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English version

Safety of power transformers, power supply units and similar — Part 1: General requirements and tests

(includes amendments A1:2002 and A11:2003)
(IEC 61558-1:1997 + A1:1998, modified)

Sécurité des transformateurs, blocs d'alimentation et analogues
Partie 1: Règles générales et essais
(Inclut les amendements A1:1998 et A11:2003)
(CEI 61558-1:1997 + A1:1998, modifiée)

Sicherheit von Transformatoren, Netzgeräten und dergleichen
Teil 1: Allgemeine Anforderungen und Prüfungen
(Enthält Änderungen A1:1998 und A11:2003)
(IEC 61558-1:1997 + A1:1998, modifiziert)

This European Standard was approved by CENELEC on 1997-07-01. Amendment A1 was approved by CENELEC on 1998-04-01, Amendment A11 was approved by CENELEC on 2002-11-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

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This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

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CENELEC

European Committee for Electrotechnical Standardization
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Foreword

The text of document 96/47/FDIS, future edition 1 of IEC 61558-1, prepared by IEC TC 96, small power transformers, reactors and power supply units and special transformers, reactors and power supply units: safety requirements, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 61558-1 on 1997-07-01, together with common modifications prepared by the CENELEC BTTF 64-1, Isolating and safety isolating transformers.

This European Standard Together with the parts 2-4, 2-5, 2-6, 2-7, 2-8 and 2-9 of EN 61558 supersedes EN 60742:1995.

The following dates were fixed:

- latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 1998-02-01
- latest date by which the national standards conflicting with the EN have to be withdrawn (dow) 2005-12-01

Annexes designated "normative" are part of the body of the standard. Annexes designated "informative" are given for information only. In this standard, Annex A to K, Annex ZA and ZB are normative and annexes L to V are informative. Annex ZA and ZB have been added by CENELEC.

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

Foreword to amendment A1

The text of document 96/106/FDIS, future amendment 1 to IEC 61558-1:1997, prepared by IEC TC 96, Small power transformers, reactors and power supply units and special transformers, reactors and power supply units: safety requirements, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as amendment A1 to EN 61558-1:1997 on 1998-04-01.

The following dates were fixed:

- latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 1999-01-01
- latest date by which the national standards conflicting with the EN have to be withdrawn (dow) 2001-01-01

Foreword to amendment A11

This amendment was prepared by the Technical Committee CENELEC TC 96, Small power transformers, reactors and power supply units: Safety requirements.

The following dates were fixed:

- latest date by which the amendment has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2003-11-01
- latest date by which the national standards conflicting with the amendment have to be withdrawn (dow) 2005-12-01

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IINTRODUCTION

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

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

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

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

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

Standards dealing with non-safety aspects of transformers are:

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

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

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

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

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

SAFETY OF POWER TRANSFORMERS, POWER SUPPLY UNITS AND SIMILAR –

Part 1: General requirements and tests

1 Scope

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

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

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

For **isolating transformers**:

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

For **safety isolating transformers**:

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

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

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

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

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

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

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

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

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

unless otherwise specified in the relevant part 2.

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

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

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

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

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

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

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

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

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

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

Transformers incorporating electronic circuits are also covered by this standard.

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

NOTE 2 – Examples are wiring, fuses and switches.

NOTE 3 – Attention is drawn to the fact that:

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

2 Normative references

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

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

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

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

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

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

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

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

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

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

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

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

IEC 60127, *Miniature fuses*

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

IEC 60851, *Methods of test for windings wires*

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

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

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

IEC 60906-1:1986, *IEC System of plugs and socket-outlets for household and similar purposes – Part 1: Plugs and socket-outlets 16 A 250 V a.c.*

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

3 Definitions

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

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

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

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

3.1 Transformers

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

NOTE – Toroïdal transformers are included in that definition.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

3.2 General terms

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

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

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

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

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

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

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

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

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

NOTE – **Power supply** cords are:

– fixed to or assembled with the transformer by **X, Y** or **Z attachment**, or

– **connected to the transformer by an appliance coupler.**

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

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

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

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

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

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

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

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

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

3.3 Operations and protections

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

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

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

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

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

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

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

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

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

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

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

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

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

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

3.3.9 continuous operation: Operation for an unlimited period.

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

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

3.4 Circuits and windings

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

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

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

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

3.5 Ratings

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

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

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

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

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

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

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

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

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

3.6 No-load values

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

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

3.7 Insulation

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

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

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

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

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

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

3.7.5 class I transformer: A transformer in which protection against electric shock does not rely on **basic insulation** only, but which includes an additional safety precaution in such a way that means, such as an earthing terminal, are provided for the connection of accessible conductive parts to the protective earthing conductor in the fixed wiring of the installation, so that accessible conductive parts cannot become live in the event of a failure of the **basic insulation**.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

4 General requirements

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

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

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

5 General notes on tests

5.1 Tests according to this standard are type tests.

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

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

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

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

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

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

For testing a series of transformers, see annex B.

