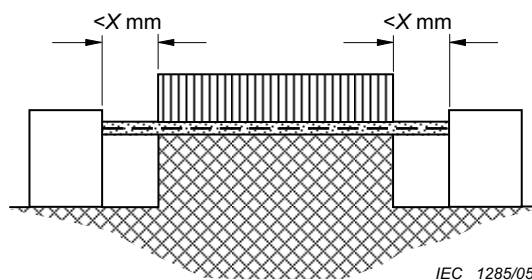
Example 4



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.

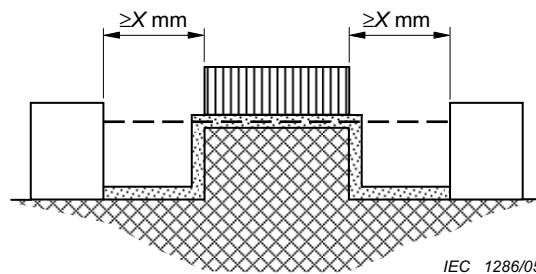
Example 5



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



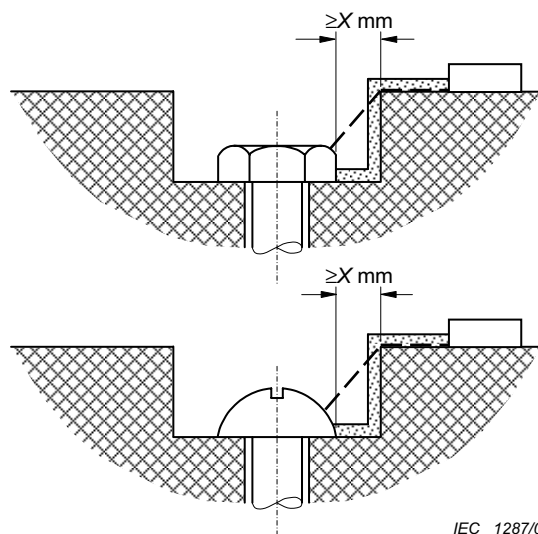
Condition: Path under consideration includes an uncemented joint with grooves equal to or more than X mm wide on each side.

Rule: Clearance path is the "line of sight" distance. Creepage follows the contour of the groove.

— — — — — Clearance

..... Creepage distance

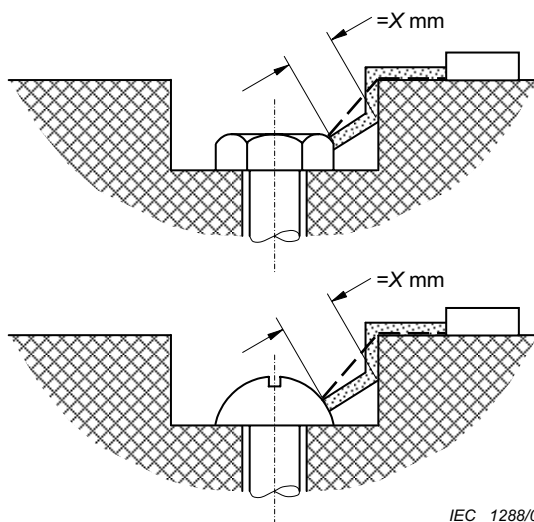
Example 9



IEC 1287/05

Gap between head of screw and wall of recess too narrow to be taken into account.

Example 10



IEC 1288/05

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 requirements 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 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:

- input voltage range;
- output voltage range;
- number of tapping and/or windings;
- supply frequency in the declared frequency range;
- **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 tappings;
- one of the highest rated output, with the lowest voltages and the lowest number of tappings;
- one of the lowest rated output, with the highest number of tappings with the highest voltage difference between adjacent windings;
- one of the medium rated output, with medium voltages and medium number of tappings;
- 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 alternatives should be used.

- b) for parameter 4): one sample of the lowest supply frequency and, in case of doubt, one sample of the highest supply 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)

Creepage distances (cr), clearances (cl) and distances through insulation (dti)
Material group II (400 ≤CTI <600)

Table C.1 – Creepage distances (cr), clearances (cl) and distances through insulation (dti) – Material group II (400 ≤CTI <600)

NOTE The following table extends over several pages. For notes and footnotes, please see the final page of the table.

Dimensions in millimetres

	Type of insulation	Measurement				Working voltages ^b V											
		Through winding enamel ^a		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
						dti		dti		dti		dti		dti		dti	
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	0,85	0,5	1,0	1,5	1,5	3,0	3,0	5,5	5,5	8,0	8,0
					X	0,8	1,7	0,8	2,0	1,5	2,2	3,0	4,2	5,5	8,6	8,0	14,0
		X				0,2	0,85	0,2	1,0	0,5	1,1	1,5	2,1	3,0	4,3	5,5	7,1
			X			0,8	1,7	0,8	2,0	0,8	2,2	1,5	4,2	3,0	8,6	5,5	14,0
	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	dti		dti		dti		dti		dti		dti	
		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	1,0	1,5	1,5	3,0	3,0	5,5	5,5	8,0	8,6	14,0	14,0
		X			X	0,8	2,0	1,5	2,8	3,0	4,2	5,5	8,6	8,0	17,2	14,0	28,0
			X			0,2	1,0	0,5	1,4	1,5	2,0	3,0	4,3	5,5	8,6	8,0	14,0
				X		0,8	2,0	0,8	2,8	1,5	4,2	3,0	8,6	5,5	17,2	8,0	28,0
		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					dti		dti		dti		dti		dti		dti	
		X	X	X	X	0,1 ^d [0,05] ^e	0,2 ^d [0,07] ^e	0,25 ^d [0,08] ^e	0,5 ^d [0,16] ^e	0,7 ^d [0,19] ^e	1,0 ^d [0,25] ^e						
	c) Distances through insulation between input and output circuits, see 26.3	X	X	X	X	0,2 ^d [0,1] ^e	0,3 ^d [0,1] ^e	0,5 ^d [0,15] ^e	1,0 ^d [0,3] ^e	1,5 ^d [0,4] ^e	2,0 ^d [0,5] ^e						

Table C.1 (continued)

	Type of insulation	Measurement		Working voltages ^b V															
				Through winding enamel ^a		Other than through winding enamel		≥25 ≤50		100		150		300		600		1 000	
		P2	P3																
3) Insulation between adjacent input circuits or insulation between adjacent output circuits ^{c g}	Creepage distances and clearances Reduced values see 26.2 (P1)	X		X		X		0,2	0,85	0,2	1,0	0,2	1,1	0,5	2,1	1,5	4,3	3,0	7,1
			X		X			0,8	1,7	0,8	2,0	0,8	2,2	0,8	4,2	1,5	8,6	3,0	14,0
								–	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 b) Over 6 A up to and including 16 A c) Over 16 A	X	X	X		X		3,0		3,6		4,0		6,0		9,0		12,5	
		X		X		X		5,0		6,0		7,0		10,0		13,0		16,0	
		X	X	X		X		10,0		11,0		12,0		14,0		17,0		20,0	
5) Basic or supplementary insulation ^h	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 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 d) live parts and an intermediate conductive part e) an intermediate conductive part and the body Reduced values, see 26.2 (P1)			X			0,2	0,9	0,5	1,0	1,5	1,5	3,0	3,0	3,0	5,5	5,5	8,0	8,0
					X			0,8	1,7	0,8	2,0	1,5	2,2	3,0	4,2	5,5	8,6	8,0	14,0
		X						0,2	0,9	0,2	1,0	0,5	1,1	1,5	2,1	3,0	4,3	5,5	7,1
			X					0,8	1,7	0,8	2,0	0,8	2,2	1,5	4,2	3,0	8,6	5,5	14,0
								–	0,03	–	0,1	–	0,24	–	0,7	–	1,7	–	3,2

Table C.1 (continued)

	Type of insulation	Measurement		Working voltages ^b V														
				≥25 ≤50		100		150		300		600		1 000				
		Through winding enamel ¹⁾	Other than through winding enamel	cl	cr	cl	cr	cl	cr	cl	cr	cl	cr	cl	cr			
		P2	P3	P2	P3													
6) Reinforced or double insulation	Between the body and live parts or where it is required by the standard (excluding insulation between input and output windings)			X		0,5	1,0	1,5	1,5	3,0	3,0	5,5	5,5	8,0	8,6	14,0	14,0	
					X	0,8	2,0	1,5	3,0	3,0	4,2	5,5	8,6	8,0	17,2	14,0	28,0	
		X			0,2	1,0	0,5	1,5	1,5	2,1	3,0	4,3	5,5	8,6	8,0	14,0		
			X		0,8	2,0	0,8	3,0	1,5	4,2	3,0	8,6	5,5	17,2	8,0	28,0		
7) Distance through insulation	Between body and live parts of the output circuit if protected by additional provisions against transient voltages	X	X	X		0,2	1,0	0,2	1,5	0,5	2,1	1,5	4,3	3,0	8,6	5,5	14,0	
	Reduced values, see 26.2 (P1)					0,8	2,0	0,8	3,0	0,8	4,2	1,5	8,6	3,0	17,2	5,5	28,0	
	a) Basic insulation ^f	X	X	X	X	–	0,25	–	0,4	–	0,7	–	1,7	–	4,0	–	7,5	
	b) Supplementary insulation ^f																	
	c) Reinforced insulation (excluding insulation between input and output circuit)	X	X	X	X	0,2 ^d [0,1] ^e	0,3 ^d [0,1] ^e	0,3 ^d [0,1] ^e	0,5 ^d [0,15] ^e	1,0 ^d [0,3] ^e	1,5 ^d [0,4] ^e	2,0 ^d [0,5] ^e						
NOTE 1 For Material Group IIIa see Table 13 in Part 1 and for Material Group I see Annex D.																		
NOTE 2 P1 = pollution degree 1, P2 = pollution degree 2, P3 = pollution degree 3.																		
NOTE 3 When a numeric figure is replaced by a dash in a column of the table, it means that no value is required.																		
NOTE 4 The minimum values of clearance in this table are applicable in air up to 2 000 m above sea level.																		
^a Measurement through winding wire enamel if at least one winding is constructed with wire complying with at least grade 1 of IEC 60317.																		
^b 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 8a is considered sufficient.																		
^c 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, if only the windings are intended to be connected in a series or parallel arrangement (e.g. input voltage 110/220 V).																		
^d For solid insulation																		
^e In case of insulation consisting of thin sheets																		
^f 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 metals parts, with the exception of insulated wires (see 19.12).																		
^g For insulation between SELV circuits and adjacent circuits other than SELV or PELV , the values of this box shall be replaced by the values of boxes 6 and 7 (according to 19.1).																		
^h In case of a physical breakdown of the basic insulation or supplementary insulation , the thickness of the insulation is added to the clearance.																		

NOTE 1 For Material Group IIIa see Table 13 in Part 1 and for Material Group I see Annex D.

NOTE 2 P1 = pollution degree 1, P2 = pollution degree 2, P3 = pollution degree 3.

NOTE 3 When a numeric figure is replaced by a dash in a column of the table, it means that no value is required.

