

AS/NZS 61558.1:2018

(Incorporating Amendments up to and including No. 2)



Australian/New Zealand Standard™

Safety of Power Transformers, Power Supplies, Reactors and Similar Products

Part 1: General requirements and tests (IEC 61558-1 Ed 3, MOD)



AS/NZS 61558.1:2018

This Joint Australian/New Zealand Standard™ was prepared by Joint Technical Committee EL-002, Safety of Household and Similar Electrical Appliances and Small Power Transformers and Power Supplies. It was approved on behalf of the Council of Standards Australia on 24 October 2018 and by the New Zealand Standards Approvals Board on 6 November 2018.

This Standard was published on 30 November 2018.

The following are represented on Committee EL-002:

- Association of Accredited Certification Bodies
- Australian Industry Group
- National Retailers Association (Australia)
- Business New Zealand
- Consumer Electronic Suppliers Association, Australia
- Consumers' Federation of Australia
- Electrical Regulatory Authorities, Australia
- Electrical consultants
- Engineers Australia
- JAS-ANZ
- Testing Interests New Zealand
- WorkSafe, New Zealand
- New Zealand Electric Fence Energizer Manufacturers' Standards Group

This Standard was issued in draft form for comment as DR 18923.

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ISBN 978 1 76072 252 4

Australian/New Zealand Standard™

Safety of Power Transformers, Power Supplies, Reactors and Similar Products

Part 1: General requirements and tests (IEC 61558-1 Ed 3, MOD)

Originated, in part, in Australia as AS C126—1939.
Second edition C126—1958.
Revised and redesignated AS 3126—1981 (withdrawn 1989).
Originated, in part, in Australia as AS C167—1962.
Revised and redesignated AS 3167—1981 (withdrawn 1987).
AS 3126—1981 and AS 3167—1981 were revised and redesignated AS 3108.1—1984,
AS 3108.2—1984 and AS 3108.3—1984.
Revised, amalgamated and redesignated AS 3108—1990.
First published in New Zealand as NZS/AS 3108:1990.
Jointly revised and redesignated AS/NZS 3108:1994.
Jointly revised and redesignated, in part, as AS/NZS 61558.1:2000.
Jointly revised and redesignated, as AS/NZS 61558.1:2008.
Jointly revised and redesignated, as AS/NZS 61558.1:2018.
Reissued incorporating Amendment No 1 (March 2020).
Reissued incorporating Amendment No 2 (November 2020).



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STANDARDS AUSTRALIA/STANDARDS NEW ZEALAND

AS/NZS 61558.1:2018

Safety of transformers, reactors, power supply units and combinations thereof —

Part 1: General requirements and tests

Foreword

A1 This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee EL-002 - Safety of Household and Similar Electrical Appliances and Small Power Transformers to supersede AS/NZS 61558.1:2008 and its amendments when the titles and contents of the parts 2 in the AS/NZS 61558 series have been updated to be used with AS/NZS 61558.1:2018. During this period AS/NZS 61558.1:2008 will also remain current. Regulatory authorities that reference this Standard in regulation may apply these requirements at a different time. Users of this Standard should consult with these authorities to confirm their requirements.

The objective of this Standard is to provide manufacturers, designers, regulatory authorities, testing laboratories and similar organizations with safety requirements designed to give the user protection against hazards that might occur during normal operation and abnormal operation of the appliance and which may be used as the basis for approval for sale or for connection to the electricity supply mains in Australia and New Zealand.

A2 This standard incorporates Amendment No.1 (March 2020) and Amendment No. 2 (November 2020). The changes introduced by amendments are indicated in the text by a marginal bar and amendment number against the part affected. Where an application date other than immediate is applicable to an amendment the date of application (DOA) and the date of withdrawal (DOW) if relevant, is indicated by the marginal bar against the part affected.

This edition includes the following significant technical changes with respect to the previous edition:

- a) fully insulated winding wires (FIW), new tables and aging tests for FIW constructions,
- b) overvoltage categories 1, 2, 3 and 4 for clearances and dielectric strength tests (new tables) are included,
- c) development of new symbols for the different overvoltage categories,
- d) symbol for maximum altitudes, if higher than 2 000 m,
- e) symbol for plug in power supply units, if the pins are damaged (tumbling barrel test),
- f) symbol for minimum temperature (even during the transportation),
- g) alternative temperature measurement, simulated load and back to back method according to IEC 60076-11,
- h) short circuit and overload protection, simulated load and back to back method according to IEC 60076-11,
- i) adjustment of temperatures in Table 2 according to IEC Guide 117,
- j) establishing partial discharge test above 750 V for FIW constructions,
- k) requirements for toroidal core constructions, division for basic and for supplementary isolation,
- l) modification of protection indexes for enclosures (IP-code),
- m) dimensioning of rectangular cross section connectors for transformers,
- n) repetition test, 80 % of required dielectric strength test voltage of Table 14,
- o) vibration test for vehicles and railway applications,

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- p) two Y1 Capacitors for working voltages above 250 V and not exceeding 500 V with overvoltage category 3.

This Standard is an adoption with national modifications of the third edition of IEC 61558-1 *Safety of transformers, reactors, power supply units and combinations thereof – Part 1 General requirements and tests*. It has been varied as indicated to take account of Australian and New Zealand conditions.

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

A1

The 2018 edition of AS/NZS 61558.1 is only to be used in conjunction with parts 2 based on this edition. Titles of existing standards in this series will be updated at the time of their next edition.

This standard may be applied, as far as is reasonable to transformers, reactors, power supply units and combinations not mentioned in the parts 2, and to transformers, reactors, power supply units and combinations designed on new principles.

In this document, the following print types are used:

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

In the text of the document, the words in **bold** are defined in Clause 3.

NOTE 1 Subclauses, notes and annexes that are additional to those in the IEC standard are prefixed with the letters AZ.

- p NOTE 2 In this document, p is used in the margin to indicate instructions for preparing a consolidated version.

The essential safety requirements in AS/NZS 3820¹ that could be applicable to transformers, reactors, power supply units and combinations thereof are covered by this standard taken in conjunction with any other relevant requirements affecting safety requirements for transformers, reactors, power supply units and combinations thereof are covered by this standard.

The national variations to IEC 61558-1 Ed 3 form the Australian and New Zealand national variations for purposes of the IECEE scheme for recognition of results of testing to standards for safety of electrical equipment (the CB scheme).

¹ AS/NZS 3820 *Essential safety requirements for electrical equipment*

The text of the International Standard IEC 61558-1 Ed 3 was approved as a joint Australia/New Zealand Standard with the agreed national variations as given below.

AUSTRALIAN NATIONAL VARIATIONS

5 General notes on tests

Add the following variation:

- A2 | p **5.2** *Add the following variation:*
If the tests of AZ.19.201 need to be performed they are carried out on separate specimens, the number of specimens is that required by AS/NZS 3112.

- p **5.5** *Replace the text with the following variation:*

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

8 Marking and other information

- p **8.1** *Insert as a new second paragraph in Item a) the following variation:*

The marking of **rated voltage** or **rated voltage range** of single-phase transformers shall cover 240 V and for polyphase transformers 415 V.

A2 |

16 Mechanical strength

Replace the variations for 16.4.1 and 16.4.2 by the following variation:

- A2 | p **16.4** *Replace the text with the following variation:*

16.4 VOID

19 Construction

Replace the variation for 19.15 by the following variation:

- A2 | p **19.15** *Replace the text with the following variation:*

19.15 VOID

- p **AZ.19.201** *After 19.23 insert the following variation:*

AZ.19.201 Transformers having integral pins for insertion into socket outlets shall comply with the appropriate requirements of AS/NZS 3112.

