

Specification for

**Separating
transformers,
autotransformers,
variable transformers
and reactors**

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Power Electrical Engineering Standards Policy Committee (PEL/-) to Technical Committee PEL/113, upon which the following bodies were represented:

Association of Consulting Engineers
British Cable Makers' Confederation
British Railways Board
Electricity Supply Industry in United Kingdom
Institution of Plant Engineers
Transmission and Distribution Association (BEAMA Ltd.)

The following bodies were also represented in the drafting of the standard, through subcommittees and panels:

British Toy and Hobby Manufacturers' Association Ltd.
Department of Trade and Industry (Consumer Safety Unit, C A Division)
EEA (the Association of Electronics, Telecommunications and Business Equipment Industries)
Electrical Installation Equipment Manufacturers' Association (BEAMA Ltd.)
Electronic Components Industry Federation
GAMBICA (BEAMA Ltd.)
Lighting Industry Federation Ltd.
Portable Electric Tool Manufacturers' Association

This British Standard, having been prepared under the direction of the Power Electrical Engineering Standards Policy Committee, was published under the authority of the Standards Board and comes into effect on 31 July 1991

© BSI 1991

The following BSI references relate to the work on this standard:
Committee reference PEL/113
Draft for comment 84/28673 DC

ISBN 0 580 19796 4

Amendments issued since publication

Amd. No.	Date	Text affected

Contents

	Page
Committees responsible	Inside front cover
National foreword	iv
General plan of the standard	1
Chapter I: General requirements	
1 Scope and object	2
2 Definitions	3
3 General requirements	10
4 General notes on tests	11
5 Rating	13
6 Classification	13
7 Marking	14
8 Protection against electric shock	19
9 Change of input voltage setting	23
10 Output voltage and output current under load	24
11 No-load output voltage	25
12 Short-circuit voltage	25
13 Heating	25
14 Short-circuit and overload protection	31
15 Mechanical strength	35
16 Protection against harmful ingress of water and moisture	36
17 Insulation resistance and electric strength	37
18 Construction	40
19 Components	44
20 Internal wiring	46
21 Supply connection and external flexible cables and cords	46
22 Terminals for external conductors	53
23 Provision for protective earthing	61
24 Screws and connections	62
25 Creepage distances and clearances	66
26 Resistance to heat, abnormal heat, fire and tracking	71
27 Resistance to rusting	77
Appendix I-A Production tests	78
Appendix I-B Void	80
Appendix I-C Examples of points of application of test voltages	81
Appendix I-D Measurement of creepage distances and clearances	83
Appendix I-E Examples of points of measurement of creepage distances and clearances	89

	Page
Chapter II: Particular requirements for special separating transformers	
Section 1. Control transformers	
1 Scope and object	91
2 Definitions	91
7 Marking	91
9 Change of input voltage setting	91
10 Output voltage and output current under load	92
11 No-load output voltage	92
13 Heating	92
17 Insulation resistance and electric strength	92
25 Creepage distances and clearances	93
Section 2. Ignition transformers for gas and oil burners	
1 Scope and object	93
2 Definitions	93
4 General notes on tests	93
5 Rating	94
6 Classification	94
7 Marking	94
8 Protection against electric shock	94
10 Output voltage and output current under load	94
11 No-load output voltage	95
13 Heating	96
14 Short-circuit and overload protection	96
16 Protection against harmful ingress of water and moisture	97
17 Insulation resistance and electric strength	97
18 Construction	98
25 Creepage distances and clearances	98
Appendix II-A Void	
Appendix II-B Measurement of leakage current for ignition transformers for gas and oil burners	99
Section 3. High insulation level transformers and separating transformers with working voltage above 1000 V	
1 Scope and object	101
2 Definitions	101
7 Marking	101
10 Output voltage and output current under load	102
11 No-load output voltage	102
17 Insulation resistance and electric strength	102
25 Creepage distances and clearances	102
Section 4. Stray field transformers	
Under consideration	106
Section 5. Stabilizing transformers (current and voltage types)	
Under consideration	106