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

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

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

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

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

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

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

5.4 *If the test results are not influenced by the temperature of the ambient air, the ambient temperature is, in general, maintained at (20 ± 5) °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 ± 2) °C or t_a ± 2 °C for transformers with t_a marking.*

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

6 Ratings

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

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

7 Classification

Transformers are classified:

7.1 According to their protection against electric shock:

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

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

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

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

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

7.4 According to their mobility:

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

7.5 According to their time of operation:

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

7.6 According to the intended use:

7.6.1 Associated

- incorporated;
- for specific use.

7.6.2 Independent

8 Marking and other information

8.1 Transformers shall be marked with:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

j) model or type reference;

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

l) symbol for **class II** construction, for **class II transformers** only;

m) symbol for **class III** construction, for **class III transformers** only;

n) indication of the protection index IP, if other than IP00 or **ordinary transformers**;

o) rated maximum ambient temperature t_a, if other than 25 °C;

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Earthing terminals shall be indicated by the symbol for earthing.

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

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

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

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

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

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

– for **type Y attachments**:

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

– for **type Z attachments**:

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

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

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

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

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

Symbol	Explanation	IEC 60417
V*	Volts	
A*	Amperes	
VA or (VAR)*	Volt amperes (or volt-amperes reactive for reactors)	
W*	Watts	
Hz*	Hertz	
PRI	Input	
SEC	Output	
⎓	Direct current	5031
N	Neutral	
~	Single-phase a.c.	5032
3~	Three-phase a.c.	
3/N~	Three-phase + neutral a.c.	
cos φ	Power factor	
	Class II construction	5172
	Class III construction	5180
	Fuse-link (add symbol for time-current characteristics)	5016
t_a	Rated maximum ambient temperature	
	Frame or core terminal	5020
	Protective earth (ground)	5019
IPXX	IP number**	
under consideration	For indoor use only	

* Multiple or submultiples are allowed.

** The X used in the IP number in this scheme indicates a missing numeral in the example, but both of the appropriate numerals shall be marked on the transformer, if applicable. Additional and supplementary letters mentioned in IEC 60529 may be used if necessary.

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

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

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

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

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

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

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

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

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

8.15 Marking shall be durable and easily legible.

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

The petroleum spirit to be used for the test is aliphatic solvent hexane with a contents of aromatics of maximum 0,1 % volume, a kauributanol value of 29, initial boiling point approximately 65 °C, dry point approximately 69 °C and specific gravity of 0,68 g/cm^3.

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

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

9 Protection against accessibility to hazardous live parts

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

Compliance is checked by the tests of 9.1 and 9.2.

9.1 *In order to verify that a **live part** is not **hazardous live**, the following measurements are carried out between any two parts or contacts, then between any part or contact and either pole of the supply source used during the test. In addition, discharge shall be measured between pins of the connecting device of the transformer, if any, and/or between the secondary conductors where they are accessible 5 s after the interruption of the supply.*

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

a) the voltage does not exceed 35 V (peak) a.c. or 60 V ripple free d.c., or

b) the touch-current measured with the measuring network according to annex J, expressed as voltages U_1 and U_2, does not exceed the following values:

- *for a.c.: U_1 = 35 V (peak) and U_2 = 0,35 V (peak);*
- *for d.c.: U_1 = 1,0 V.*

NOTE 1 – The limit values of U_2 = 0,35 V (peak) for a.c. and U_1 = 1,0 V for d.c. corresponds to the values 0,7 mA (peak) a.c. and 2,0 mA d.c.
The limit value U_1 = 35 V (peak) for a.c. corresponds to the value 70 mA (peak) a.c. for higher frequencies.

and in addition, when b) is applicable:

c) the discharge does not exceed 50 μC for stored voltages between 60 V and 15 kV, or

d) the energy of discharge does not exceed 350 mJ for stored voltages exceeding 15 kV.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

10 Change of input voltage setting

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

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

Compliance is checked by inspection.

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

11 Output voltage and output current under load

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

a) 10 % for the output voltage of **inherently short-circuit proof transformers** with one **rated output voltage**;

b) 10 % for the highest output voltage of **inherently short-circuit proof transformers** with more than one **rated output voltage**;

c) 15 % for the other output voltages of **inherently short-circuit proof transformers** with more than one **rated output voltage**;

d) 5 % for the output voltages of other transformers.

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

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

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

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

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

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

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

Compliance is checked by calculation.

12 No-load output voltage

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

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

13 Short-circuit voltage

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

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

14 Heating

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Flush type transformers are tested as described in 5.10.

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

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

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

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

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

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

The temperatures of windings are determined by the resistance method.