Compliance is checked as specified in Appendix J of AS/NZS 3112.

A2 |

A2 |

20 Components

- p 20 *Replace* the first paragraph with the following variation:

Components shall comply with the safety requirements specified in the relevant IEC or Australian/New Zealand Standards as far as they reasonably apply.

Replace the third paragraph with the following variation:

Compliance with the IEC or Australian/New Zealand Standards for the relevant component does not necessarily ensure compliance with the requirements of this Standard.

- p 20.6 *Insert* in the second paragraph in the requirement, before IEC 60906-3 the following variation:

A2 | Appendix E in AS/NZS 3112 or

22 Supply connect and other external flexible cables or cords

- p 22.4 *Replace* the text with the following variation:

- p 22.4 VOID.

- p 22.6 *Replace* in the requirement, “16” with the following variation: “10”.

- p 22.8 *Replace* the second paragraph in the requirement, with the following variation:

Power supply cords of portable transformers shall be fitted with an appropriately rated plug complying with AS/NZS 3112 or AS/NZS 3123 or IEC 60309-1.

Annex H

- p H.3.1 *Insert after the existing fourth paragraph the following variation:*

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

NEW ZEALAND NATIONAL VARIATIONS

5 General notes on tests

- p 5.2 *Add* the following variation:

A2 | *If the tests of AZ.19.201 need to be performed they are carried out on separate specimens, the number of specimens is that required by AS/NZS 3112.*

- p 5.5 *Replace* the text with the following variation:

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

8 Marking and other information

- p 8.1 *Replace the variation for 8.1 by the following:*

The marking of **rated voltage** of single-phase transformers shall be 230 V and for polyphase transformers shall be 400 V.

The marking of **rated voltage range** of single-phase transformers shall cover 230 V and for polyphase transformers shall cover 400 V.

A2

16 Mechanical strength

Replace the variations for 16.4.1 and 16.4.2 by the following variation:

A2

- p **16.4** *Replace the text with the following variation:*

16.4 VOID

19 Construction

Replace the variation for 19.15 by the following variation:

A2

- p **19.15** *Replace the text with the following variation:*

19.15 VOID

- p **AZ.19.201** After 19.23 *insert* the following variation:

AZ.19.201 Transformers having integral pins for insertion into socket outlets shall comply with the appropriate requirements of AS/NZS 3112.

Compliance is checked as specified in Appendix J of AS/NZS 3112.

A2

20 Components

- p **20** *Replace the first paragraph with the following variation:*

Components shall comply with the safety requirements specified in the relevant IEC or Australian/New Zealand Standards as far as they reasonably apply.

Replace the third paragraph with the following variation:

Compliance with the IEC or Australian/New Zealand Standards for the relevant component does not necessarily ensure compliance with the requirements of this Standard.

- p **20.6** *Insert* in the second paragraph in the requirement, before IEC 60906-3 the following variation:

A2

Appendix E in AS/NZS 3112 or

22 Supply connect and other external flexible cables or cords

- p **22.4** *Replace the text with the following variation:*

- p **22.4** VOID.

- p **22.6** *Replace* in the requirement, “16” with the following variation: “10”.

- p **22.8** *Replace* the second paragraph in the requirement, with the following variation:

Power supply cords of portable transformers shall be fitted with an appropriately rated plug complying with AS/NZS 3112 or AS/NZS 3123 or IEC 60309-1.

Annex H

- p **H.3.1** *Insert after the existing fourth paragraph the following variation:*

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

Annex ANZ
(normative)
Normative references to international publications with their corresponding joint
Australia/New Zealand publications

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

NOTE When an international publication has been modified by national variations the relevant joint Australia/New Zealand publications applies if the national variations are needed to ensure the safety of the appliance for Australia/New Zealand conditions. These international publications are indicated by (mod). If an international publication is not so indicated, then either it or the listed Australia/New Zealand publication may be used.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>AS/NZS</u>	<u>Year</u>
		<i>Approval and test specification — Plugs and socket-outlets</i>	3112	
		<i>Plugs, socket-outlets and couplers for general industrial application</i>	3123	
IEC 60065	2014	<i>Audio, video and similar electronic apparatus – Safety requirements</i>	60065	2018
IEC 60068-2-6		<i>Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal)</i>		
IEC 60068-2-14		<i>Environmental testing – Part 2-14: Tests – Test N: Change of temperature</i>		
IEC 60068-2-31		<i>Environmental testing – Part 2-31: Tests – Test Ec: Rough handling shocks, primarily for equipment- type specimens</i>		
IEC 60068-2-75		<i>Environmental testing – Part 2-75: Tests – Test Eh: Hammer tests</i>		
IEC 60076-1		<i>Power transformers – Part 1: General</i>		
IEC 60076-11	2004	<i>Power transformers – Part 11: Dry-type transformers</i>		
IEC TR 60083		<i>Plugs and socket-outlets for domestic and similar general use standardized in member countries of IEC</i>		
IEC 60085	2011	<i>Electrical insulation – Thermal evaluation and designation</i>		
IEC 60112	2003	<i>Method for the determination of the proof and the comparative tracking indices of solid insulating materials</i>		
IEC 60112/AMD1	2009			
IEC 60127 (all parts)	2014	<i>Miniature fuses</i>		
IEC 60127-3		<i>Miniature fuses – Part 3: Sub-miniature fuse-links</i>		
IEC 60216 (all parts)		<i>Electrical insulating materials – Thermal endurance properties</i>		

IEC 60227 (all parts)		<i>Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V</i>		
IEC 60227-5	2011	<i>Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V – Part 5: Flexible cables (cords)</i>	60227.5 A1	2003 2004
IEC 60245 (all parts)		<i>Rubber insulated cables – Rated voltages up to and including 450/750 V</i>		
IEC 60245-4	2011	<i>Rubber insulated cables – Rated voltages up to and including 450/750 V – Part 4: Cords and flexible cables</i>	60245.4 A1	2003 2004
IEC 60269 (all parts)		<i>Low voltage fuses</i>		
IEC 60269-2	2013	<i>Low voltage fuses – Part 2: Supplementary requirements for fuses for use by authorized persons (fuses mainly for industrial application) – Examples of standardized systems of fuses A to K</i>	60269.2	2000
IEC 60269-3	2010	<i>Low voltage fuses – Part 3: Supplementary requirements for fuses for use by unskilled persons (fuses mainly for household or similar applications) – Examples of standardized systems of fuses A to F</i>	60269.3	2000
IEC 60309 (all parts)		<i>Plugs, socket-outlets and couplers for industrial purposes</i>		
IEC 60317 (all parts)		<i>Specifications for particular types of windings wires</i>		
IEC 60317-0-7	2012	<i>Specifications for particular types of winding wires – Part 0-7: General requirements – Fully insulated (FIW) zero-defect enamelled round copper wire with nominal conductor diameter of 0,040 mm to 1,600 mm</i>		
IEC 60317-56		<i>Specifications for particular types of winding wires – Part 56: Solderable fully insulated (FIW) zero-defect polyurethane enamelled round copper wire with nominal conductor diameter 0,040 mm to 1,600 mm, class 180</i>		
IEC 60320 (all parts)		<i>Appliance couplers for household and similar general purposes</i>		
IEC 60320-2-3		<i>Appliance couplers for household and similar general purposes – Part 2-3: Appliance couplers with a degree of protection higher than IPX0</i>		