	Page
Chapter III: Particular requirements for autotransformers	
1 Scope and object	106
2 Definitions	106
5 Rating	106
7 Marking	106
8 Protection against electric shock	107
10 Output voltage and output current under load	107
17 Insulation resistance and electrical strength	107
25 Creepage and clearance distances	107
26 Resistance to heat, abnormal heat, fire and tracking	107
Appendix III-A Production tests	108
Chapter IV: Supplementary specifications for variable transformers	
1 Scope and object	109
2 Definitions	109
6 Classification	110
7 Marking	110
8 Protection against electric shock	111
10 Output voltage and output current under load	111
11 No-load output voltage	112
13 Heating	112
15 Mechanical strength	112
18 Construction	113
21 Supply connection and external flexible cables and cords	113
25 Creepage distances and clearances	113
Appendix IV-A Tests during production	114
Chapter V: Supplementary particular requirements for reactors	
Under consideration	115
Figures	116

National foreword

This British Standard has been prepared under the direction of the Power Electrical Engineering Standards Policy Committee. It is identical with IEC 989 : 1991 'Separating transformers, autotransformers, variable transformers and reactors' published by the International Electrotechnical Commission (IEC).

Cross-references

International standard	Corresponding British Standard
IEC 50(151) : 1978	BS 4727 Glossary of electrotechnical, power, telecommunications, electronics, lighting and colour terms Part 1 : Group 02 : 1980 Electrical and magnetic devices terminology (Technically equivalent)
IEC 51-2	BS 89 Direct acting indicating analogue electrical measuring instruments and their accessories Part 2 : 1990 Specification for special requirements for ammeters and voltmeters (Identical)
IEC 68-2-2 (1974)	BS 2011 Environmental testing Part 2.1B : 1977 Tests B. Dry heat (Identical)
IEC 76-4 (1976)	BS 171 Power transformers Part 4 : 1978 Specifications for tappings and connections (Identical)
IEC 85 (1984)	BS 2757 : 1986 Method for determining the thermal classification of electrical insulation (Identical)
IEC 127 (1974)	BS 4265 : 1977 Specification for cartridge fuse links for miniature fuses (Identical)
IEC 269-2 (1986)	BS 88 Cartridge fuses for voltages up to and including 1000 V a.c. and 1500 V d.c. Section 2.1 : 1988 Supplementary requirements (Identical)
IEC 335-1 (1970)	BS 3456 Specification for safety of household and similar electrical appliances Part 201 : 1990 General requirements (Technically equivalent)
IEC 617-6 (1983)	BS 3939 Guide for graphical symbols for electrical power, telecommunications and electronics diagrams Part 6 : 1985 Production and conversion of electrical energy (Identical)
IEC 742 (1983)	BS 3535 Isolating transformers and safety isolating transformers Part 1 : 1990 General requirements (Technically equivalent)

The Technical Committee has reviewed the provisions of IEC Publication 65 : 1985, IEC Publication 83 : 1975, IEC Publication 227 : IEC Publication 245, IEC Publication 269-3 : 1987, IEC Publication 529 : 1976 and IEC Publication 664 : 1980 to which reference is made in the text and has decided that they are acceptable for use in conjunction with this British Standard. A related British Standard to IEC 65 : 1985 is BS 415 : 1990 'Specification for safety requirements for mains-operated electronic and related apparatus for household and similar general use'. A related British Standard to IEC 83 : 1975 is BS 1363 : 1984 'Specification for 13 A fused plugs and switched and unswitched socket outlets'.

A related British Standard to IEC 227 is BS 6746 : 1990 'Specification for PVC insulation and sheath of electric cables'. A related British Standard to IEC 245 is BS 6899 : 1984 'Specification for rubber insulation and sheath of electric cables'. A related British Standard to IEC 269-3 : 1987 is BS 1362 : 1973 'Specification for general purpose fuse links for domestic and similar purposes (primarily for use in plugs)'. A related British Standard for IEC 529 : 1976 is BS 5490 : 1977 'Specification for classification of degrees of protection provided by enclosures'. A related British Standard to IEC 664 : 1980 is PD 6499 'Guide to insulation coordination within low-voltage systems including clearances and creepage distances for equipment'.

There is no British Standard corresponding to IEC 364-5-51 : 1979 however the publication has been harmonized in Europe as HD 384-5-51 S1 : 1985. There are no British Standards corresponding to IEC 685-1, IEC 685-2-1, IEC 685-2-2; these publications are being superseded by the IEC 998 series. There is no British Standard corresponding to IEC 726 : 1982, however the publication has been harmonized in Europe as HD 464 S1 : 1988.