NOTE 4 The minimum values of clearance in this table are applicable in air up to 2 000 m above sea level.

a Measurement through winding wire enamel if at least one winding is constructed with wire complying with at least grade 1 of IEC 60317.

b 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 8a is considered sufficient.

c 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, if only the windings are intended to be connected in a series or parallel arrangement (e.g. input voltage 110/220 V).

d For solid insulation

e In case of insulation consisting of thin sheets

f 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 metals parts, with the exception of insulated wires (see 19.12).g For insulation between **SELV circuits** and adjacent **circuits** other than **SELV** or **PELV**, the values of this box shall be replaced by the values of boxes 6 and 7 (according to 19.1).h In case of a physical breakdown of the **basic insulation** or **supplementary insulation**, the thickness of the insulation is added to the clearance.

Annex D (normative)

Creepage distances (cr), clearances (cl) and distances through insulation (dti) Material group I (CTI ≥600)

**Table D.1 – Creepage distances (cr), clearances (cl) and distances through insulation (dti) –
Material group I (CTI ≥600)**

NOTE The following table extends over several pages. For notes and footnotes, please see the final page of the table.

	Type of insulation	Measurement		Working voltages ^b V											
				100			150			300			600		
		Through winding enamel ^a		≥25		≤50		100		150		300		600	
		P2	P3	P2	P3	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	8,0
					X	0,8	1,5	0,8	1,8	1,5	2,0	3,0	3,9	5,5	7,7
	Reduced values, 26.2 (P1)	X				0,2	0,6	0,2	0,7	0,5	0,8	1,5	1,5	3,0	5,5
			X			0,8	1,5	0,8	1,8	0,8	2,0	1,5	3,9	3,0	7,7
2) Insulation between input and output circuits (double or reinforced insulation)	b) Distances through insulation between input or output circuits and an earthed metal screen	X	X	X	X	dti		dti		dti		dti		dti	
	c) Distances through insulation between input and output circuits	X	X	X	X	dti		dti		dti		dti		dti	
	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	14,0
		X			X	0,8	1,8	1,5	2,5	3,0	3,9	5,5	7,7	8,0	14,0
	Reduced values, see 26.2 (P1)		X			0,2	0,7	0,5	1,0	1,5	1,5	3,0	3,0	5,5	10,0
						0,8	1,8	0,8	2,5	1,5	3,9	3,0	7,7	5,5	25,0
	b) Distances through insulation between input or output circuits and an earthed metal screen, see 26.3					–	0,25	–	0,4	–	0,7	–	1,7	–	7,5
		X	X	X	X	dti		dti		dti		dti		dti	
	c) Distances through insulation between input and output circuits, see 26.3					0,1 ^d	0,2 ^d	0,2 ^d	0,2 ^d	0,25 ^d	0,25 ^d	0,5 ^d	0,5 ^d	0,7 ^d	1,0 ^d
		X	X	X	X	[0,05] ^e	[0,07] ^e	[0,07] ^e	[0,07] ^e	[0,08] ^e	[0,08] ^e	[0,16] ^e	[0,16] ^e	[0,19] ^e	[0,25] ^e

Dimensions in millimetres

Table D.1 (continued)

	Type of insulation	Measurement				Working voltages ^b V											
		Through winding enamel ^a		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 ^{c, g}	Creepage distances and clearances	X		X		0,2	0,6	0,2	0,7	0,2	0,8	0,5	1,5	1,5	3,0	3,0	5,0
			X		X	0,8	1,5	0,8	1,8	0,8	2,0	0,8	3,9	1,5	7,7	3,0	12,5
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	Reduced values see 26.2 (P1)					–	0,18	–	0,25	–	0,3	–	0,7	–	1,7	–	3,2
		X	X	X	X	3,0		3,6		4,0		6,0		9,0		12,5	
		X	X	X	X	5,0		6,0		7,0		10,0		13,0		16,0	
		X	X	X	X	10,0		11,0		12,0		14,0		17,0		20,0	
5) Basic or supplementary insulation ^h	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 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 d) live parts and an intermediate conductive part e) an intermediate conductive part and the body Reduced values, see 26.2 (P1)	X	X	X	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
						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
						0,8	1,5	0,8	1,8	0,8	2,0	1,5	3,9	3,0	7,7	5,5	12,5
						–	0,03	–	0,1	–	0,24	–	0,7	–	1,7	–	3,2

Table D.1 (continued)

	Type of insulation	Measurement		Working voltages ^b V														
		Through winding enamel ^a		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 or where it is required by the standard (excluding insulation between input and output windings)					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	0,8	1,8	1,5	2,5	3,0	3,9	5,5	7,7	8,0	16,0	14,0	25,0	25,0	
	X				0,2	0,7	0,5	1,0	1,5	1,5	3,0	3,0	5,5	6,0	8,0	10,0	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	25,0	
7) Distance through insulation	Between body and live parts of the output circuit if protected by additional provisions against transient voltages	X		X		0,2	0,7	0,2	1,0	0,5	1,5	3,0	3,0	6,0	5,5	10,0	10,0	
	Reduced values, see 26.2 (P1)					0,8	1,8	0,8	2,5	0,5	3,9	1,5	7,7	3,0	16,0	5,5	25,0	
					–	0,25	–	0,4	–	0,7	–	1,7	–	4,0	–	7,5	7,5	
	a) Basic insulation ^f	X	X	X	X	No requirement of thickness												
	b) Supplementary insulation ^f					dti	dti	dti	dti	dti	dti	dti	dti	dti	dti	dti	dti	
		X	X	X	0,1 ^d [0,05] ^e	0,15 ^d [0,05] ^e	0,15 ^d [0,05] ^e	0,25 ^d [0,08] ^e	0,25 ^d [0,08] ^e	0,5 ^d [0,15] ^e	0,5 ^d [0,15] ^e	0,75 ^d [0,20] ^e	0,75 ^d [0,20] ^e	1,0 ^d [0,25] ^e	1,0 ^d [0,25] ^e	1,0 ^d [0,25] ^e	1,0 ^d [0,25] ^e	
	c) Reinforced insulation (excluding insulation between input and output circuit)	X	X	X	X	0,2 ^d [0,1] ^e	0,3 ^d [0,1] ^e	0,3 ^d [0,1] ^e	0,5 ^d [0,15] ^e	0,5 ^d [0,15] ^e	1,0 ^d [0,3] ^e	1,0 ^d [0,3] ^e	1,5 ^d [0,4] ^e	1,5 ^d [0,4] ^e	2,0 ^d [0,5] ^e	2,0 ^d [0,5] ^e	2,0 ^d [0,5] ^e	
NOTE 1 For Material Group IIIa, see Table 13, and for Material Group II, see Annex C.																		
NOTE 2 P1 = pollution degree 1, P2 = pollution degree 2, P3 = pollution degree 3.																		
NOTE 2 When a numeric figure is replaced by a dash in a column of the table it means that no value is required.																		
NOTE 4 The minimum values of clearance in this table are applicable in air up to 2000 m above sea level.																		
^a Measurement through winding wire enamel if at least one winding is constructed with wire complying with at least grade 1 of IEC 60317.																		
^b 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 8a is considered sufficient.																		
^c 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, if only the windings are intended to be connected in a series or parallel arrangement (e.g. input voltage 110/220 V).																		
^d For solid insulation																		
^e In case of insulation consisting of thin sheets																		
^f 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 metals parts, with the exception of insulated wires (see 19.12).																		
^g For insulation between SELV circuits and adjacent circuits other than SELV or PELV , the values of this box shall be replaced by the values of boxes 6 and 7 (according to 19.1).																		
^h In case of a physical breakdown of the basic insulation or supplementary insulation , the thickness of the insulation is added to the clearance.																		

Annex E (normative)

Glow-wire test

The glow-wire test is carried out in accordance with IEC 60695-2-10 and IEC 60695-2-11.

For the purpose of this standard, the following applies with reference to the relevant clauses and subclauses of IEC 60695-2-11.

E.1 Severity

The requirements of Clause 6, “Severities,” of IEC 60695-2-11 apply, except that the temperature of the tip of the glow-wire is that stated in 27.3 of this standard.

E.2 Conditioning

The requirements of Clause 8, “Conditioning”, of IEC 60695-2-11 apply, but preconditioning is required.

E.3 Test procedure

The requirements of Clause 10, “Test procedure”, of IEC 60695-2-11 apply with the following addition to 10.1.

“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 manually operated switches which are parts of transformers assembly

F.1 General

The tests on switches being either integrated or incorporated in the **transformers** are carried out in accordance with IEC 61058-1 as stated in F.2 or F.3.

Manually operated mechanical switches shall comply with the requirements of F.2 or F.3.

F.2 Switches tested as a separate component

The switch, tested as a separate component, shall comply with the requirements and tests of IEC 61058-1, modified as follows:

- subclause 7.1.6.2: the switch shall be suitable for use in the relevant **pollution degree** situation;
- subclause 7.1.9.3: the switch shall be of category D regarding the resistance to heat and fire.

In addition, the characteristics of the switches as described in IEC 61058-1 shall be appropriate for the function of the switches under normal operating conditions with regard to:

- a) Clause 6: the rating of the switches;
- b) The classification of the switches according to:
 - subclause 7.1.1: nature of supply,
 - subclause 7.1.2: type of load to be controlled by the switches,
 - subclause 7.1.3: ambient air temperature

If the switch energises or de-energises the socket-outlet(s) in the **secondary circuit**, the rated output current and the rated peak surge current of the socket-outlet(s) of Table F.1 shall be taken into account as specified in F.3.2.

Compliance is checked by inspection and by measurements according to test specifications of IEC 61058-1.

F.3 Switches tested as part of the transformer

The switch, tested as part of the apparatus **transformer** working under normal operating conditions, shall meet the requirements of F.3.1, F.3.2 and F.3.3.

F.3.1 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 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.3.2 If the switch energises or de-energises the socket-outlet(s) in the **secondary circuit**, 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 d) of 8.1). The peak surge current of the additional load shall have a value as shown in Table F.1.

Table F.1 – Peak surge current of the additional load

Rated current I 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 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 F.3.3 and F.3.4, respectively, in the given order.

F.3.3 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 are 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), i) and m) of IEC 61058-1, taking into account the rated current of the socket-outlet(s), if any, including the peak surge current according to Clause F.3.

F.3.4 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

G.1 General

The tracking tests on the **transformers** are carried out in accordance with IEC 60112 as follows.

For the purpose of this standard, materials are classified into three groups by their comparative tracking index (CTI) values, as follows:

- material group I $600 < (CTI)$;
- material group II $400 < (CTI) < 600$;
- material group IIIa $175 < (CTI) < 400$.

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.

G.2 Test specimen

The requirements of Clause 3 “Test specimen”, of IEC 60112 apply except that the last sentence of the first paragraph does not apply.

G.3 Test apparatus

The requirements of Clause 5 “Test apparatus”, of IEC 60112 apply except that the:

- *The note in 5.1 does not apply*
- *Note 4 in 5.3 does not apply*
- *Test solution A as described in 5.4 is used.*

G.4 Procedure

The requirements of Clause 6 “Procedure”, of IEC 60112 apply except that:

- *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

For **transformers** including **electronic circuits**, the following requirements apply additionally to Clauses 5, 15, 26.

H.1 General notes on tests (addition to Clause 5)

H.1.1 All clauses of Part 1, as modified in this annex, and in the parts 2 for the specific **transformers**, apply to electronic circuits.

H.1.2 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.2 Short circuit and overload protection (addition to Clause 15)

H.2.1 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.2.3 for all circuits or parts of circuits, unless they comply with the conditions specified in H.2.2.