IEC 60335-1		<i>Household and similar electrical appliances – Safety – Part 1: General requirements</i>	60335.1
IEC 60384-14	2013	<i>Fixed capacitors for use in electronic equipment – Part 14: Sectional specification: Fixed capacitors for electromagnetic interference suppression and connection to the supply mains</i>	
IEC 60417		<i>Graphical symbols for use on equipment</i> (available at http://www.graphical-symbols.info/equipment)	
IEC 60454 (all parts)		<i>Pressure-sensitive adhesive tapes for electrical purposes</i>	
IEC 60529	1989	<i>Degrees of protection provided by enclosures (IP Code)</i>	
IEC 60529/AMD1	1999		
IEC 60529/AMD2	2013		
IEC 60664-1	2007	<i>Insulation coordination for equipment within low voltage systems – Part 1: Principles, requirements and tests</i>	
IEC 60664-3	2016	<i>Insulation coordination for equipment within low-voltage systems – Part 3: Use of coating, potting or moulding for protection against pollution</i>	
IEC 60691	2015	<i>Thermal-links – Requirements and application guide</i>	
IEC 60695-2-10	2013	<i>Fire hazard testing – Part 2-10: Glowing/hot-wire based test methods – Glow-wire apparatus and common test procedure</i>	
IEC 60695-2-11	2014	<i>Fire hazard testing – Part 2-11: Glowing/hot-wire based test methods – Glow-wire flammability test method for end-products</i>	
IEC 60721-3-2		<i>Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities – Section 2: Transportation</i>	
IEC 60730 (all parts)		<i>Automatic electrical controls</i>	
IEC 60730-1	2013	<i>Automatic electrical controls – Part 1: General requirements</i>	
IEC 60851-3	2009	<i>Winding wires – Test methods: Part 3: Mechanical properties</i>	
IEC 60851-5	2008	<i>Winding wires – Test methods: Part 5: Electrical properties</i>	
IEC 60851-6	2012	<i>Winding wires – Test methods: Part 6: Thermal properties</i>	

IEC 60884-1	2002	<i>Plugs and socket-outlets for household and similar purposes – Part 1: General requirements</i>		
IEC 60884-1AMD1	2006			
IEC 60884-1AMD2	2013			
IEC 60884-2-4		<i>Plugs and socket-outlets for household and similar purposes – Part 2-4: Particular requirements for plugs and socket-outlets for SELV</i>		
IEC 60898 (all parts)		<i>Electrical accessories – Circuit-breakers for overcurrent protection for household and similar installations</i>		
IEC 60906-1		<i>IEC system of plugs and socket-outlets for household and similar purposes – Part 1: Plugs and socket-outlets 16 A 250 V a.c.</i>		
IEC 60906-3		<i>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.</i>		
IEC 60947-7-1		<i>Low-voltage switchgear and controlgear – Part 7-1: Ancillary equipment – Terminal blocks for copper conductors</i>	60947.7.1	
IEC 60990	2016	<i>Methods of measurement of touch current and protective conductor current</i>		
IEC 60998-2-1		<i>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</i>	60998.2.1	
IEC 60998-2-2		<i>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</i>	60998.2.2	
IEC 60999-1		<i>Connecting devices – Electrical copper conductors – Safety requirements for screw-type and screwless-type clamping units – Part 1: General requirements and particular requirements for clamping units for conductors from 0,2 mm² up to 35 mm² (included)</i>	60999.1	
IEC 61032		<i>Protection of persons and equipment by enclosures – Probes for verification</i>		
IEC 61058-1	2016	<i>Switches for appliances – Part 1: General requirements</i>	61058.1	2008
IEC 61058-1-1	2016	<i>Switches for appliances – Part 1-1: Requirements for mechanical switches</i>		
IEC 61140	2016	<i>Protection against electric shock – Common aspects for installation and equipment</i>		
IEC 61373		<i>Railway applications – Rolling stock equipment – Shock and vibration tests</i>		

ISO 8820		<i>Road vehicles – Fuse-links</i>
EN 50075	1990	<i>Specification for flat non-wirable two-pole plugs 2.5 A 250 V, with cord, for the connection of class II-equipment for household and similar purposes</i>
DIN 43671	1975	<i>Copper bus bars; design for continuous current</i>
DIN 43670	1995	<i>Aluminium bus bars; design for continuous current</i>
DIN 43670-2	1985	<i>Aluminium bus bars copper cladding; design for continuous current</i>

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

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International Standard IEC 61558-1 has been prepared by IEC technical committee 96: Transformers, reactors, power supply units and combinations thereof.

This third edition cancels and replaces the second edition published in 2005 and Amendment 1:2009. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) fully insulated winding wires (FIW), new tables and aging tests for FIW constructions,
- b) overvoltage categories 1, 2, 3 and 4 for clearances and dielectric strength tests (new tables) are included,
- c) development of new symbols for the different overvoltage categories,
- d) symbol for maximum altitudes, if higher than 2 000 m,
- e) symbol for plug in power supply units, if the pins are damaged (tumbling barrel test),

- f) symbol for minimum temperature (even during the transportation),
- g) alternative temperature measurement, simulated load and back to back method according to IEC 60076-11,
- h) short circuit and overload protection, simulated load and back to back method according to IEC 60076-11,
- i) adjustment of temperatures in Table 2 according to CENELEC Guide 29,
- j) establishing partial discharge test above 750 V for FIW constructions,
- k) requirements for toroidal core constructions, division for basic and for supplementary isolation,
- l) modification of protection indexes for enclosures (IP-code),
- m) dimensioning of rectangular cross section connectors for transformers,
- n) repetition test, 80 % of required dielectric strength test voltage of Table 14,
- o) vibration test for vehicles and railway applications,
- p) two Y1 Capacitors for working voltages above 250 V and not exceeding 500 V with overvoltage category 3.

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

FDIS	Report on voting
96/466/FDIS	96/468/RVD

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

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

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

A list of all parts of the IEC 61558 series, published under the general title *Safety of transformers, reactors, power supply units and combination thereof*, can be found on the IEC website.

Future standards in this series will carry the new general title as cited above. Titles of existing standards in this series will be updated at the time of the next edition.

In this document, the following print types are used:

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

In the text of the document, the words in **bold** are defined in Clause 3.

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

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

INTRODUCTION

This document covers safety requirements for **transformers**. Where the term **transformer** is used, it covers **transformers**, **reactors** and **power supply units** where applicable.

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

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

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

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

The document dealing with non-safety aspects of electromagnetic compatibility (EMC) of **transformers** is IEC 62041. However, that document also includes tests that can subject the **transformer** to conditions involving safety aspects.

The objective of IEC 61558-1 is to provide a set of requirements and tests considered to be generally applicable to most types of **transformers**, and which can be called up as required by the relevant part of IEC 61558-2. IEC 61558-1 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 of IEC 61558-2. IEC 61558-1 also contains normative routine tests.