Additional information. In subclause 1.1, Scope, of chapter I, the words 'the relevant IEC Technical Committees' should be changed to 'the relevant Technical Committee'. In clause 2, Definitions, of chapter I, the words 'IEC International Electrotechnical Vocabulary' should be changed to 'BS 4747 : Part 1 Group 02'. In subclause 19.1 of chapter I the words 'IEC Standard' should be changed to 'British Standard'. In subclause 21.4 of chapter I and subclause 21.4 of chapter IV, the text '(code designation 245 IEC 53)' should read '(code designation 53, IEC Publication 245);' and the text '(code designation 227 IEC 53)' should read '(code designation 53, IEC Publication 227)'.

NOTE. Typographical error. In 15.3 of chapter I, 'hundrer' should be 'hundred'.

References in the text to IEC page numbers should be ignored.

This British Standard complements BS 3535 'Isolating transformers and safety isolating transformers, Part 1 : 1990 General requirements'. BS 3535 : Part 1 : 1990 is the English language version of EN 60 742 : 1989.

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

GENERAL PLAN OF THE STANDARD

The following standard has several chapters:

- Chapter I gives general requirements for all separating transformers, autotransformers, variable transformers, small reactors and special separating transformers and reactors, whatever their use. For separating transformers for general use chapter I applies without any particular requirements;
- Chapter II gives particular requirements applicable to special separating transformers. It is divided into sections applicable to various kinds of appliances:
 - Section One: Control transformers
 - Section Two: Ignition transformers for gas and oil burners
 - Section Three: High insulation level transformers and separating transformers with working voltage above 1 000 V
 - Section Four: Stray field transformers
 - Section Five: Stabilizing transformers
- Chapter III gives particular requirements applicable to autotransformers.
- Chapter IV gives particular requirements applicable to variable transformers.
- Chapter V gives particular requirements applicable to small reactors.

Chapter I and one of the which follow it chapters or sections form a whole, independent of any other chapter or section. However, for separating transformers for general use chapter I applies alone.

Clauses and sub-clauses of the following chapters or sections modify ("modification"), replace ("replacement") or supplement ("addition") the corresponding clauses and sub-clauses of Chapter I or introduce new sub-clauses ("additional sub-clause").

All other clauses and sub-clauses of Chapter I apply.

In the individual chapters and sections starting with Chapter II:

- additional sub-clauses are numbered from 101;
- appendices are numbered according to the chapter or section number and in chronological order (e.g. Appendix II-20).

SEPARATING TRANSFORMERS, AUTOTRANSFORMERS, VARIABLE TRANSFORMERS AND REACTORS

CHAPTER 1: GENERAL REQUIREMENTS

1. Scope and object

1.1 *Scope*

This standard is applicable to stationary or portable, single-phase or polyphase, air-cooled separating transformers, autotransformers, 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 500 Hz, a rated no-load or load output voltage not exceeding 15 kV a.c. or d.c. and a rated output not exceeding:

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

unless otherwise specified in the relevant chapters.

This standard is applicable to transformers where double or reinforced insulation between circuits is not required by the installation rules or by the appliance specification.

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

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

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.

This standard is applicable to dry type or encapsulated transformers.

For transformers filled with liquid dielectric or pulverized material, such as sand, requirements are under consideration.

In locations where special environmental conditions prevail, particular requirements may be necessary in accordance with IEC Publication 364-5-51.

This standard is not applicable to transformers where double or re-inforced insulation between circuits is required by the installation rules or the requirements for appliances and transformers covered by IEC Publication 742.

1.2 Object

The main object of this standard is to establish safety requirements for transformers and reactors which are the subject of this standard.

2. Definitions

For the definitions of general terms used in this standard, reference should be made to the IEC International Electrotechnical Vocabulary.

- 2.1 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.
- 2.2 *Transformer* is a static piece of apparatus which, by electro-magnetic induction, transforms alternating voltage and current between two or more windings at the same frequency and usually at different values of voltage and current.
- 2.3 *Separating transformer* denotes a transformer with one or more input winding(s) separated from the output winding(s) by at least basic insulation.
- 2.4 Void.
- 2.5 *Flush-type transformer* is a transformer designed to be mounted in a flush-type mounting box.
- 2.6 *Associated transformer* denotes a transformer designed to supply specific appliances or equipment and either incorporated in, or specially designed to be used only with, the specific appliance(s) or equipment.