*If the safety of the **transformer** under any of the fault conditions depends on the operation of a fuse-link, the test of H.2.4 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;
- 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.2.2, 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.2.2 Fault conditions a) to f) specified in H.2.3 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 to the electronic circuit.*

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 to the electronic circuit, 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.2.3 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.
- d) Short circuit of any two terminals of an electronic component, other than integrated circuits. This fault condition is not applied between the two circuits of an optocoupler.
- e) Open circuit or short circuit inside an integrated circuit. In that case, the possible hazardous situations of the **transformer** are assessed to ensure that safety does not rely on the correct functioning of such a component.

All possible output signals of the integrated circuit are considered in the result. If it can be shown that a particular output signal is unlikely to occur, then the relevant fault is not considered.

NOTE 1 Microprocessors are tested as integrated circuits.

NOTE 2 Semiconductor components such as thyristors and triacs are subjected to fault conditions b) and d).

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

For simulation of the fault conditions, the **transformer** is operated at any supply voltage between 0,94 times and 1,06 times the **rated supply voltage**.

Where any of the fault conditions are simulated, the test is continued until steady conditions are established.

In each case, the test is ended if interruption of the supply occurs within the **transformer**.

If the **transformer** incorporates an electronic circuit which operates to ensure compliance with Clause 15, the relevant test is repeated with a single fault simulated, as indicated in a) to e) above.

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

Positive temperature coefficient resistors (PTCs) and negative temperature coefficient resistors (NTCs) are not short-circuited if they are used within their manufacturer's declared specification.

H.2.4 If, for any of the fault conditions specified in H.2.3, the safety of the **transformer** depends on the operation of a fuse-link, the test is repeated but with the fuse-link replaced by an ammeter.

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

For miniature fuse-links complying with IEC 60127-3 the following applies.

If the current measured does not exceed 2,1 times the rated current of the fuse-link, the circuit is not considered to be adequately protected, and the test is carried out with the fuse-link short-circuited.

If the current is at least 2,75 times the rated current of the fuse-link, the circuit is considered to be adequately protected.

If the current measured exceeds 2,1 times the rated current of the fuse-link, but does not exceed 2,75 times the rated current, the fuse-link is short-circuited and the test is carried out:

- for quick acting fuse-links for the relevant period, or for 30 min, whichever is the shorter;
- for time lag fuse-links, for the relevant period, or for 2 min, whichever is the shorter.

NOTE The verification whether the fuse-link acts as a protective device is based on the fusing characteristics specified in IEC 60127-3, which also gives the information necessary to calculate the maximum resistance of the fuse-link.

For fuses other than those complying with IEC 60127-3, the test is carried out as specified in 15.3.2 to 15.3.5.

H.3 Creepage distances, clearances and distances through insulation (addition to Clause 26)

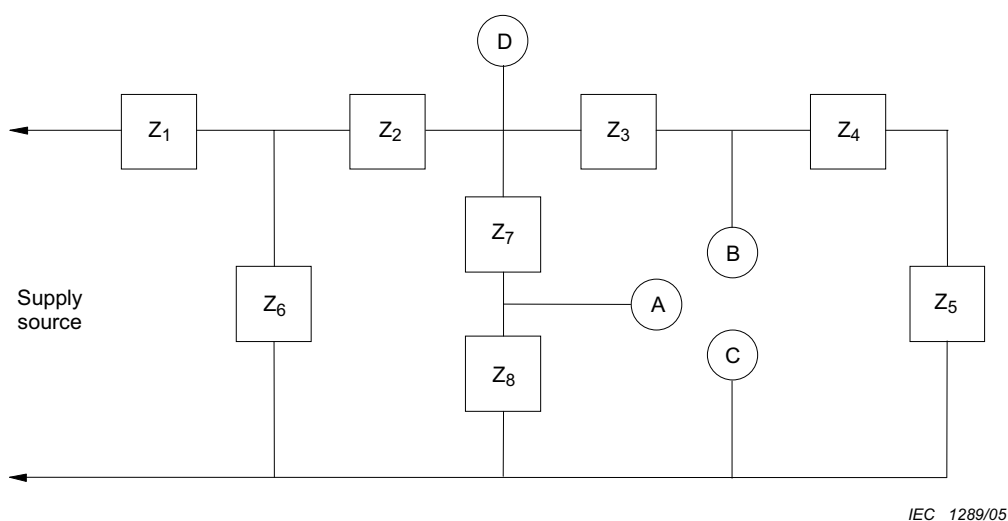
H.3.1 For **live parts** of different polarity separated by **basic insulation** only, **creepage distances** and **clearances** smaller than those specified in Clause 26 are allowed, provided the requirements of Clause H.2 are met if these **creepage distances** and **clearances** are short-circuited in turn.

Creepage distances and **clearances** within optocouplers are not measured if the individual insulation is adequately sealed, and if air is excluded between individual layers of the material.

If coatings are used on printed circuit boards to protect the microenvironment or to provide **basic insulation**, Annex W applies. Smaller distances as required in IEC 60664-3, Clause 4 are applicable (type 1 protection: P1 value; type 2 protection distances to insulation).

For cycling tests for potted **transformers** see 26.2 .

H.3.2 For optocouplers, the conditioning procedure is carried out at a temperature of 50 K in excess of the maximum temperature measured on the surface of the optocoupler during the tests of Clauses 14 or 15, the optocoupler being operated under the most onerous conditions which occur during these tests.



D is a point furthest from the supply source where the maximum power delivered to external load exceeds 15 W.

A and B are points closest to the supply source where the maximum power delivered to external load does not exceed 15 W. These are low-power points.

Points A and B are separately short-circuited to C.

The fault conditions a) to e) specified in H.2.3 are applied individually to Z_1 , Z_2 , Z_3 , Z_6 , and Z_7 .

Figure H.1 – Example of an electronic circuit with low-power points (see H.2.2)

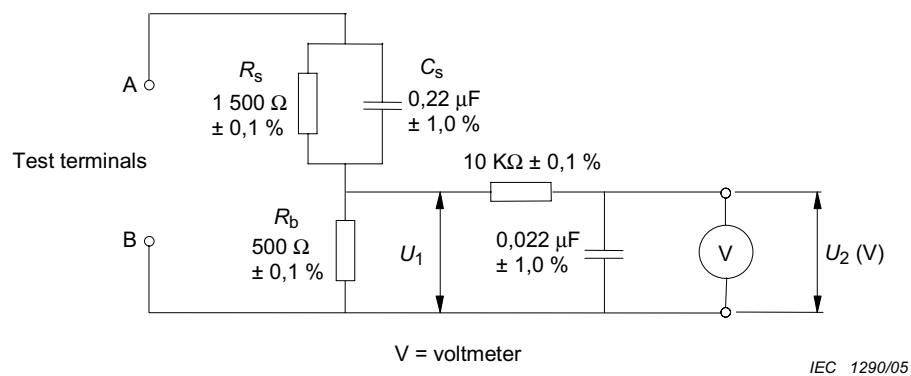
Annex I

(void)

Annex J (normative)

Measuring network for touch-currents

(Taken from Figure 4 of IEC 60990.)



True r.m.s. reading

Input capacitance: $\leq 200\,\text{pF}$

Uncertainty: $\leq 2\,\%$

Supply frequency range: 15 Hz to 1 MHz

Input resistance: $0,1\,\text{M}\Omega$

Figure J.1 – Measuring network for touch-current

Annex K (normative)

Insulated winding wires for use as multiple layer insulation

This annex specifies winding wire insulated with polyimide film or equivalent insulation, that may be used to provide **basic**, **supplementary** or **reinforced insulation** in wound parts without additional interleaved insulation.

NOTE Typical values of some properties of polyimide are given below for information. Adherence to these values is not part of this standard.

– Dielectric strength	180 kV/mm
– Dielectric constant	3,5
– Dissipation factor	0,003 at 1 kHz
– Insulation resistance	10^5 M Ω
– Surface resistivity	10^{16} Ω at 50 % relative humidity
– Folding endurance	10^4 cycles.

K.1 Wire construction

Winding wire shall be insulated with two or more layers. In case of spirally wrapped layers of tape, contra-rotation layers shall be used. Overlap of these layers shall be adequate to ensure continued overlap during manufacture of the wound part.

Such layers of tape shall be sealed to eliminate creepage paths between layers.

K.2 Conformance tests

The wire shall pass the following five type tests K.2.1 to K.2.5.

K.2.1 Dielectric strength

Test 13 of IEC 60851-5, applied for the same duration as in 18.3, with a test voltage not less than the appropriate voltage in Table 8a of this standard, or 3 kV in case of two layers and 5,5 kV in case of three layers, whichever is the greater in each case.

K.2.2 Adherence and flexibility

Test 8 of 5.1 of IEC 60851-3, followed by the dielectric strength test of K.2.1, carried out at rated ambient temperature.

K.2.3 Heat shock

Test 9 of 3.1.1 and 3.2 of IEC 60851-6, followed by the dielectric strength test of K.2.1.

K.2.4 Retention of dielectric strength after bending

Test 13 of 4.1 to 4.5 of IEC 60851-5, followed by the dielectric strength test of K.2.1.

K.2.5 Resistance to abrasion

Test 11 of IEC 60851-3 is applicable.

K.3 Routine test (production tests)

The wire shall be subjected by the wire manufacturer to 100 % dielectric strength testing in accordance with IEC 60851-5, with a test voltage not less than the appropriate voltage in Table 8a of this standard, or 3 kV in the case of two layers and 5,5 kV in the case of three layers, whichever is the greater in each case.

Annex L (normative)

Routine tests (production tests)

The tests specified in this annex are intended to reveal, as far as safety is concerned, unacceptable variations in material or manufacture. These tests are intended not to impair the properties and the reliability of the **transformer**, and shall be made by the manufacturer on each **transformer** after production. The inspection is to check that the following is ascertained on 100 % of the products by the manufacturer production system.

These test should be made at the temperature of the production line.

Further tests may have to be made to ensure that every **transformer** conforms with the specimens that withstood the tests of this standard, depending on the experience gained by the manufacturer.

The routine tests shall in principle be carried out at the end of the production. However they may be carried out at an earlier stage if it can be shown that the procedure provide the same degree of safety.

L.1 Protective earthing continuity test

For **class I transformers**, a current of at least 10 A, derived from a source with a no-load voltage not exceeding 12 V, is passed in turn between the protective earth terminal and each of accessible conductive parts which have to be earthed for safety reasons.

During this test, no interruption of the connections or substantial decrease of the current shall occur between the protective earth terminal and the relevant accessible metal part conductive parts.

L.2 Checking of no-load output voltage

The **no-load output voltage** shall comply with the declared value and tolerance stated by the manufacturer and shall in addition not exceed the maximum **no-load output voltage** required by the relevant part 2.

L.3 Dielectric strength test

The test is made in accordance with Table 8a of 18.3 at ambient temperature and without the moisture test of 17.2.

The specified test voltage is applied for 1 s.

The tests are made between:

- a) **live parts** of the **input circuits** and accessible conductive parts of the **transformer**;
- b) **input circuits** and **output circuits**.

No flashover or breakdown shall occur during the test.

Additional tests may be required for high insulation level **transformers** and **separating transformers** with **working voltage** above 1 000 V.

L.4 Checking of protective devices mounting

The operation of a protection device, if any, shall not be prevented by incorrect mounting of the device in the **transformer**.