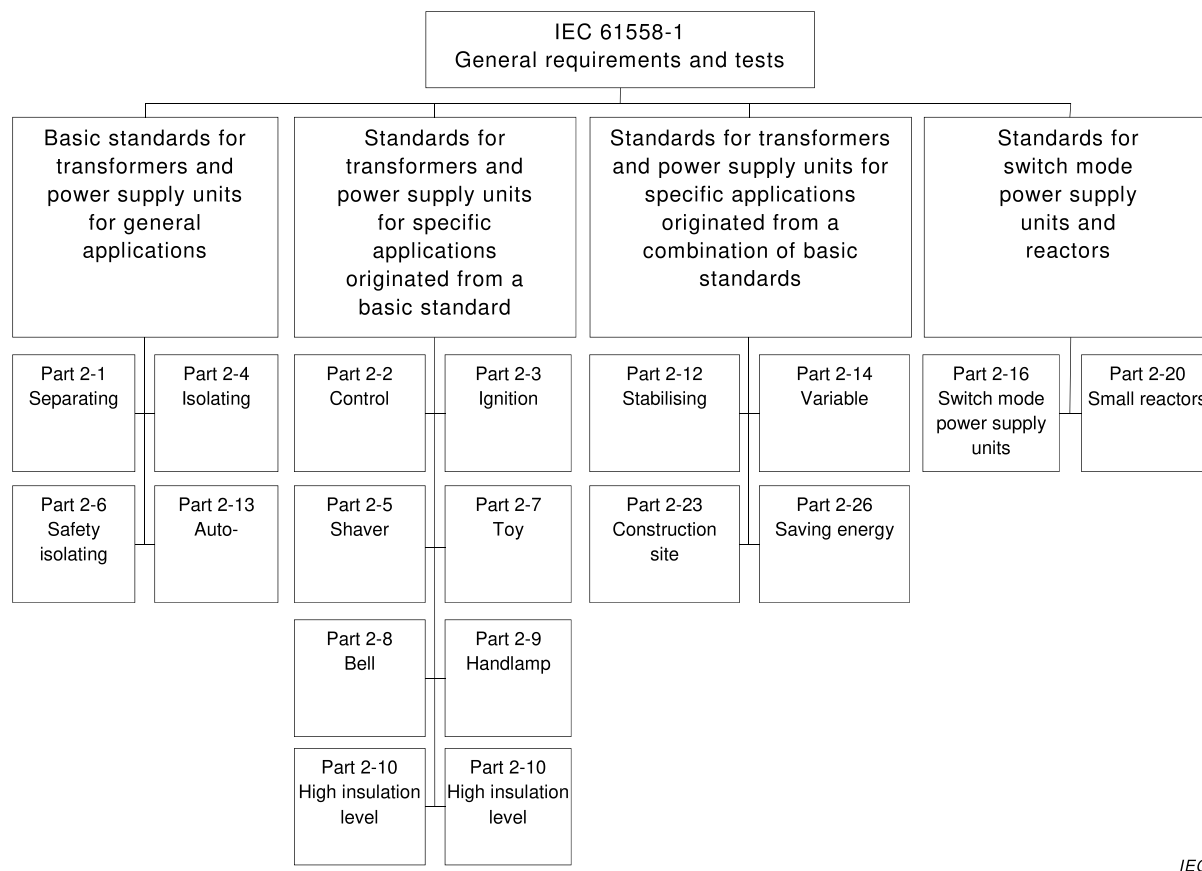
Each part of IEC 61558-2 in conjunction with this document contains all the necessary requirements for the **transformer** being covered and does not contain references to other parts of IEC 61558-2. For **transformers** with a protection index IP00 and associated **transformers**, it is possible to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

If an appropriate part of IEC 61558-2 does not exist for a particular **transformer** or group of **transformers**, the nearest applicable part may be used as a guide to the requirements and tests.

However, individual countries may wish to consider its application, to the extent reasonable, to transformers not mentioned in the IEC 61558-2 series, and to transformers designed on new principles.

Where the requirements of any of the clauses of a part of IEC 61558-2 refer to IEC 61558-1 by the phrase "This clause of Part 1 is applicable", this phrase means that all the requirements of that clause of IEC 61558-1 are applicable, except those requirements that are clearly not applicable to the particular type of **transformer** covered by that part of IEC 61558-2.

The principle for the preparation of the different parts of IEC 61558-2 is as shown in Figure 1.



IEC

Figure 1 – IEC 61558 principle

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

The IEC 61558 series consists of the following parts, under the general title *Safety of transformers, reactors, power supply units and combination thereof*:¹

- Part 1: General requirements and tests
- Part 2-1: Particular requirements and tests for separating transformers for general applications
- Part 2-2: Particular requirements and tests for control transformers
- Part 2-3: Particular requirements and tests for ignition transformers for gas and oil burners
- Part 2-4: Particular requirements and tests for isolating transformers
- Part 2-5: Particular requirements and tests for shaver transformers and shaver supply units
- Part 2-6: Particular requirements and tests for safety isolating transformers
- Part 2-7: Particular requirements and tests for transformers for toys
- Part 2-8: Particular requirements and tests for transformers for bells and chimes
- Part 2-9: Particular requirements and tests for transformers for class III handlamps for tungsten filament lamps

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

- Part 2-10: Particular requirements and tests for separating transformers with high insulation level and separating transformers with output voltages exceeding 1 000 V
- Part 2-12: Particular requirements and tests for constant voltage transformers
- Part 2-13: Particular requirements and tests for auto transformers
- Part 2-14: Particular requirements and tests for variable transformers
- Part 2-15: Particular requirements and tests for isolating transformers for the supply of medical locations
- Part 2-16: Particular requirements and tests for switch mode power supply units and transformers for switch mode power supply units
- Part 2-20: Particular requirements and tests for small reactors
- Part 2-23: Particular requirements and tests for transformers and power supply units for construction sites
- Part 2-26: Particular requirements and tests for transformers and power supply units all for saving energy and other purposes

Other parts are under consideration.

SAFETY OF TRANSFORMERS, REACTORS, POWER SUPPLY UNITS AND COMBINATIONS THEREOF –

Part 1: General requirements and tests

1 Scope

This part of IEC 61558 deals with safety aspects of **transformers**, reactors, power supply units and combinations thereof such as electrical, thermal and mechanical safety.

This document covers the following **independent** or **associated** stationary or portable types of **dry-type transformers**, **power supply units**, including **switch mode power supply units**, **reactors** and combinations thereof in the field of safety. The windings can be encapsulated or non-encapsulated. They are not forming a part of the distribution network.

NOTE 1 The distinction between transformers, power supply units and switch mode power supply units is as follows:

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

The relevant parts of IEC 61558-2 can be found in the introduction of this document.

a) Stationary or portable, single-phase or poly-phase, air-cooled (natural or forced), **isolating** and **safety isolating transformers**, **independent** or **associated** with the following characteristics:

- **rated supply voltage** not exceeding 1 000 V AC;
- **rated supply frequency** not exceeding 500 Hz;

and complying with the following values, unless otherwise specified in the relevant part of IEC 61558-2:

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

NOTE 2 **Isolating** and **safety isolating transformers** are used where **double** or **reinforced insulation** between circuits is required by the installation rules or by the appliance specification (for example toys, bells, portable tools, handlamps).

b) **Stationary** or **portable**, single-phase or polyphase, air-cooled (natural or forced) **separating transformers**, **auto-transformers**, **variable transformers** and small **reactors**, **independent** or **associated** with the following characteristics:

- **rated supply voltage** not exceeding 1 000 V AC;

- **rated supply frequency** not exceeding 500 Hz;

and complying with the following values, unless otherwise specified in the relevant part of IEC 61558-2:

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

NOTE 3 **Separating transformers** are used where **double** or **reinforced insulation** between circuits is not required by the installation rules or by the appliance specification.