These types of transformer may be either:

- incorporated transformers, or
- transformers for specific use.

- 2.7 *Incorporated transformer* denotes an associated transformer which is designed to be built into the specific appliance or equipment.
- 2.8 *Transformer for specific use* denotes an associated transformer which is supplied with, or attached to, a specific appliance or equipment.
- 2.9 *Input winding* denotes the winding intended to be connected to the supply.
- 2.10 *Output winding* denotes a winding to which the distribution circuit, appliance or other equipment is to be connected.
- 2.11 *Rated supply voltage* denotes the supply voltage (for polyphase supply, the phase to phase voltage) assigned to the transformer by the manufacturer for the specified operating condition of the transformer.
- 2.12 *Rated supply voltage range* denotes the supply voltage range assigned to the transformer by the manufacturer, expressed by its lower and upper limits.
- 2.13 *Rated frequency* denotes the frequency assigned to the transformer by the manufacturer for the specified operating condition of the transformer.
- 2.14 *Rated output current* denotes the output current at rated supply voltage and rated frequency, assigned to the transformer by the manufacturer for the specified operating condition of the transformer.

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.

- 2.15 *Rated output voltage* denotes 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 condition of the transformer.
- 2.16 *Rated power factor* denotes the power factor assigned to the transformer by the manufacturer for the specified operating conditions of the transformer.
- 2.17 *Rated output* is 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 sum of the products of rated output voltage and rated output current for such circuits that may be loaded simultaneously.

2.18 *No-load input* denotes the input of the transformer when connected to rated supply voltage at rated frequency, with no load on the output.

2.19 *No-load output voltage* denotes the output voltage when the transformer is connected to rated supply voltage at rated frequency, with no load on the output.

2.20 *Short-circuit voltage* denotes the voltage to be applied to the input winding, when the windings are at room temperature, to produce in the short-circuited output winding a current equal to the rated output current.

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

2.21 *Power supply cord* denotes a flexible cable or cord for supply purposes, fixed to or assembled with the transformer according to one of the following methods of attachment:

- *Type X attachment*, which denotes a method of attachment such that the flexible cable or cord can be replaced easily without the aid of special purpose tools, by a flexible cable or cord not requiring any special preparation;
- *Type M attachment*, which denotes a method of attachment such that the flexible cable or cord can be replaced easily without the aid of special purpose tools, by a special cable or cord with, for example, a moulded-on cord guard or crimped terminations;
- *Type Y attachment*, which denotes a method of attachment such that the flexible cable or cord can be replaced only with the aid of special purpose tools normally available only to the manufacturer or his agents;

Type Y attachments may be used either with common flexible cables or cords, or with special cables or cords.

- *Type Z attachment*, which denotes a method of attachment such that the flexible cable or cord cannot be replaced without breaking or destroying a part of the transformer.

2.22 *Detachable part* denotes a part which can be removed without the aid of a tool.

Non-detachable part denotes a part which can be removed only with the aid of a tool.

2.23 *Tool* denotes a screwdriver, a coin or any other object which may be used to operate a screw or similar fixing means.

2.24 *Basic insulation* denotes the insulation applied to live parts to provide basic protection against electric shock.

Basic insulation does not necessarily include insulation used exclusively for functional purposes.

- 2.25 *Supplementary insulation* denotes 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.
- 2.26 *Double insulation* denotes insulation comprising both basic insulation and supplementary insulation.
- 2.27 *Reinforced insulation* denotes a single insulation system applied to live parts, which provides a degree of protection against electric shock equivalent to double insulation.

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

- 2.28 *Class I transformer* denotes 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 in such a way that accessible conductive parts cannot become live in the event of a failure of the basic insulation.

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

- 2.29 *Class II transformer* denotes 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.

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.

In certain cases, it may be necessary to distinguish between "all-insulated" and "metal-encased" Class II transformers.

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 live parts by insulation at least equivalent to reinforced insulation, is called an all-insulated Class II transformer.

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.