Compliance is checked by inspection.

L.5 Visual inspection

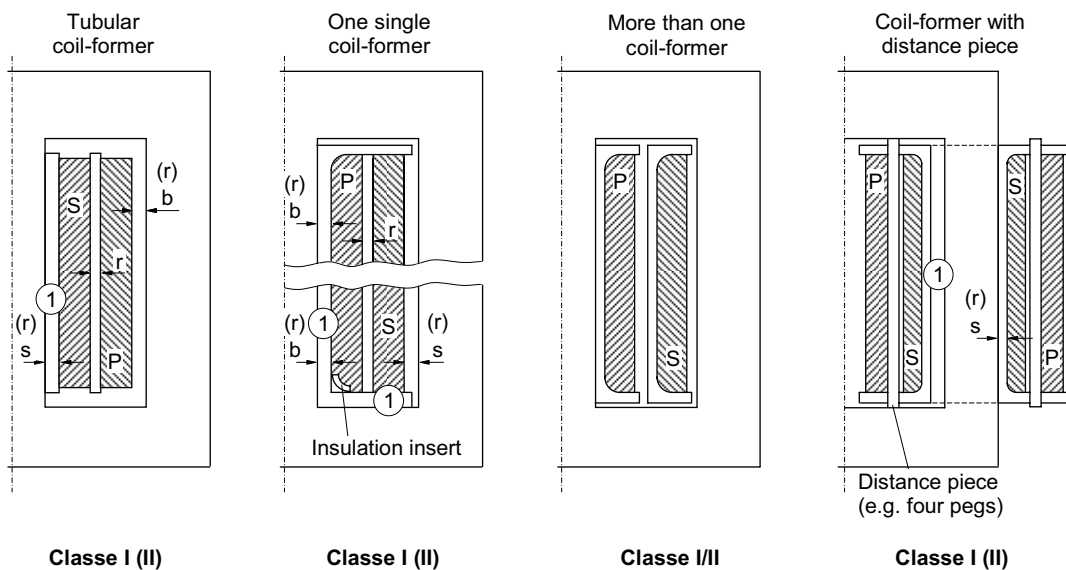
Visual inspection shall ensure that all required and relevant markings are provided.

Annex M (informative)

Examples to be used as a guide for 19.1

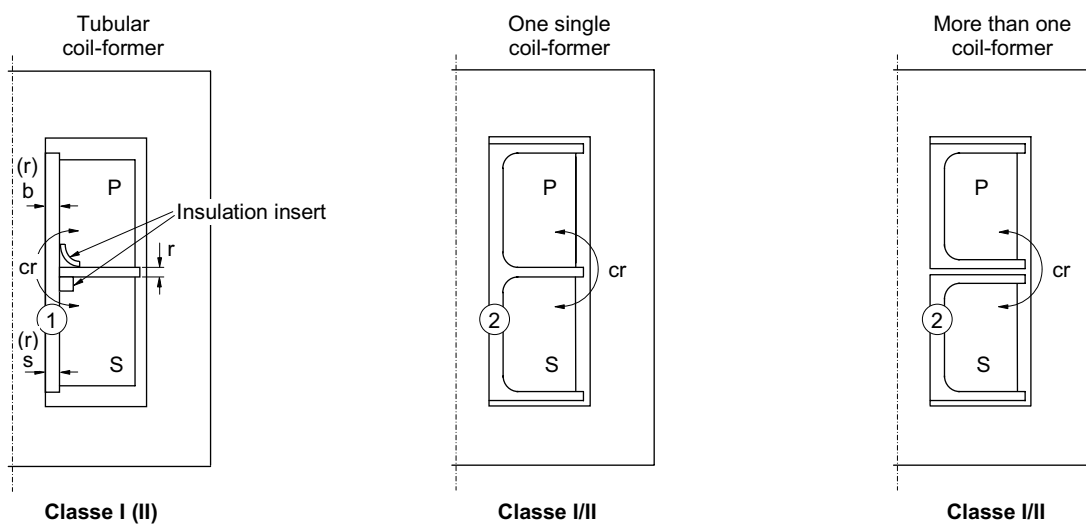
M.1 Coil-former

M.1.1 Concentric type



IEC 1291/05

M.1.2 Side-by-side type

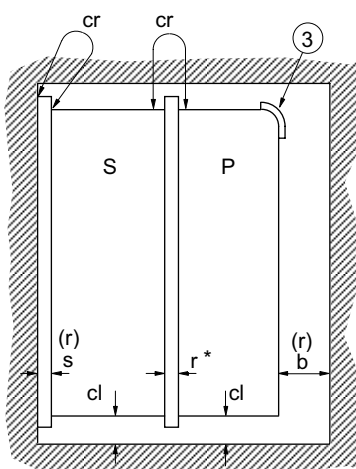


IEC 1292/05

- 1: A tube of a specified thickness for **supplementary insulation** or at least three layers of tape (see Clause 26).
- 2: Formed part of thickness as specified for **supplementary insulation** in Clause 26.

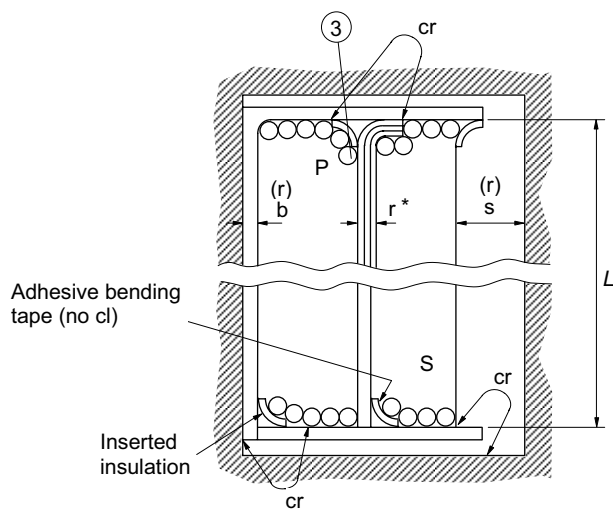
M.2 Windings

M.2.1 Without screen



Class I (II)

M.2.1 a)



Class I (II)

IEC 1293/05

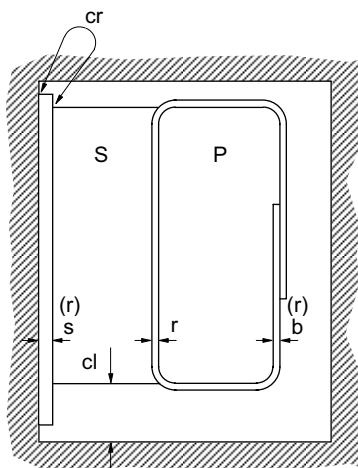
M.2.1 b)

r^* : One piece of specified thickness or at least three layers of tape.

r^{**} : One piece of specified thickness plus an adhesive tape or an insulation insert or at least three layers of tape plus, for example, an adhesive tape or at least four layers of serrated tape

3: Last turn of winding prevented from being displaced.

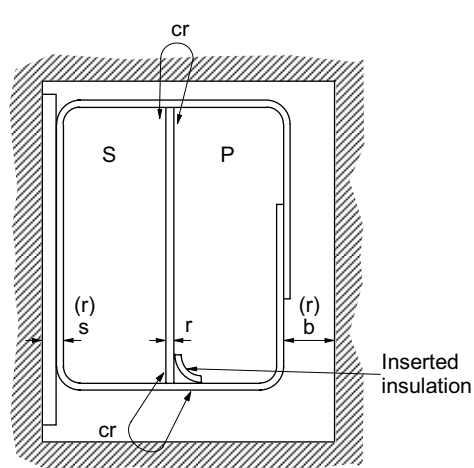
For example adhesive bonding tape or a bonding agent.



Input or output wrapped with insulating material

Class I (II)

M.2.1 c)



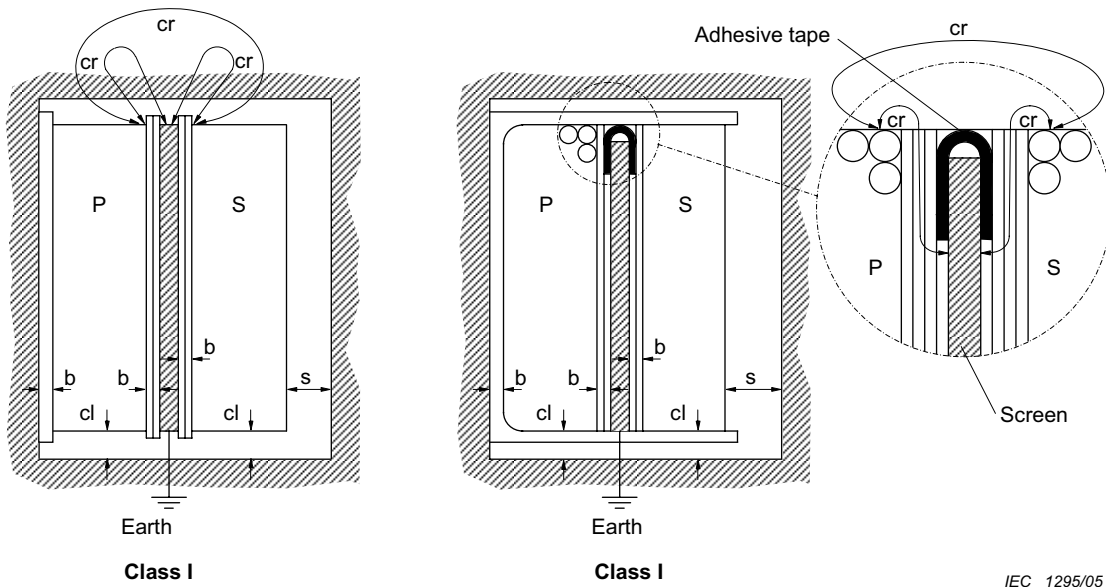
Input and output wrapped with insulating material (no cr)

Class I (II)

M.2.1 d)

IEC 1294/05

NOTE For class II construction the abbreviations are given in brackets.

M.2.2 With screen

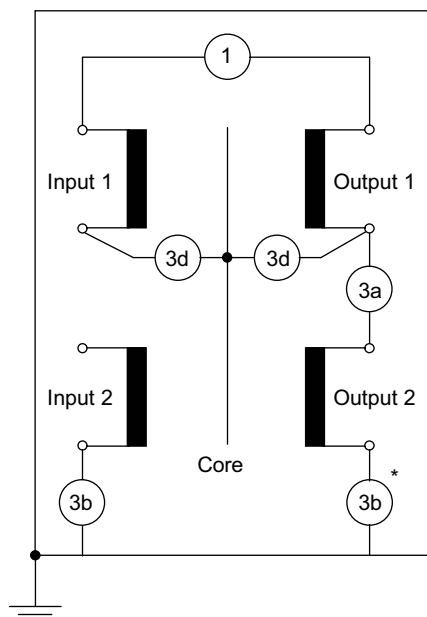
IEC 1295/05

For class I constructioncr = **creepage distance**cl = **clearance**b = **basic insulation**s = **supplementary insulation**r = **reinforced insulation or double insulation**P = **input or first winding**S = **output or second winding**

Annex N (informative)

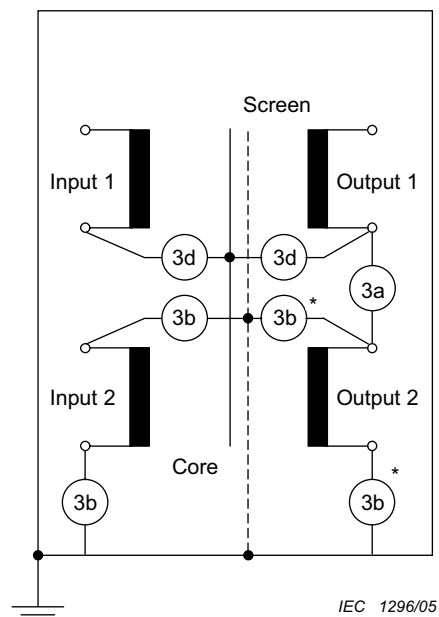
Examples of points of application of test voltages

NOTE Numbers in circles refer to certain items in Table 8a. Other methods of construction or layout may be used.