NOTE 4 Normally, the **transformers** of type b) are intended to be associated with the equipment to provide voltages different from the supply voltage for the functional requirements of the equipment. The protection against electric shock can be provided or completed by other features of the equipment, such as the **body**. Parts of **output circuits** can be connected to the **input circuit** or to the protective earthing.

c) **Stationary** or **portable**, single-phase or polyphase, air-cooled (natural or forced), **independent** or **associated power supply units** and **switch mode power supply units** incorporating one or more **transformer(s)** of type a) or b) with the following characteristics:

- **rated supply voltage** not exceeding 1 000 V AC;
- **rated supply frequency** not exceeding 500 Hz;
- internal operational frequency for power supply units not exceeding 500 Hz and for switch mode power supply units not exceeding 100 MHz;

and with the following values, unless otherwise specified in the relevant part of IEC 61558-2:

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

NOTE 5 **Power supply units** and **switch mode power supply units** incorporating **isolating** and **safety isolating transformers** are used where **double** or **reinforced insulation** between circuits is required by the installation rules or by the appliance specification (for example toys, bells, portable **tools**, handlamps).

- for **power supply units** and **switch mode power supply units** incorporating **separating transformers**, **auto-transformers**, and **variable transformers**:
 - **rated output** for single-phase or polyphase **power supply units** and **switch mode power supply units** not exceeding 1 kVA;

- **no-load output voltage** and **rated output voltage** for both, **independent** and **associated transformers** not exceeding 15 kV AC, and for **independent transformers**, a **rated output voltage** not less than 50 V AC.

NOTE 6 **Power supply units** and **switch mode power supply units** incorporating **separating transformers** are used where **double** or **reinforced insulation** between circuits is not required by the installation rules or by the appliance specification.

This document also applies to **transformers**, **power supply units**, **switch mode power supply units** and **reactors** incorporating electronic circuits.

This document is applicable to **transformers** without limitation of the **rated output** subject to an agreement between the purchaser and the manufacturer.

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

Attention is drawn to the following:

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

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

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

IEC 60068-2-6, *Environmental testing – Part 2-6: Tests – Test FC: Vibration (sinusoidal)*

IEC 60068-2-14, *Environmental testing – Part 2-14: Tests – Test N: Change of temperature*

IEC 60068-2-31, *Environmental testing – Part 2-31: Tests – Test Ec: Rough handling shocks, primarily for equipment-type specimens*

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

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

IEC 60076-11:2004, *Power transformers – Part 11: Dry-type transformers*

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

IEC 60085:2007, *Electrical insulation – Thermal evaluation and designation*

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

IEC 60127 (all parts), *Miniature fuses*

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

IEC 60216 (all parts), *Electrical insulating materials – Thermal endurance properties*

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

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

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

IEC 60245-4:2011, *Rubber insulated cables – Rated voltages up to and including 450/750 V – Part 4: Cords and flexible cables*

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

IEC 60269-2:2013, *Low voltage fuses – Part 2: Supplementary requirements for fuses for use by authorized persons (fuses mainly for industrial application) – Examples of standardized systems of fuses A to K*

IEC 60269-3:2010, *Low voltage fuses – Part 3: Supplementary requirements for fuses for use by unskilled persons (fuses mainly for household or similar applications) – Examples of standardized systems of fuses A to F*

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

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

IEC 60317-0-7:2012, *Specifications for particular types of winding wires – Part 0-7: General requirements – Fully insulated (FIW) zero-defect enamelled round copper wire with nominal conductor diameter of 0,040 mm to 1,600 mm*

IEC 60317-56, *Specifications for particular types of winding wires – Part 56: Solderable fully insulated (FIW) zero-defect polyurethane enamelled round copper wire with nominal conductor diameter 0,040 mm to 1,600 mm, class 180*

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

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

IEC 60384-14:2013, *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, *Graphical symbols for use on equipment*
(available at <http://www.graphical-symbols.info/equipment>)

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

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

IEC 60529:1989/AMD1:1999

IEC 60529:1989/AMD2:2013

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

IEC 60664-3:2016, *Insulation coordination for equipment within low-voltage systems – Part 3: Use of coating, potting or moulding for protection against pollution*

IEC 60691:2015, *Thermal-links – Requirements and application guide*

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IEC 60730 (all parts), *Automatic electrical controls*

IEC 60730-1:2013, *Automatic electrical controls – Part 1: General requirements*

IEC 60851-3:2009, *Winding wires – Test methods: Part 3: Mechanical properties*

IEC 60851-5:2008, *Winding wires – Test methods: Part 5: Electrical properties*

IEC 60851-6:2012, *Winding wires – Test methods: Part 6: Thermal properties*

IEC 60884-1:2002, *Plugs and socket-outlets for household and similar purposes – Part 1: General requirements*

IEC 60884-1:2002/AMD1:2006

IEC 60884-1:2002/AMD2:2013

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

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

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

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

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

IEC 60990:2016, *Methods of measurement of touch current and protective conductor current*

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

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

IEC 60999-1, *Connecting devices – Electrical copper conductors – Safety requirements for screw-type and screwless-type clamping units – Part 1: General requirements and particular requirements for clamping units for conductors from 0,2 mm² up to 35 mm² (included)*

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

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

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

IEC 61140:2016, *Protection against electric shock – Common aspects for installation and equipment*

IEC 61373, *Railway applications – Rolling stock equipment – Shock and vibration tests*

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

EN 50075:1990, *Specification for flat non-wirable two-pole plugs 2.5 A 250 V, with cord, for the connection of class II-equipment for household and similar purposes*

DIN 43671:1975, *Copper bus bars; design for continuous current*

DIN 43670:1975, *Aluminium bus bars; design for continuous current*

DIN 43670-2:1985, *Aluminium bus bars copper cladding; design for continuous current*

3 Terms and definitions

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

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

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

NOTE Further definitions of **transformers** intended for particular use are indicated in the relevant parts of IEC 61558-2.

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

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

“Ripple-free” is conventionally an RMS ripple voltage not more than 10 % of the DC component.

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

3.1 Transformers

3.1.1

transformer

static piece of apparatus with two or more windings which, by electromagnetic induction, transforms a system of alternating voltage and current into another system of voltage and current usually of different values and at the same frequency for the purpose of transmitting electrical power

Note 1 to entry: The term frequency also implies that the waveform remains the same.

[SOURCE: IEC 60050-421:1990, 421-01-01, modified – “power” deleted and “NOTE” added]

3.1.2

isolating transformer

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

3.1.3

safety isolating transformer

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

3.1.4

separating transformer

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

3.1.5

auto-transformer

transformer in which **input** and **output windings** have a common part

Note 1 to entry: **Auto-transformers** may have supplementary windings or tapings for adjustment purposes.

Note 2 to entry: Transformers with windings separated at least by functional insulation and electrically connected, will be treated as **auto-transformers**.

3.1.6

associated transformer

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

3.1.6.1

incorporated transformer

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

3.1.6.2

transformer for specific use

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

3.1.7

independent transformer

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

Note 1 to entry: Such a **transformer** can be either a portable **transformer** or a stationary **transformer**.

3.1.8

void

3.1.9**short-circuit proof transformer**

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

Note 1 to entry: "Continues to meet all the requirements of this document" does not imply that all types of short-circuit proof **transformers** continue to operate.