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

- 2.30 *Class III transformer* denotes a transformer in which protection against electric shock relies on supply at safety extra-low voltage (SELV) and in which voltages higher than those of SELV are not generated.

A Class III transformer shall not be provided with means for protective earthing.

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

- 2.31 *Short-circuit proof transformer* denotes a transformer in which the temperature rise 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.

- 2.32 *Non-inherently short-circuit proof transformer* denotes 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.

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

- 2.33 *Inherently short-circuit proof transformer* denotes a short-circuit proof transformer in which the temperature in the case of overload or short circuit and in the absence of a protective device does not exceed the specified limits and which continues to meet all the requirements of this standard after the removal of the overload or short circuit.

- 2.34 *Fail-safe transformer* denotes a transformer which, after abnormal use, fails to function but presents no danger to the user or surroundings.

2.35 *Non-short-circuit proof transformer* denotes a transformer which is intended to be protected against excessive temperature by means of a protective device not incorporated in the transformer.

2.36 *Portable transformer* denotes 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.

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.

2.37 *Hand-held transformer* denotes a portable transformer intended to be held in the hand during normal use.

2.38 *Stationary transformer* denotes either a fixed transformer or a transformer which cannot easily be moved from one place to another.

2.39 *All pole disconnection* denotes disconnection of all supply conductors by a single switching action.

A protective conductor is not considered to be a supply conductor.

A neutral conductor is considered to be a supply conductor.

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

2.40 *Thermal cut-out* denotes 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.

2.41 *Self-resetting thermal cut-out* denotes 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.

2.42 *Non-self-resetting thermal cut-out* denotes a thermal cut-out which requires resetting by hand or replacement of a part, in order to restore the current.

2.43 *Overload release* denotes a current-operated switch which protects a circuit from overload by opening when the current in that circuit reaches a predetermined value.

2.44 The term "*body*" 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.

2.45 The term "*accessible part*" 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.

2.46 *Rated ambient temperature* denotes the maximum temperature at which the transformer may be operated continuously under normal conditions of use.

The value of the rated ambient temperature (t_a) does not preclude temporary operation of the transformer at a temperature not exceeding $(t_a + 10) ^\circ\text{C}$.

2.47 *Clearance* denotes the shortest distance in air between two conductive parts.

For the purpose of determining a clearance to accessible parts, the accessible surface of an insulating enclosure shall be considered conductive as if it were covered by a metal foil wherever it can be touched by the standard test finger (see Figure 3).

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

For the purpose of determining a creepage distance to accessible parts, the accessible surface of an insulating enclosure shall be considered conductive as if it were covered by a metal foil wherever it can be touched by the standard test finger (see Figure 3).

2.49 *Working voltage* denotes the highest r.m.s. voltage that may occur across any insulation system at rated supply voltage, phase angle and transients being neglected, in no-load conditions or during normal operation.

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.

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.

2.50 *Pollution* denotes any addition of foreign matter, solid, liquid, or gaseous (ionized gases) that may produce a reduction of dielectric strength or surface resistivity.

2.51 *Micro-environment* denotes the ambient conditions which surround a clearance or creepage distance.

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, electromagnetic, generation of pollution, etc.

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

Normal pollution: Normally only non-conductive pollution occurs. Occasionally, however, a temporary conductivity caused by condensation must be expected.

Severe pollution: Conductive pollution occurs, or dry non-conductive pollution occurs which becomes conductive, due to the condensation which is expected.

2.53 *Continuous operation* denotes operation for an unlimited period.

2.54 *Short-time operation* denotes 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 room temperature.

2.55 *Intermittent operation* denotes operation in a series of specified identical cycles.

3. General requirements

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. General notes on tests

4.1 Tests according to this standard are type tests.

Recommendations for production tests are given in Appendix I-A of Chapter I.

4.2 *Tests are made on specimens as delivered. If it is not necessary to do the tests of Sub-clauses 13.3 and 14.5, the number of specimens is one for all rated outputs.*

If the tests of Sub-clause 13.3 have to be made, three additional specimens are needed. A further three specimens are needed if the tests have to be repeated.

All specimens shall withstand all the relevant tests, except as mentioned in Sub-clause 13.3.

If the tests of Sub-clause 14.5 have to be made, they are carried out on three additional specimens. These specimens are used only for the tests of Sub-clause 14.5.