Example 1

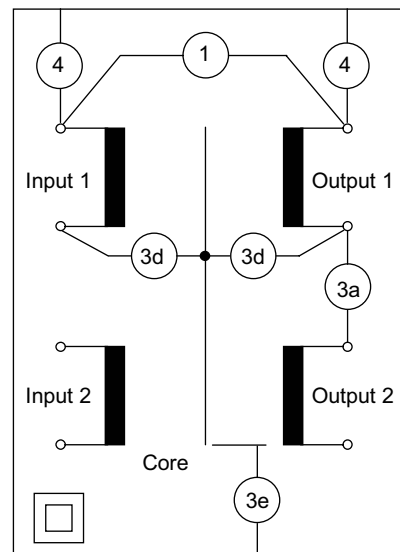
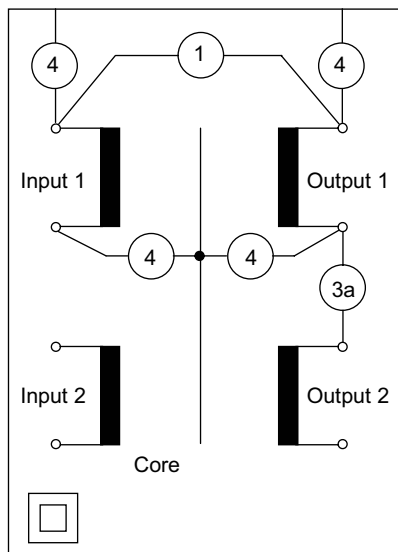
Transformer of class I construction.



Example 2

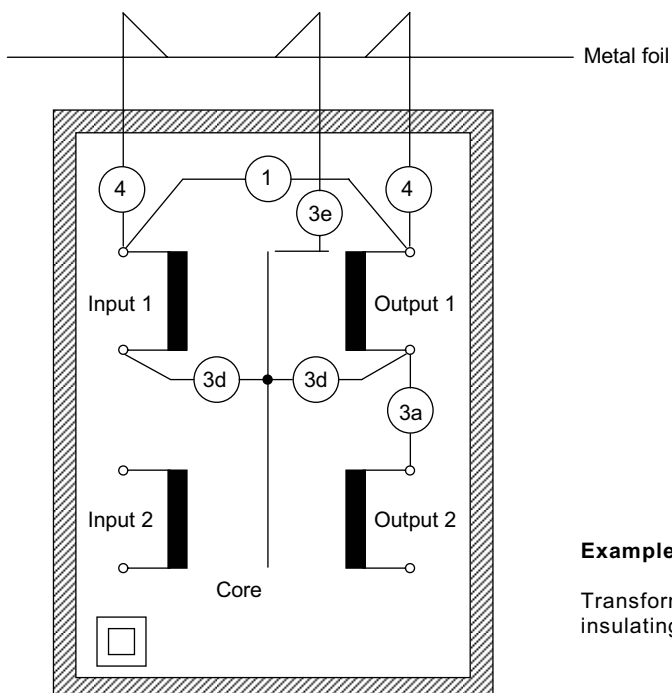
Transformer of class I construction with earthed metal screen

IEC 1296/05



IEC 1297/05

Example 3 Transformer of class II construction with metal enclosure

a) Core connected to the **body**b) Core not connected to the **body**

Example 4

Transformer of class II construction with **enclosure** of insulating material

IEC 1298/05

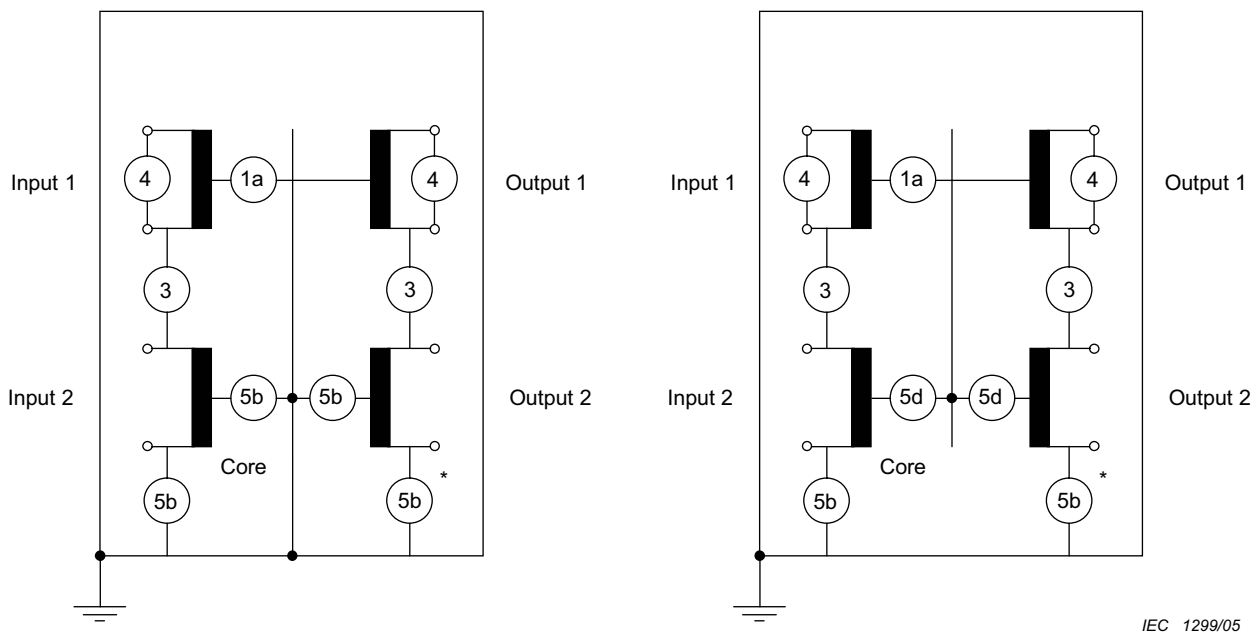
Annex O

(void)

Annex P (informative)

Examples of points of measurement of creepage distances and clearances

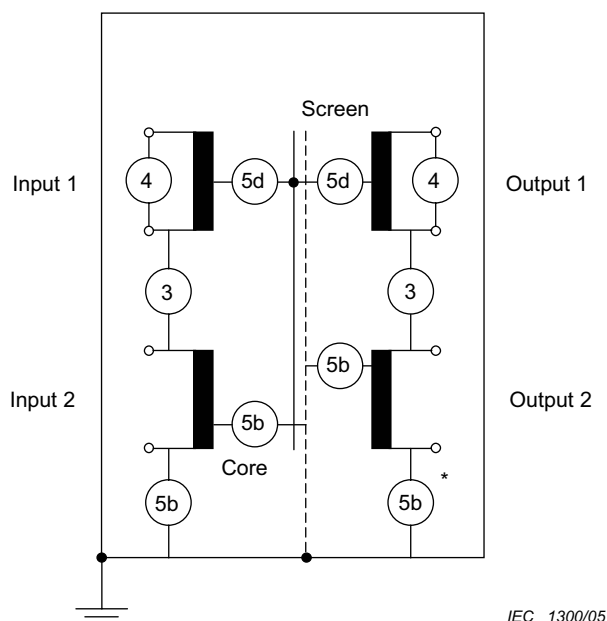
NOTE Numbers in circles refer to certain items in Table 13, Table C.1 and Table D.1. Other methods of construction or layout may be used.



Example 1 – Transformer of class I construction

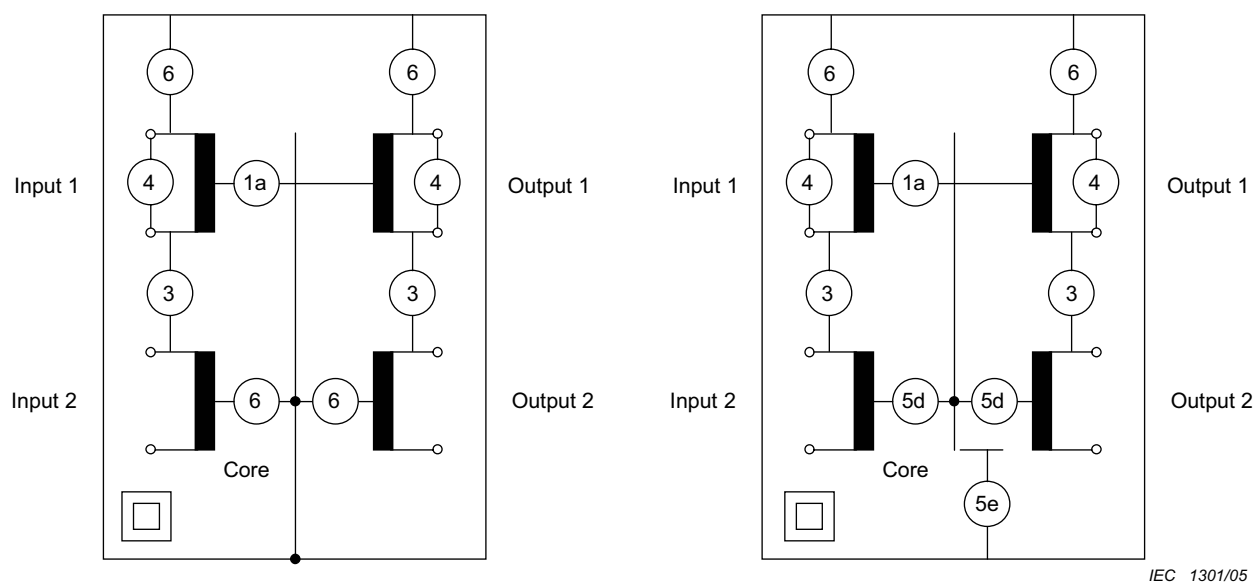
a) Core connected to the **body**

b) Core not connected to the **body**



Example 2

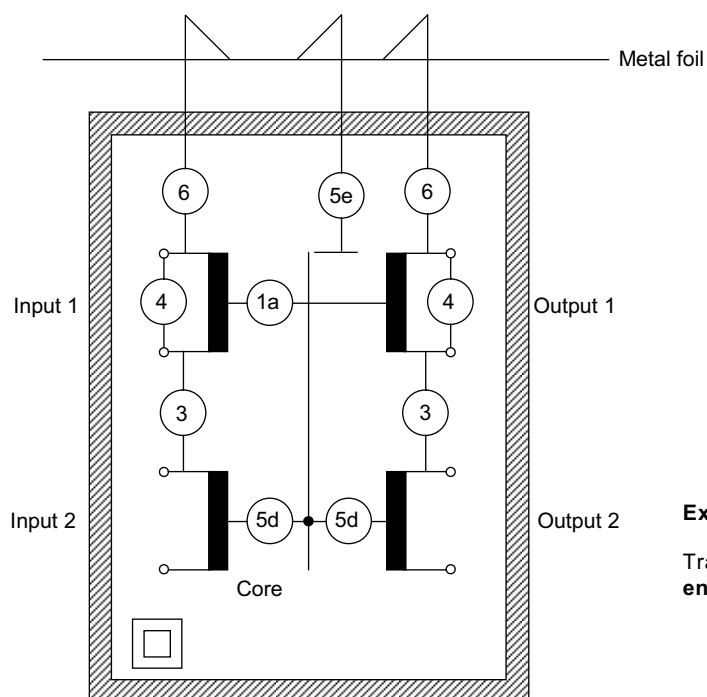
Transformer of class I construction with earthed metal screen



Example 3 – Transformer of class II construction with metal enclosure

a) Core connected to the **body**

b) Core not connected to the **body**



Example 4

Transformer of class II construction with **enclosure** of insulating material

IEC 1302/05

Annex Q (informative)

Explanation of IP numbers for degrees of protection

For full details see IEC 60529 from which the following is an extract.