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

short-circuit proof transformer equipped with a protective device or with an **intentional weak part** which opens the **input circuit** or the **output circuit**, or reduces the current in the **input circuit** or the **output circuit** when the **transformer** is overloaded or short-circuited, and continues to meet all the requirements of this document after removal of the overload or short circuit

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

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

Note 1 to entry: Examples of self-resetting or non self-resetting protective devices are fuses, **overload relays**, thermal fuses, thermal links, **thermal cut-outs** and PTC resistors and automatic break-off mechanical devices.

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

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

3.1.9.2**inherently short-circuit proof transformer**

short-circuit proof transformer not equipped with any device for protection against overload or short circuit

Note 1 to entry: The **transformer**, by construction, does not exceed the specified temperature limits, and continues to operate and meet all the requirements of this document after the removal of the overload or short circuit.

3.1.10**non-short-circuit proof transformer**

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

3.1.11**fail-safe transformer**

transformer equipped with a protective device or with an **intentional weak part**, which permanently fails to function by the interruption of the **input circuit** when the **transformer** is overloaded or short-circuited, but presents no danger to the user or surroundings

Note 1 to entry: It continues to meet all the requirements of this document after removal of the overload or short circuit.

Note 2 to entry: “Continues to meet all the requirements of this document” does not imply that the fail-safe **transformer** continues to operate. After failing it fulfils the dielectric strength test based on 35 % of the original values (see 15.5).

3.1.12

portable transformer

either a **transformer** which is moved while in operation, or a **transformer** which can easily be moved from one place to another while connected to the supply or being a plug-in **transformer**

3.1.13

flush-type transformer

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

3.1.14

fixed transformer

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

3.1.15

stationary transformer

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

3.1.16

hand-held transformer

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

3.1.17

void

3.1.18

dry-type transformer

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

3.1.19

power supply unit

electronic device incorporating **transformer(s)** and electronic circuitry(ies), that converts electrical power into single or multiple power outputs

Note 1 to entry: It may also isolate the **input circuit** from the **output circuit**, and regulate and/or convert the output voltage and current. The device may consist of one or more individual units with identical or different waveforms and frequencies including DC output, and the **internal operating frequency** and waveform are different from the supply frequency and waveform and the **internal operating frequency** does not exceed 500 Hz.

3.1.20

switch mode power supply unit

electronic device incorporating **transformer(s)** and electronic circuitry(ies), that converts electrical power into single or multiple power outputs

Note 1 to entry: It may also isolate the **input circuit** from the **output circuit**, and regulate and/or convert the output voltage and current. The device may consist of one or more individual units with identical or different waveforms and frequencies including DC output, and the **internal operating frequency** and waveform are different from the supply frequency and waveform and the **internal operating frequency** does exceed 500 Hz, but not exceed 100 MHz.

3.1.21**reactor**

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

Note 1 to entry: **Reactors** with toroidal cores are also included in this definition.

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

flexible cable or cord for external connection to the **input** or **output circuit**, fixed to or assembled with the **transformer** according to type X, type Y or type Z attachment

3.2.1.1**type X attachment**

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

3.2.1.2**type Y attachment**

method of attachment intended to be replaced only by the manufacturer, his service agent, or similar qualified person

Note 1 to entry: **Type Y attachments** may be used either with ordinary flexible cables or cords, or with special cables or cords.

3.2.1.3**type Z attachment**

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

3.2.2**power supply cord**

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

Note 1 to entry: **Power supply cords** are:

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

3.2.3**connecting lead**

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

Note 1 to entry: **Connecting leads** are considered as an internal wire.

3.2.4**body**

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

3.2.5**accessible part**

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

3.2.6**detachable part**

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

3.2.7**non-detachable part**

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

3.2.8**tool**

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

3.2.9**enclosure**

housing affording the type and degree of protection suitable for the intended application

Note 1 to entry: Protection against for example mechanical impacts, corrosion, fungi, vermin, solar radiation, icing and moisture.

[SOURCE: IEC 60050-195:1998, 195-02-35, modified – “NOTE” added]

3.2.10**intermediate conductive part**

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

3.2.11**conductive part**

part which can carry electric current

[SOURCE: IEC 60050-195:1998, 195-01-06]

3.2.12**electronic component**

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

Note 1 to entry: Neon indicators are not considered to be electronic components

3.2.13**electronic circuit**

circuit incorporating at least one electronic component

3.2.14

void

3.2.15**electrical separation**

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

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

disconnection of all live conductors by a single switching action

Note 1 to entry: **Protective earthing conductor** is not considered to be a supply conductor.

Note 2 to entry: A neutral conductor is considered to be a supply conductor.

Note 3 to entry: National wiring rules may or may not require the disconnection of the neutral conductor.

3.3.2

thermal cut-out

temperature sensitive device which limits the temperature of a **transformer**, or of parts of it, during abnormal operation by automatically opening the circuit or by reducing the current, and which is so constructed that its setting cannot be altered by the user

3.3.3

self-resetting thermal cut-out

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

3.3.4

non-self-resetting thermal cut-out

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

3.3.5

thermal-link

thermal cut-out which operates only once

3.3.6

overload relay

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

3.3.7

intentional weak part

part other than overload protective device (fuses, circuit-breaker, thermal cut-outs, etc.) intended to rupture under conditions of abnormal operation to prevent the occurrence of a condition which could impair compliance with this document

Note 1 to entry: Such a part may be a replaceable component, such as a resistor or a capacitor or a non replaceable part of a component such as an inaccessible weak point in a winding.

3.3.8

working voltage

highest RMS value of the AC or DC voltage which may occur (locally) across any insulation at **rated supply voltage** under no-load or normal operating conditions, transients being disregarded

Note 1 to entry: 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 to entry: On three phase systems, the **working voltage** can be different from the nominal voltage.

3.3.9

short-circuit voltage

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

Note 1 to entry: The **short-circuit voltage** is usually expressed as a percentage of the **rated supply voltage**.

3.3.10

duty-type

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

3.3.10.1**continuous duty**

operation for an unlimited period

3.3.10.2**short-time duty cycle**

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

3.3.10.3**intermittent duty cycle**

operation in a series of specified identical cycles

3.3.11**protective earthing conductor****PE**

protective conductor provided for protective earthing

[SOURCE: IEC 60050-195:1998, 195-02-11]

3.4 Circuits and windings**3.4.1****input circuit**

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

3.4.2**output circuit**

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

3.4.3**input winding**

winding of the **input circuit**

3.4.4**output winding**

winding of the **output circuit**

3.4.5**internal circuit**

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

3.4.6**fully insulated winding wire****FIW**

wire according to IEC 60317-0-7, IEC 60317-56 and tested according to IEC 60851-5:2008 which is a zero-defect wire construction

3.4.7**grade of FIW**

range of overall diameter of a wire (FIW3 to FIW9)

3.4.8**insulated winding wire**

winding wire for basic-, supplementary-, or reinforced insulation

Note 1 to entry: Requirements are provided in Annex K.

3.4.9**extruded winding wire****TIW**

winding wires with basic-, supplementary-, or reinforced insulation obtained by extrusion

Note 1 to entry: The term TIW is commonly used to cover all types of extruded winding wires.

3.5 Ratings**3.5.1****rated supply voltage**

supply voltage (for polyphase supply, the phase-to-phase voltage) assigned to the **transformer** by the manufacturer for the specified operating conditions of the **transformer**

3.5.2**rated supply voltage range**

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

3.5.3**rated frequency**

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

3.5.3.1**rated supply frequency**

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

Note 1 to entry: The supply frequency is the frequency of the mains.