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

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

4.3 *Tests are carried out in the order of the clauses and sub-clauses, unless otherwise specified.*

4.4 *If the test results are influenced by the temperature of the ambient air, the room temperature is, in general, maintained at (20 ± 5) °C. 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 room temperature is, in case of doubt, maintained at (23 ± 2) °C.*

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.

4.5 *For a.c., test voltages are of substantially sinewave form.*

4.6 *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.*

- 4.7 *As far as is possible, measurements are made with instruments which do not appreciably affect the values to be measured; if necessary, corrections for their influence are made.*
- 4.8 *Unless otherwise specified, transformers intended to be used with a power supply cord are tested with the power supply cord (see definition of Sub-clause 2.21) connected to the transformer.*
- 4.9 *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 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.*
- 4.10 *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.*
- 4.11 *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.*
- 4.12 *Associated transformers for use with an appliance or equipment for which a relevant appliance or equipment standard exists are tested under the conditions present in the appliance or equipment for which they are intended, account being taken of the requirements of the corresponding specifications for the appliance or equipment.*

Consequently the specifications of the following clauses or sub-clauses do not apply and any reference to these sub-clauses is replaced, where applicable, by a reference to the corresponding clauses or sub-clauses of the standards for the appliance or equipment: 4.8 - 4.9 - 4.10 - 4.13 - 5 - 6.3 - 6.4 - 7.1 - 7.3 - 7.4 - 7.5 - 7.6 - 7.7 - 7.8 - 7.10 - 7.11 - 7.12 - 8.1 - 8.3 - 8.4 - 8.5 - 8.7 - 9 - 10 - 11 - 12 - 13.2 (only temperatures of windings will be measured) - 14.1 (the second paragraph and Table III are not applicable) - 14.3 - 15 - 16 - 17.3 (Items 2 and 3 of Table VI) - 18.2 - 18.3 - 18.4 - 18.5 - 18.6 - 18.7 - 18.8 - 18.9 - 18.10 - 18.12 - 18.13 - 19.1 - 19.2 - 19.4 - 19.5 - 19.6 - 19.7 - 20 - 21 - 22 - 23 - 24 - 25 (Items 1b, 3, 4, 5 and 6 of Table XV) - 26 - 27 - and Appendix I-A.

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

For these transformers, the relevant requirements of the following clauses or sub-clauses are not applicable: Sub-clauses 8.1 and 8.3, Clauses 16 and 20.

Clause 20 is applied if the transformer has external metal parts other than terminals and connecting leads.

5. Rating

Rating is indicated in the separate chapters for different types of transformers.

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.

6. Classification

Transformers are classified:

6.1 According to their protection against electric shock:

- Class I transformers;
- Class II transformers;
- Class III transformers.

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

6.2 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.

6.3 According to the degree of protection ensured by the enclosure and defined in accordance with IEC Publication 529.

6.4 According to their mobility:

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

7. Marking

7.1 Transformers shall be marked with:

- rated supply voltage(s) or rated supply voltage range(s) in volts;
- rated output voltage(s) in volts or kilovolts.

For transformers combined with 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.

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

- rated output in voltamperes or kilovoltamperes and VAR or kVAR for reactors;

For transformers combined with a rectifier, the output may be expressed in watts, instead of voltamperes or kilovoltamperes.

- rated output current(s) in amperes or milliamperes as an alternative to the marking of the rated output;
- rated frequency(ies) in hertz;
- rated power factor, if other than unity;
- symbol for nature of output current for transformers combined with a rectifier;
- symbol indicating any particular application of the transformer;
- manufacturer's name or trade mark;
- manufacturer's model or type reference;
- vector group in accordance with IEC Publication 76-4 (if required);
- symbol for Class II construction, for Class II transformers only;
- indication of the protection index IP, if other than IP00 or IP20;
- rated maximum ambient temperature t_a , if other than 25 °C;

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

- symbols indicating their electrical function.

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 chapter or section.

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

- 7.2 Transformers with protection index IP00 or associated transformers, may be marked with only the manufacturer's name (or trade mark) and the type reference (or catalogue reference), when the available space is inadequate. The other characteristics shall be given in the data sheets of the transformer.

In certain cases, the manufacturer's name and the type reference may be replaced by a code number.

- 7.3 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.

- 7.4 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.