Q.1 The type of protection covered by this system of classification is as follows:

- a) protection of persons against contacts with, or approach to, **live parts** and against contact with moving parts (other than smooth rotating shafts and the like) inside the **enclosure**;
- b) protection of the equipment against ingress of solid foreign objects.

Q.2 Protection of the equipment inside the **enclosure** against harmful ingress of water.

The designation indicating the degrees of protection consists of the characteristic letters IP followed by two numerals (the "characteristic numerals") indicating conformity with the conditions stated in Tables Q.1 and Q.2 respectively. The first numeral indicates the degree of protection described under item a) above and the second numeral the degree of protection described under item b) above.

Table Q.1 – Degrees of protection indicated by the first characteristic numeral

First characteristic numeral	Degree of protection	
	Short description	Brief details of objects which will be "excluded" from the enclosure
0	Non-protected	No special protection
1	Protected against solid objects greater than 50 mm	A large surface of the body, such as a hand (but no protection against deliberate access). Solid objects exceeding 50 mm in diameter
2	Protected against solid objects greater than 12,5 mm	Fingers or similar objects not exceeding 80 mm in length. Solid objects exceeding 12,5 mm in diameter
3	Protected against solid objects greater than 2,5 mm	Tools , wires, etc., of diameter or thickness greater than 2,5 mm. Solid objects exceeding 2,5 mm in diameter
4	Protected against solid objects greater than 1,0 mm	Wires or strips of thickness greater than 1,0 mm. Solid objects exceeding 1,0 mm in diameter
5	Dust-protected	Ingress of dust is not totally prevented but dust does not enter in sufficient quantity to interfere with satisfactory operation of the equipment
6	Dust-tight	No ingress of dust

Table Q.2 – Degrees of protection indicated by the second characteristic numeral

Second characteristic numeral	Degree of protection	
	Short description	Details of the type of protection provided by the enclosure
0	Non-protected	No special protection
1	Protected against dripping water	Dripping water (vertically falling drops) shall have no harmful effect
2	Protected against dripping water when enclosure tilted up to 15°	Vertically dripping water shall have no harmful effect when the enclosure is tilted at any angle up to 15° from its normal position
3	Protected against spraying water	Water sprayed at an angle up to 60° on either side of the vertical shall have no harmful effects Water falling as a spray at an angle up to 60° from the vertical shall have no harmful effect
4	Protected against splashing water	Water splashed against the enclosure from any direction shall have no harmful effect
5	Protected against water jets	Water projected by a nozzle against the enclosure from any direction shall have no harmful effect
6	Protected against powerful waterjet	Water projected in powerful jets shall not enter the enclosure in harmful quantities
7	Protected against the effects of temporary immersion in water	Ingress of water in a harmful quantity shall not be possible when the enclosure is temporarily immersed in water under defined conditions of pressure and time
8	Protected against the effects of continuous immersion in water	The equipment is suitable for continuous immersion in water under conditions which shall be specified by the manufacturer ^a
^a Normally, this will mean that the equipment is hermetically sealed. However, with certain types of equipment it can mean that water can enter but only in such a manner that it produces no harmful effects.		

Annex R (normative)

Explanations of the application of 4.1.1.2.1 of IEC 60664-1 (see 26.2)

R.1 Impulse dielectric test:

- wave-form: 1,2 / 50 µs
- three impulses of each polarity
- interval between impulses at least 1 s
- impulse voltage according to Table 5 of IEC 60664-1
- rated impulse voltage according to **working voltage** and overvoltage category of Table 1 of IEC 60664-1
- for **double** or **reinforced insulation** the next higher value according to 2.1.1.2 of IEC 60664-1 is to be used (See 3.1.5 of IEC 60664-1). With this value the applicable impulse voltage in Table 5 of IEC 60664-1 can be found.

R.2 Example:

Working voltage: 300 V (r.m.s.) cat. III

⇒ acc. Table 1: 4 000 V (rated impulse voltage)

⇒ **double insulation** ⇒ 6 000 V (next higher value according to 2.1.1.2 rated impulse voltage)

⇒ acc. Table 5 (6 000 V) = 7,3 kV (impulse test voltage)

Table R.1 – Impulse test voltage according to 4.1.1.2.1 of IEC 60664-1

Working voltage V a.c.	Overvoltage category III		Overvoltage category II	
	Double or reinforced insulation V a.c.	basic insulation V a.c.	double or reinforced insulation V a.c.	basic insulation V a.c.
50	1 750	910	910	550
100	2 950	1 750	1 750	910
150	4 800	2 950	2 950	1 750
300	7 300	4 800	4 800	2 950
600	9 800	7 300	7 300	4 800
1 000	14 800	9 800	9 800	7 300

Values of test voltage for intermediate values of **working voltage** are found by interpolation between tabulated values.

Example:

AC 230 V	6130 V	3940 V	3940 V	2390 V
----------	--------	--------	--------	--------

NOTE Definitions of overvoltage categories are given in item f) of 2.2.2.1 of IEC 60664-1.

Transformers for general use are in overvoltage category III.

Transformers for use in household appliance are in overvoltage category II

Annex S

(void)

Annex T

(void)

Annex U (informative)

Optional t_w -marking of transformers

For **transformers** with t_w marking, the following requirements apply additionally.

Based on empirical data, the t_w test is only applicable to **transformers** with a **rated output** up to 1 000 VA. Similarly, the maximum t_w temperature has been limited to 140 °C.

For checking the rated maximum operating temperature t_w , this standard specifies an endurance test period of 30 days as the standard method. In other standards where t_w -marking occurs other test periods may be used.

This standard permits the use of constants S other than 4 500 in t_w tests. If a claim is not made to the contrary, the endurance testing of **transformers** is based on the constant S , given in U.5.2, having a value of 4 500. A manufacturer may claim the use of other values if this can be justified by either of the tests specified.

Windings of t_w -marked **transformers** shall have adequate thermal endurance.

Compliance is checked by applying the indicated changes in the different clauses/subclauses specified and by carrying out the tests described.

U.1 General notes on tests (addition to Clause 5)

Introduce the following third and fourth paragraphs in 5.2:

*For t_w -marked **transformers** the type test is carried out on one sample consisting of eight **transformers** submitted for the purpose of type test. Seven **transformers** are for the endurance test and one for all other tests. For conditions of compliance test, see 14.4.*

*The t_w -tests are made under the conditions specified in U.5. In general all tests are made for each type of **transformer** or, where a range of similar **transformers** is involved, for each **rated output** in the range or on a representative selection from the range as agreed with the manufacturer. A reduction of the number of samples for the endurance test according to 14.4 including the use of constants S other than 4 500 according to U.5.2, or even the omission of these tests is allowed when **transformers** of the same construction but with different characteristics are submitted together for approval, or when test reports from the manufacturer or other authority are accepted by the testing station.*

Amend the present fifth paragraph of 5.2 as follows: "... in 14.3 and 14.4."

U.2 Heating (addition to Clause 14)

Change the heading of Clause 14 to "Heating and endurance".

Add the following phrase to the first sentence in 14.1:

"... and windings shall have adequate thermal endurance."

Amend the second paragraph of 14.1 to read as follows:

"Compliance is checked by the test of 14.2 when the temperature of Table 1 shall not be exceeded. When applicable, the thermal endurance of windings is checked by the tests in 14.3 or 14.4. Moreover, the following conditions apply to the windings of not t_w -marked **transformers**. Materials in windings complying with the requirements in 14.4 are regarded as classified materials."

Add the following sentence to the end of the ninth paragraph of 14.1:

For the determination of the average temperature of a winding with t_w -marking the test voltage shall not be increased.

Introduce the following new first indent in Table 1:

Parts	Temperature °C
- with t_w -marking	t_w

Introduce the following new subclause 14.4:

14.4 Thermal endurance

Windings of t_w -marked **transformers** shall have adequate thermal endurance.

Compliance is checked by the following test.

The windings of the **transformers** are subjected to the thermal endurance test described in U.5. The test is carried out on seven new **transformers**, which have been subjected to measurements according to 11.1. They shall not be used for further testing.

This test may also be applied to **transformers** which form an integral part of an appliance and which cannot be tested separately, thereby enabling such integral **transformers** to be assigned with a t_w value.

The thermal conditions shall be so adjusted that the objective duration of the test is as indicated by the manufacturer. If no indication is given, the test period shall be 30 days.

After the test, when the **transformers** have returned to room temperature, they shall satisfy the following requirements:

- The output voltage shall not have changed from the value measured before the test by more than the percentages given for the relevant type of **transformer** in 11.1.

NOTE This test is to determine any adverse change in the **transformer** setting.

- The insulation resistance between the **input** and **output winding(s)** for **safety isolating, isolating** and **separating transformers** and for all kind of **transformers** between winding(s) and the **transformer** enclosure/body measured at 500 V d.c. shall be not less than 1 MΩ.

- c) The **transformer** shall withstand a dielectric strength test; the test voltage being 35 % of the values specified in Clause 18 Table 8a. The test voltage is applied as specified in item b) above.

The result of the test is considered to be satisfactory if at least six of the seven **transformers** satisfy these requirements. The test is considered to be failed if more than two **transformers** fail the test.

In the case of two failures, the test is repeated with seven more **transformers** and no failure of these **transformers** is permitted.

U.3 Short circuit and overload protection (addition to Clause 15)

Add the following new column at the right side of Table 3:

Insulation classification		t_w
Retain the present text without change		See Table U.1

Introduce the following new table U.1:

Table U.1 – Example of maximum temperatures of windings under short circuit or overload conditions and at 110 % of rated voltage for transformers subjected to an endurance test duration of 30 days and a life expectancy of 10 years

Constant S	Maximum temperature °C					
	S4.5	S5	S6	S8	S11	S16
For $t_w = 90$	171	161	147	131	119	110
95	178	168	154	138	125	115
100	186	176	161	144	131	121
105	194	183	168	150	137	126
110	201	190	175	156	143	132
115	209	198	181	163	149	137
120	217	205	188	169	154	143
125	224	212	195	175	160	149
130	232	220	202	182	166	154
135	240	227	209	188	172	160
140	248	235	216	195	178	166

Unless otherwise indicated on the **transformer**, the limiting temperatures specified in column S4.5 apply.