3.5.3.2**internal operational frequency**

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

3.5.4**rated output current**

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

3.5.5**rated output voltage**

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

3.5.6**rated power factor**

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

3.5.7**rated output**

product of the **rated output voltage** and the **rated output current** or, for three-phase **transformers**, $\sqrt{3}$ times the product of the **rated output voltage** and the **rated output current**

Note 1 to entry: If the **transformer** has more than one **output winding** or a tapped **output winding**, the **rated output** denotes the maximum sum of the products of **rated output voltage** and **rated output current** for **output circuits** intended to be loaded simultaneously.

3.5.8**rated ambient temperature** t_a

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

Note 1 to entry: The value of the **rated ambient temperature** (t_a) does not preclude temporary operation of the **transformer** at a temperature not exceeding ($t_a + 10$) °C.

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

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

3.5.10**rated minimum temperature** t_{min}

minimum temperature only for transportation and storage

3.5.11**overvoltage category**

numeral defining a transient overvoltage condition

Note 1 to entry: Overvoltage categories I, II, III and IV are used, see IEC 60664-1:2007, 4.3.3.2.

[SOURCE: IEC 60050-581:2008, 581-21-02, modified – “NOTE” added]

3.5.11.1**overvoltage category I****OVC I**

equipment for connection to circuits in which measures are taken to limit transient overvoltages to an appropriately low level

Note 1 to entry: Examples of such equipment are those containing electronic circuits protected to this level. However, unless the circuits are designed to take the temporary overvoltages into account, equipment of overvoltage category I cannot be directly connected to the mains supply.

3.5.11.2**overvoltage category II****OVC II**

energy-consuming equipment to be supplied from the fixed installation

Note 1 to entry: Examples of that equipment are transformers for household appliances, telecommunications, toys, and similar loads.

3.5.11.3**overvoltage category III****OVC III**

equipment used in fixed installations and for cases where the reliability and the availability of the equipment is subject to special requirements

Note 1 to entry: Examples of such equipment are transformers in fixed installations and **transformers** for industrial use with permanent connection to the fixed installation.

3.5.11.4

overvoltage category IV

OVC IV

equipment used at the origin of installation

Note 1 to entry: Examples of such equipment are **transformers** in fixed installations of power plants or immediate to such installations.

3.6 No-load values

3.6.1

no-load input

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

3.6.2

no-load output voltage

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

3.7 Insulation

3.7.1

basic insulation

insulation of **live parts** which provides basic protection

Note 1 to entry: **This concept does not apply to insulation used exclusively for functional purposes**, for example wire enamel.

[SOURCE: IEC 60050-195:1998, 195-06-06, modified – “hazardous” deleted and “,for example wire enamel” added]

3.7.1.1

functional insulation

insulation between conductive parts, necessary for the proper functioning of the transformer

Note 1 to entry: For **transformers**, proper functional insulation may have influence on the safety. **Functional insulation** is checked by the requirements of this document but additional requirements may exist in IEC 61558-2 (all parts).

[SOURCE: IEC 60050-195:1998, 195-02-41, modified – “transformer” replaces “equipment” and “NOTE” added]

3.7.2

supplementary insulation

independent insulation of **hazardous-live-parts** applied in addition to **basic insulation**, for fault protection

Note 1 to entry: Fault protection means in order to provide protection against electric shock in the event of a **basic insulation** failure.

[SOURCE: IEC 60050-195:1998, 195-06-07, modified – “hazardous-live-parts” and “NOTE” added]

3.7.3

double insulation

insulation comprising both **basic insulation** and **supplementary insulation**

[SOURCE: IEC 60050-195:1998, 195-06-08]

3.7.4**reinforced insulation**

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

Note 1 to entry: Reinforced insulation may comprise several layers which cannot be tested singly as basic insulation or supplementary insulation.

[SOURCE: IEC 60050-195:1998, 195-06-09]

3.7.5**class I transformer**

transformer in which protection against electric shock does not rely on **basic insulation** only, but which includes an additional safety precaution such as a protective earthing terminal for the connection of accessible **conductive parts** to the fixed wiring of the installation

Note 1 to entry: The protective earthing connection prevents that accessible **conductive parts** become live in the event of a **basic insulation** failure.

Note 2 to entry: **Class I transformers** may have parts with **double** or **reinforced insulation**.

3.7.6**class II transformer**

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

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

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

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

Note 4 to entry: 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 to entry: If a **transformer** with **double insulation** and/or **reinforced insulation** throughout has a protective earthing terminal, it is deemed to be of **class I** construction.

Note 6 to entry: A **class II transformer** may be provided with functional earthing circuit.

3.7.7**class III transformer**

transformer in which protection against electric shock relies on supply at **SELV**, and in which voltages higher than those of **SELV** are not generated

Note 1 to entry: The classification I, II or III does not refer to the insulation system between **input windings** and **output windings**.

3.7.8**clearance****CL**

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

Note 1 to entry: 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 4).

[SOURCE: IEC 60664-1:2007, 3.2, modified – “NOTE” added]

3.7.9

creepage distance

CR

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

Note 1 to entry: For the purpose of determining a **creepage distance** from **transformer conductive parts** to **accessible parts**, the accessible surface of an insulating **enclosure** is to be considered conductive as if it were covered by a metal foil wherever it can be touched by the standard test finger (see Figure 4).

[SOURCE: IEC 60050-151:2001, 151-15-50, modified – “through air” and “NOTE” added]

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

[SOURCE: IEC 60664-1:2007, 3.11]

3.7.11

micro-environment

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

Note 1 to entry: 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.

[SOURCE: IEC 60664-1:2007, 3.12.2, modified – “or clearances” and “NOTE” added]

3.7.12

degree of pollution

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

3.7.12.1

pollution degree 1

P1

pollution degree in which no **pollution** or only dry, non-conductive **pollution** occurs

Note 1 to entry: The **pollution** has no influence.

3.7.12.2

pollution degree 2

P2

pollution degree in which only non-conductive **pollution** occurs, except that occasionally a temporary conductivity caused by condensation is to be expected

Note 1 to entry: **Transformers** having a reasonably tight **enclosure** are considered to have **pollution degree 2** (P2), hermetic sealing is not required.

3.7.12.3

pollution degree 3

P3

pollution degree in which conductive **pollution** occurs, or dry non-conductive **pollution** occurs which becomes conductive due to the condensation which is to be expected

3.7.13**protective separation**

separation between circuits by means of basic and supplementary protection (**basic insulation** plus **supplementary insulation** or **protective screening**) or by an equivalent protective provision (for example **reinforced insulation**)

[SOURCE: IEC 60050-195:1998, 195-06-19, modified – “(electrically)” removed and definition redrafted]

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 earthing conductor

[SOURCE: IEC 60050-195:1998, 195-06-18, modified – “(electrically)” removed and definition redrafted]

3.7.15**ELV****extra-low voltage**

voltage which does not exceed 50 V AC or 120 V ripple free DC between conductors, or between any conductor and protective earthing

3.7.16**SELV****safety extra low voltage**

ELV in a circuit which is isolated from the mains supply by such means as a **safety isolating transformer**

Note 1 to entry: Maximum voltage lower than 50 V AC or 120 V ripple-free DC may be specified in particular requirements, especially when direct contact with **live parts** is allowed.

Note 2 to entry: The maximum peak value does not exceed 140 V for a nominal 120 V ripple-free DC system and 70 V for a nominal 60 V ripple-free DC system.

3.7.17**SELV-circuit**

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

3.7.18**PELV-circuit****protective extra low voltage**

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

Note 1 to entry: **PELV-circuits** are used where the circuits are earthed and **SELV** is not required.