NOTE 2 – One of the methods consists of measuring each winding separately, and of determining the resistance of windings at the end of the test by taking resistance measurements, as soon as possible after switching off, and then at short intervals, so that a curve of resistance against time can be plotted to ascertain the resistance at the instant of switching off.

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

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

where

$x = 234{,}5$ *for copper;*

$x = 225$ *for aluminium;*

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

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

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

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

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

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

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

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

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

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

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

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

Table 1 – Values of maximum temperatures in normal use

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

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

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

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

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

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

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

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

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

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

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

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

14.3.1 Heat run

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

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

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

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

14.3.2 Moisture treatment

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

14.3.3 Vibration test

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

duration: 30 min;

amplitude: 0,35 mm;

frequency range: 10 Hz, 55 Hz, 10 Hz;

sweep rate: approximately one octave per minute.

14.3.4 Measurements

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

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

15 Short circuit and overload protection

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

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

- *for* ***inherently short-circuit proof transformers****, by the tests of 15.2;*
- *for* ***non-inherently short-circuit proof transformers****, by the tests of 15.3;*
- *for* ***non-short-circuit proof transformers****, by the tests of 15.4;*
- *for* ***fail-safe transformers****, by the tests of 15.5;*
- *for transformers combined with a rectifier, the tests of 15.2 or 15.3 are made twice, once with the short circuit applied on one side of the rectifier, and again with the short circuit applied on the other side of the rectifier;*
- *for transformers with more than one* ***output winding*** *or a tapped* ***output winding****, the results to be considered are those showing the highest temperature. In the first case, all windings which are intended to be loaded at the same time are loaded at* ***rated output*** *and then the chosen* ***output winding*** *is short-circuited.*

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

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

Insulation classification	A	E	B	F	H
	Maximum temperature °C				
Winding protected inherently	150	165	175	190	210
Winding protected by protective device:					
– during the time *T* given in table 4[1)]	200	215	225	240	260
– after the first hour, peak value[2)]	175	190	200	215	235
– after the first hour, arithmetic mean value[2)]	150	165	175	190	210
External **enclosures** (which can be touched with the standard test finger)	105				
Rubber insulation of wiring	85				
PVC insulation of wiring	85				
Supports (i.e. any area on the pine plywood surface covered by the transformer)	105				

[1)] After the tests of 15.3.3, these values may be exceeded due to the thermal inertia of the transformer.

[2)] Does not apply to the tests of 15.3.3

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

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

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

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

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

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

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

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

Table 4 – Values of *T* and *k* for fuses

Values marked as rated current I_n of protecting fuse-link for gG A	*T* h	*k*
$I_n \leq 4$	1	2,1
$4 < I_n < 16$	1	1,9
$16 \leq I_n \leq 63$	1	1,6
$63 < I_n \leq 160$	2	1,6
$160 < I_n \leq 200$	3	1,6

NOTE 1 – For cylindrical fuses gG type B for use by unskilled persons (IEC 60269-3-1), and for fuses for use by authorised persons with fuses-links for bolted connections (IEC 60269-2-1), the value of *k* is 1,6 for $I_n < 16$ A.

NOTE 2 – For D-type fuses for use by unskilled persons (IEC 60269-3-1) for a rated current of 16 A, the value of *k* is 1,9.

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

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

C11 *If the **transformer** is protected by miniature fuses in accordance to IEC 60127, an additional overload test shall be performed with 1,5 times of the rated fuse current until steady state condition.* C11

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

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

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

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

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

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

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

15.5 Fail-safe transformers

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

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

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

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

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

15.5.2 *At any time during the tests of 15.5.1:*

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

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

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

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

16 Mechanical strength

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Compliance is checked by the following tests:

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

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

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

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

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

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

All three specimens shall withstand the test.

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

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

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

The pull force is applied within a heating cabinet at a temperature of (70 ± 2) °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 3	40 50
Above 10 A up to and including 16 A 130/250 V	2 3	50 54
Above 10 A up to and including 16 A/440 V	3 More than 3	54 70

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

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

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

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

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

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

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

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

The water for the test shall be at a temperature of 15 °C ± 10 °C.

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

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

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

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

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

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

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

a) no deposit of talcum powder in dust-proof transformers, so that, if the powder were conductive, the insulation would fail to meet the requirements of this standard;

*b) no deposit of talcum powder inside **enclosures** for dust-tight transformers;*

*c) no trace of water on **live parts** or on insulation where it could become a hazard for the user or surroundings, for example where it could reduce the **creepage distances** below the values specified in clause 26;*

d) no accumulation of water in drip-proof, rain-proof, splash-proof and jet-proof transformers, so as to impair safety;

e) no trace of water entered in any part of a watertight transformer;

f) no entry into the transformer by the relevant test probe for solid-object-proof transformers.