Maximum temperatures for a life expectancy of 5 years will be found by calculation using Equation (U.2) in U.5.1 .

U.4 Testing a series of transformers (modification to Annex B)

Change Annex B as follows:

Clause B.1

Replace the first line of item c) by the following:

c) They are designed for the same minimum and maximum ambient temperature and, if relevant, for the same t_w -marking.

Clause B.2

Add the following new item d):

d) for t_w -marked **transformers**, the parameters above apply with the addition that the samples used for the thermal endurance test shall be of the type in the series having the highest current density (i.e. the highest current per mm² copper conductor area).

U.5 General requirements and information about thermal endurance test on windings

U.5.1 Thermal endurance test

The test is carried out in an appropriate oven.

*The **transformer** shall function electrically in a manner similar to that in normal use, and in the case of capacitors, components or other auxiliaries which should not be subjected to the test, these shall be disconnected and reconnected again in the circuit but outside the oven. Other components which do not influence the operating conditions of the windings may be removed.*

***Transformers** incorporating a protective device shall comply with the thermal endurance test on windings with the protector short-circuited.*

NOTE 1 In the case, e.g. of type testing, where it is necessary to short-circuit protectors and disconnect capacitors, components or other auxiliaries which should not be subjected to the test, it is recommended that the manufacturer supplies special **transformers** with these parts short-circuited or removed and if applicable, any necessary additional connections brought out from the **transformer**.

*In general, to obtain normal operating conditions, the **transformer** is tested with the **rated output**.*

*The **transformer** enclosure, if of metal, is earthed. Loads are always kept outside the oven.*

*The seven **transformers** are placed in the oven, and the rated voltage applied to each of the circuits.*

*The oven thermostats are then regulated so that the internal temperature of the oven attains a value such that the temperature of the hottest winding in each of the **transformers** is approximately equal to the objective value given in Table U.2.*

Table U.2 –Theoretical test temperatures for transformers subjected to an endurance test duration of 30 days and a life expectancy of 10 years

Constant S	Theoretical test temperatures t °C					
	S4.5	S5	S6	S8	S11	S16
For $t_w = 90$	163	155	142	128	117	108
95	171	162	149	134	123	113
100	178	169	156	140	128	119
105	185	176	162	146	134	125
110	193	183	169	152	140	130
115	200	190	175	159	146	136
120	207	197	182	165	152	141
125	215	204	189	171	157	147
130	222	211	196	177	163	152
135	230	219	202	184	169	158
140	238	226	209	190	175	163
<p>Unless otherwise indicated on the transformer, the theoretical test temperatures specified in column S4.5 apply. The use of a constant other than S4.5 shall be justified in accordance with U.5.2</p> <p>Theoretical test temperatures for a life expectancy of 5 years will be found by calculation using Equation (U.2) of this clause.</p>						

After 4 h, the actual temperature of the winding is determined by the "change in resistance" method, and if necessary the oven thermostats are readjusted to approximate as closely as possible the objective test temperature. Thereafter a daily reading of the air temperature in the oven is taken to ensure that the thermostats are maintained at the correct value to within ± 2 °C.

The winding temperatures are measured again after 24 h and the final test period for any **transformer** is determined from Equation (U.2). Figure U.1 illustrates this in graphical form. The permissible difference between the actual temperature of the hottest winding of any of the **transformers** under test and the theoretical value shall be such that the final test period is at least equal to, but not more than twice, the objective test period.

NOTE 2 For the measurement of winding temperature by the "change in resistance" method, the following Equation (U.1) is applicable:

$$t_2 = \frac{R_2}{R_1} (234,5 + t_1) - 234,5 \quad (\text{U.1})$$

where:

t_1 = initial temperature (°C);

t_2 = final temperature (°C);

R_1 = resistance at temperature t_1 ;

R_2 = resistance at temperature t_2 .

The constant 234,5 relates to copper windings, for aluminium this constant should be 225.

No attempt shall be made to hold the winding temperature constant after the measurement at 24 h. Only the ambient air temperature shall be stabilized by the thermostatic control.

*The test period for each **transformer** starts from the time the **transformer** is connected to the supply. At the end of its test, the relevant **transformer** is disconnected from the supply, but is not removed from the oven until the test on the other **transformer** have been completed.*

NOTE 3 The theoretical test temperatures given in Table U.2 correspond to a working life of 10 years continuous operation at the rated maximum operating temperature t_w .

They are computed using the following equation (see Figure U.B1):

$$\log L = \log L_o + S \left(\frac{1}{T} - \frac{1}{T_w} \right) \quad (\text{U.2})$$

where:

L is the objective endurance test life in days (30)

L_o is 3 652 days (10 years)

T is the theoretical test temperature ($t + 273$) K

T_w is the rated maximum operating temperature ($t_w + 273$) K

S is the constant depending on the design of the **transformer** and the materials used. If no claim is made to the contrary, S is taken to be 4 500 but a manufacturer may claim the use of other values if this is justified by the relevant tests.

Consequently the endurance test can be carried out in a much shorter time than 10 years or the chosen life expectancy at a related higher winding temperature.

U.5.2 The use of constants S other than 4 500 in t_w tests

U.5.2.1 The tests outlined in this annex are intended to enable the manufacturer to prove a claimed value of S other than 4 500.

Theoretical test temperatures T for use in ballast endurance tests are calculated from equation (U.2) in U.5.1.

If no claim is made to the contrary, S shall be taken to be 4 500 but a manufacturer may claim the use of any of the values in Table U.2 if this can be justified by procedures a) and b) below.

If the use of a constant other than 4 500 for a particular **transformer** has been proved on the basis of procedures a) and b), then that constant may be used in endurance tests for that **transformer** and others using the same construction and materials.

U.5.2.2 Procedure a)

The manufacturer submits experimental data relating life to winding temperature for the **transformer** design concerned, based on enough samples, but no fewer than 30.

From these data, the regression line relating T to $\log L$, together with the 95 % confidence lines associated with it, are computed.

A straight line is then drawn through the points where the 10 days and 120 days abscissae intersect the upper and lower 95 % confidence lines respectively. See Figure U.2 for a typical presentation. If the inverse of the slope of this is greater than or equal to the claimed value of S , then the latter has been proved within 95 % confidence limits. For failure criteria, see procedure b).

NOTE 1 The points at 10 days and 120 days represent the smallest interval needed for the application of the confidence lines. Other points may be used provided a similar or greater interval is covered.

NOTE 2 Information in respect of the techniques involved and the method of calculating regression lines at confidence limits are given in IEC 60216.

U.5.2.3 Procedure b)

The testing authority shall test 14 new **transformers** submitted by the manufacturer in addition to those required for the endurance test, divided at random into two groups of seven. The manufacturer shall state the value of S claimed and the test temperature T_1 , required to achieve a nominal average **transformer** life of 10 days, together with the corresponding test temperature T_2 , for a nominal average **transformer** life of at least 120 days, calculated using T_1 and the claimed value of S in the following version of the Equation (U.2).

$$\frac{1}{T_2} = \frac{1}{T_1} + \frac{1}{S} \log \frac{120}{10} \quad \text{or} \quad \frac{1}{T_2} = \frac{1}{T_1} + \frac{1.079}{S} \quad (\text{U.3})$$

where

T_1 = theoretical test temperature in K for 10 days

T_2 = theoretical test temperature in K for 120 days

S = claimed constant

Endurance tests are then carried out using the basic method in U.5.1 on the two groups of seven **transformers**, based on the theoretical temperature T_1 (Test 1) and T_2 (Test 2) respectively.

If the current deviates more than 15 % from the initial value measured 24 h after the commencement of the test, the test is repeated at a lower temperature. The duration of the test is calculated with the help of Equation (U.2) in U.5.1. A **transformer** is considered to have failed if during operation in the oven:

- a) the **transformer** becomes open-circuit;
- b) breakdown of the insulation occurs, as indicated by the operation of a fast acting fuse with a current rating of 150 % – 200 % of the initial supply current measured after 24 h.

Test 1, the duration of which shall be equal to or greater than 10 days, is continued until all the **transformers** have failed and the mean life L_1 , has been calculated from the mean of the logarithm of the individual lives at temperature T_1 . From this, the corresponding mean life L_2 at temperature T_2 is calculated with the help of another arrangement (Equation U.4) of Equation (U.2):

$$L_2 = L_1 \exp \left[\frac{S}{\log e} \frac{1}{T_2} - \frac{1}{T_1} \right] \quad (\text{U.4})$$

where

L_1 is the mean life

L_2 is the corresponding mean life (the mean life for T_2)

T_1 is the theoretical test temperature in K for 10 days

T_2 is the theoretical test temperature in K for 120 days

S is the claimed constant

NOTE 1 Care should be taken to ensure that the failure of one or more **transformers** does not affect the temperature of the remaining **transformers** on test.

Test 2 is continued until such time as the mean life at temperature T_2 exceeds L_2 ; this result implies that the constant for the sample is at least that claimed. If all the samples in Test 2 fail before the mean life reaches L_2 , then the constant claimed for the samples has not been verified.

The test lives shall be normalized from the actual test temperature to the theoretical test temperature using the claimed constant S .

NOTE 2 It is not generally necessary to continue Test 2 until all the **transformers** have failed. Calculation of the necessary duration of the test is simple but needs to be updated whenever a failure occurs.

In the case of **transformers** incorporating temperature-sensitive materials, a nominal **transformer** life of 10 days might not be appropriate. In such cases, the manufacturer may adopt a longer life providing this is shorter than the appropriate endurance test period of 30 days. In such cases, the longer nominal **transformer** life shall be at least ten times that of the shorter (e.g. 15/150 days, 18/180 days, etc.).

These curves are for information only and illustrate equation (2) using a constant S of 4 500 (see Annex U.1).