3.7.19**FELV-circuit****functional extra low voltage-circuit**

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

3.7.20**live part**

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

Note 1 to entry: This concept does not necessarily imply a risk of electric shock.

Note 2 to entry: For definitions of PEM and PEL see IEC 60050-195:1998, 195-02-13 and 195-02-14

[SOURCE: IEC 60050-195:1998, 195-02-19, modified – “NOTE 2” added]

3.7.21

hazardous-live-part

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

Note 1 to entry: In case of high voltage, a hazardous voltage may be present on the surface of solid insulation. In such a case, the surface is considered to be a **hazardous-live-part**

[SOURCE: IEC 60050-195:1998, 195-06-05, modified – “NOTE” added]

3.8 Touch current and protective earthing conductor current

3.8.1

touch current

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

[SOURCE: IEC 60050-195:1998, 195-05-21]

3.8.2

protective earthing conductor current

current which flows in a protective earthing conductor

Note 1 to entry: This current may have influence on the operation of RCDs (residual current protection devices) connected in the same circuit.

4 General requirements

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

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

4.2 When associated transformers are used in an appliance or equipment for which a relevant appliance or equipment standard exists, they may be tested under the conditions present in the appliance or equipment for which they are intended.

*If a **transformer** is tested under the conditions present in the appliance or equipment for which it is intended, it shall comply with the following clauses or subclauses thereof of this document:*

1 – 2 – 3 – 4 – 5.1 – 5.2 – 5.3 – 5.4 – 5.5 – 5.6 – 5.7 – 7.1 – 7.2 – 7.5 – 7.6 – 7.8 – 8.2 – 8.11 – 14.1 – except for the requirements in Table 2 starting with the first: “external enclosures”..., 14.2 – 14.3 – 15.1, restricted to the first box of Table 5 – 18.1 – 18.2 – 18.3 only between input and output circuits – 18.4 – 19.1 – 19.12 – 20.10 – 26.1 – 26.2 – 26.3 – Annexes A, G, L, M, N, P

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

4.3 For other hazards not covered by this document (e.g. EMF, functional safety linked to electric, magnetic and electromagnetic disturbances, etc.), the manufacturer has to perform a risk assessment.

5 General notes on tests

5.1 Tests according to this document are:

- type tests (defined from 8.1 up to Clause 28);
- routine tests (defined in Annex L).

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

Unless otherwise specified, the tests shall be carried out under steady-state conditions.

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

5.2 Tests are carried out on specimens as delivered and installed as in normal use taking into account the manufacturer's installation instructions. If it is not necessary to do the tests of 14.3, 15.5, 16.4 and 26.2, the number of specimens is one for all **rated outputs**.

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

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

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

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

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

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

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

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

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

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

5.4 *If the test results are not influenced by the temperature of the ambient air, the ambient temperature is, in general, maintained at $(20 \pm 5) ^\circ\text{C}$. Otherwise and if, however, the temperature attained by any part is limited by a temperature-sensitive device, or is influenced by the temperature at which a change of state occurs, the ambient temperature is, in case of doubt, maintained at $(23 \pm 2) ^\circ\text{C}$ or $(t_a \pm 2) ^\circ\text{C}$ for **transformers** with t_a marking.*

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

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

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

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

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

5.9 If **class I transformers** have accessible conductive 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 conductive part** that is connected to a protective earthing terminal or protective earthing contact, such parts are checked for compliance with the appropriate requirements specified for **class II transformers** in this document.

5.10 A **flush-type transformer** is tested with an appropriate flush-mount box of insulating material. This box is placed in an **enclosure** as indicated in Figure 2, made from plywood, with a thickness of 20 mm, the inside painted dull black, and the distance between the back of the mounting box and the rear wall of the **enclosure** being 5 mm.

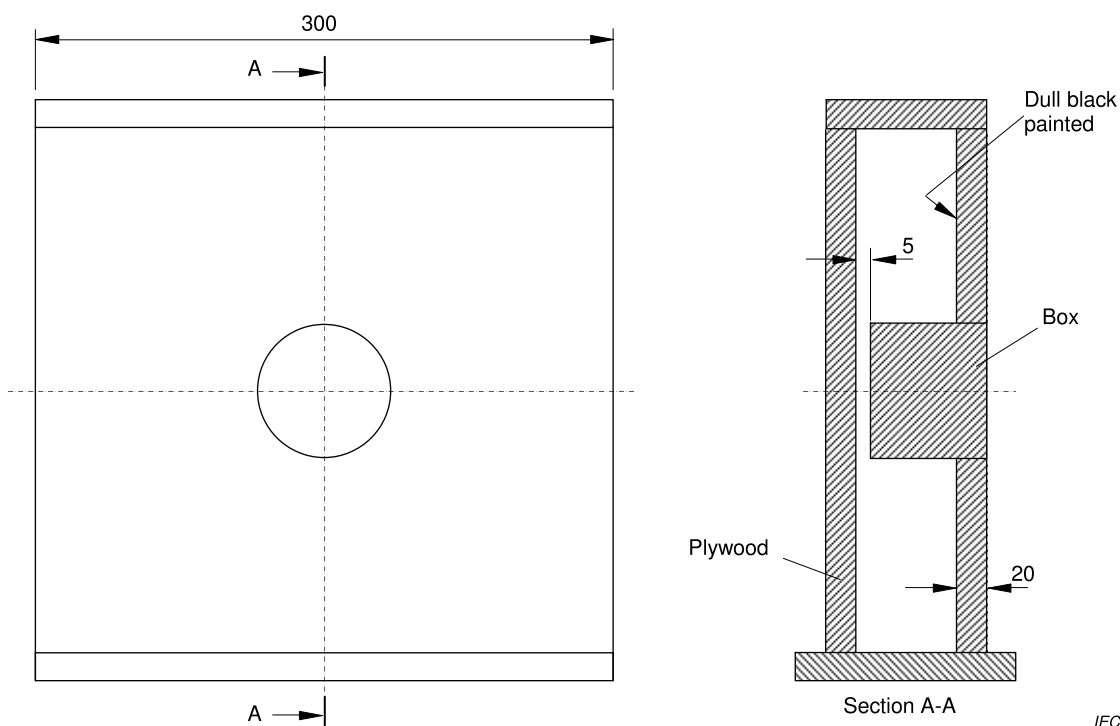


Figure 2 – Mounting box for flush-type transformer

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

5.12 Void

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

*For these **transformers**, the requirements of Clause 9 are not applicable. Furthermore, the test in 27.2 is not performed as the result can be influenced by the **enclosure** in the final application, for example on the fixing point of the **transformer** fixed on plastic support. For the fault condition test, if applicable, the product standard for the final product applies.*

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

5.15 *The tests in Clauses 18 and 26 are based on an elevation of 2 000 m above sea level. If tested in elevations in excess of 2 000 m above sea level, Annex A of IEC 60664-1:2007 applies.*

6 Ratings

Ratings are indicated in the relevant part of IEC 61558-2 for different types of **transformers**.

7 Classification

7.1 Transformers are classified according to their protection against electric shock:

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

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

7.2 Transformers are classified according to the short-circuit characteristic 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 Transformers are classified according to the degree of protection ensured by the **enclosure** and defined in accordance with IEC 60529 (IP code) except IP1X.

NOTE For further information see Annex Q.

7.4 Transformers are classified according to their mobility:

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

7.5 Transformers are classified according to their duty type:

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