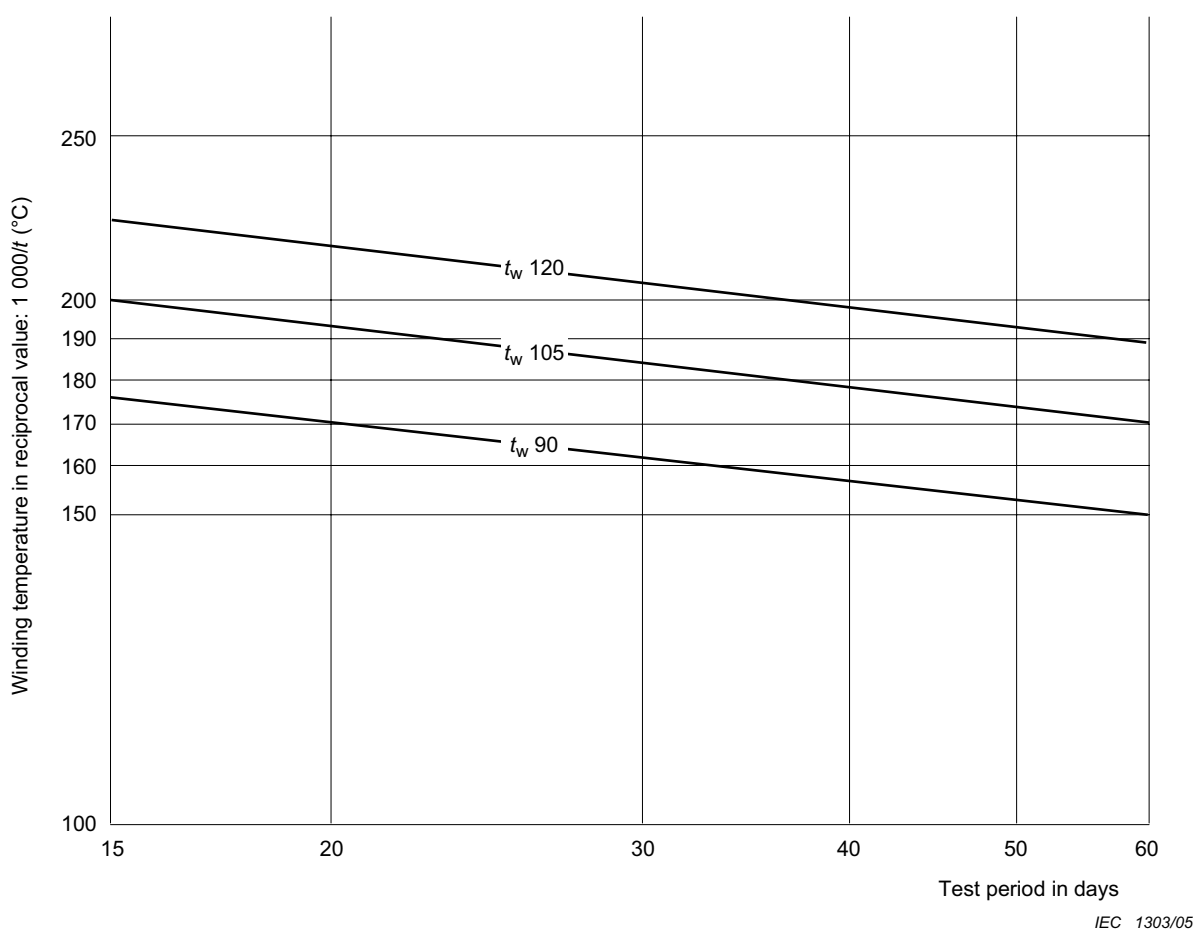
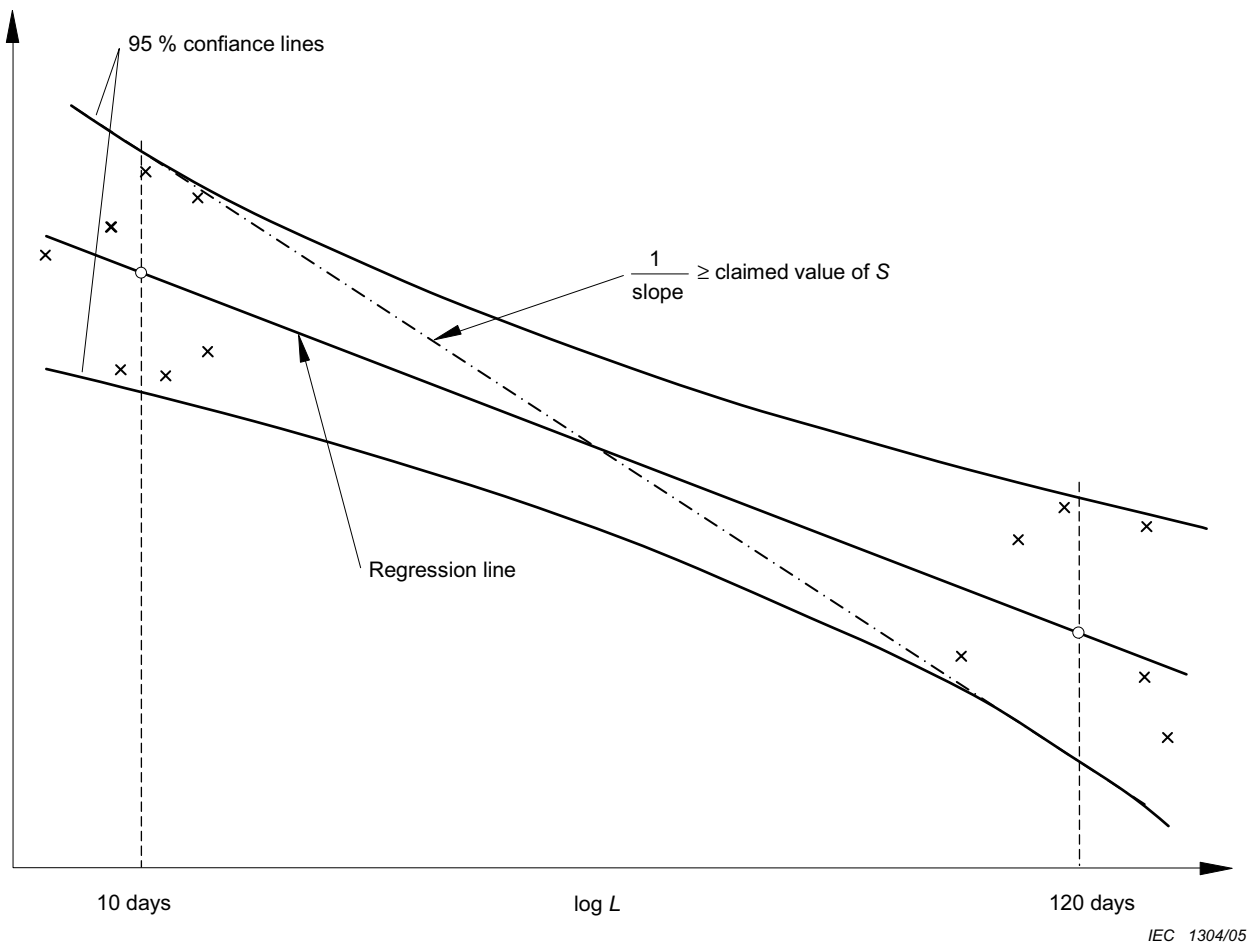


Figure U.1 – Relation between winding temperature and endurance test duration

**Figure U.2 – Assessment of claimed value of S**

Annex V (informative)

Symbols to be used for thermal cut-outs

V.1 Introduction

The purpose of this annex is to give information to the equipment manufacturer and the end user on the way to proceed for resetting the **transformer** after operation of the thermal cut-out.

When the symbols are used, they are intended for information. In the future, when they are known and recognized, the intention is to make them mandatory.

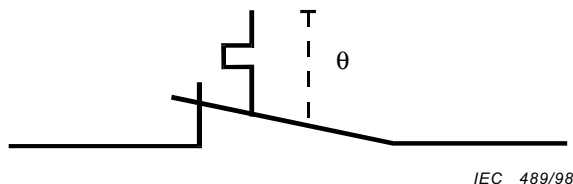
V.2 The symbols, when used, are placed on the **transformer**. They apply to both **independent** and **associated transformers**.

The following drawings should be used.

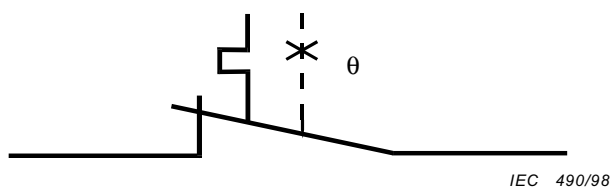
NOTE θ is the symbol used to show that the device is operated by temperature.

V.2.1 Non-self-resetting thermal cut-out (see 3.3.4)

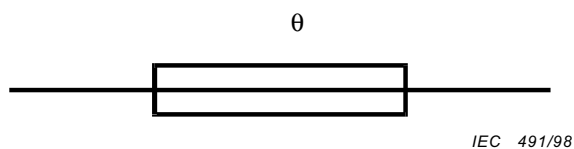
V.2.1.1 Restored by manual operation



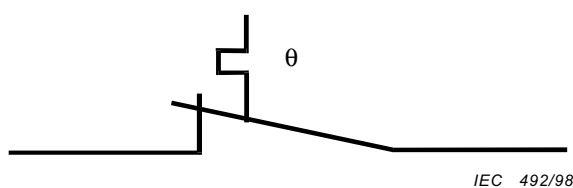
V.2.1.2 Restored by disconnection of the supply



V.2.1.3 Thermal link (see 3.3.5)



V.2.2 Self-resetting thermal cut-out (see 3.3.3)



Annex W (normative)

Coated printed circuit boards

The testing of protective coatings of printed circuit boards is carried out in accordance with IEC 60664-3 with the following modifications:

W.1 General

The requirements of 5.1 of IEC 60664-3 apply, but when production samples are used, three samples of the printed circuit board are tested

W.2 Cold

The test of 5.7.1 of IEC 60664-3 is carried out at –25 °C.

W.3 Rapid change of temperature

In the requirement of 5.7.3 of IEC 60664-3 , severity 1 is specified.

W.4 Additional tests

The requirements of 5.9 of IEC 60664-3 are not applicable.

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Standards Survey

The IEC would like to offer you the best quality standards possible. To make sure that we continue to meet your needs, your feedback is essential. Would you please take a minute to answer the questions overleaf and fax them to us at +41 22 919 03 00 or mail them to the address below. Thank you!

Customer Service Centre (CSC)

International Electrotechnical Commission

3, rue de Varembé

1211 Genève 20

Switzerland

or

Fax to: **IEC/CSC** at +41 22 919 03 00

Thank you for your contribution to the standards-making process.

A Prioritaire

Nicht frankieren
Ne pas affranchir



Non affrancare
No stamp required

RÉPONSE PAYÉE

SUISSE

Customer Service Centre (CSC)

International Electrotechnical Commission

3, rue de Varembé

1211 GENEVA 20

Switzerland



Q1 Please report on **ONE STANDARD** and **ONE STANDARD ONLY**. Enter the exact number of the standard: (e.g. 60601-1-1)

.....

Q2 Please tell us in what capacity(ies) you bought the standard (tick all that apply). I am the/a:

- purchasing agent ☐
librarian ☐
researcher ☐
design engineer ☐
safety engineer ☐
testing engineer ☐
marketing specialist ☐
other.....

Q3 I work for/in/as a:
(tick all that apply)

- manufacturing ☐
consultant ☐
government ☐
test/certification facility ☐
public utility ☐
education ☐
military ☐
other.....

Q4 This standard will be used for:
(tick all that apply)

- general reference ☐
product research ☐
product design/development ☐
specifications ☐
tenders ☐
quality assessment ☐
certification ☐
technical documentation ☐
thesis ☐
manufacturing ☐
other.....

Q5 This standard meets my needs:
(tick one)

- not at all ☐
nearly ☐
fairly well ☐
exactly ☐

Q6 If you ticked NOT AT ALL in Question 5 the reason is: (tick all that apply)

- standard is out of date ☐
standard is incomplete ☐
standard is too academic ☐
standard is too superficial ☐
title is misleading ☐
I made the wrong choice ☐
other

Q7 Please assess the standard in the following categories, using the numbers:

- (1) unacceptable,
(2) below average,
(3) average,
(4) above average,
(5) exceptional,
(6) not applicable

- timeliness.....
quality of writing.....
technical contents.....
logic of arrangement of contents
tables, charts, graphs, figures.....
other

Q8 I read/use the: (tick one)

- French text only ☐
English text only ☐
both English and French texts ☐

Q9 Please share any comment on any aspect of the IEC that you would like us to know:

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