- 7.5 Short-circuit proof transformers may, in addition, 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 shall, in addition, be marked with the rated current, in amperes or milliamperes, of the protecting fuse-link, followed by the symbol for the time-current characteristics of the fuses, if applicable.

Non-inherently short-circuit proof transformers with incorporated replaceable 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.

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

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

Fail-safe transformers may also be marked with their characteristic symbol.

7.6 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.

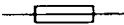
If any point of a winding or a terminal is connected to the frame or core, it shall be marked with the relevant symbol.

7.7 Transformers shall be provided with markings clearly indicating the manner in which the transformer is to be connected.

7.8 For transformers with type M, Y and Z attachments, the instruction sheet shall contain the substance of the following information:

- for type M attachments:
"if the supply cord of this transformer is damaged, a special cord supplied by the manufacturer or his agent must be obtained and fitted";
- for type Y attachments:
"if the supply cord of this transformer is damaged, the transformer must be returned to the manufacturer or his agent for the cord to be replaced";
- for type Z attachments:
"the supply cord of this transformer cannot be replaced; if the cord is damaged, the transformer should be discarded".

7.9 When symbols are used, they shall be as follows:

V (or kV)	volts (or kilovolts)
A (or mA)	amperes (or milliamperes)
VA (or VAR)	voltamperes (or voltamperes reactive for reactors)
kVA (or kVAR)	kilovoltamperes (or kilovoltamperes reactive for reactors)
W	watts
Hz	hertz
PRI	input
SEC	output
---	direct current
N	neutral
~	single-phase
3~	three-phase
3N~	three-phase + neutral
$\cos \phi$	power factor
	Class II construction
	fuse-link (add symbol for time-current characteristic)
t_a	rated maximum ambient temperature
	frame or core terminal
	protective earth (ground)
	separating transformer



autotransformer



or



fail-safe separating transformer



or



non-short-circuit proof separating transformer



or

short-circuit proof separating transformer
(inherently or non-inherently)

The dimensions of the symbol for Class II construction shall be such that the length of the sides of the outer square is about twice the length of the sides of the inner square. The length of the sides of the outer square shall be not less than 5 mm, unless the largest dimension of the transformer is 15 cm in length or less, in which case the dimension of the symbol may be reduced but the length of the sides of the outer square shall be not less than 3 mm.

- 7.10 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.

- 7.11 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.

The symbol for Class II construction shall be so positioned that it will be obvious that it is part of the technical information and is unlikely to be confused with the manufacturer's name or trade mark.

Compliance with the requirements of Sub-clauses 7.1 to 7.11 is checked by inspection.

7.12 Marking shall be durable and easily legible.

Compliance is checked by inspection and by the following test.

The marking is rubbed by hand for 15 s with a piece of cloth soaked with water and again for 15 s with a piece of cloth soaked with petroleum spirit.

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

It is recommended that the petroleum spirit used consist of a solvent hexane with an aromatic content of maximum 0,1 volume percentage, a kauributanol value of 29, an initial boiling point of approximately 65 °C, a dry point of approximately 69 °C and a specific gravity of approximately of 0,68 g/cm³).

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

8. Protection against electric shock

8.1 Enclosures of transformers shall have no openings other than the openings necessary for the correct operation of the transformer and which meet the requirements of this clause.

In addition, transformers with a protection index other than IP00 shall be so constructed and enclosed that there is adequate protection against accidental contact with live parts and, for Class II transformers, with metal parts separated from 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 live parts.

Self-hardening resins are not regarded as sealing compound.

Compliance is checked by inspection and by the tests of IEC Publication 529 corresponding to index IP2X with the test finger shown in Figure 3.

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 4.

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

Apertures preventing the entry of the finger are further tested by means of a straight unjointed test finger of the same dimensions, which is applied with a force of 20 N. If this finger enters, the test with the normal finger is repeated, the finger being introduced, if necessary, through the aperture. If the unjointed test finger does not enter, the force applied is increased to 30 N. If the apertures are then so distorted that the standard test finger can be inserted without force, the test with the latter finger is repeated.

It shall not be possible to touch bare live parts or 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 live parts by basic insulation only, with the test finger.

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

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

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

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

a) Ageing test

The coated part is subjected to the conditions described in Section One (Test Ba) of IEC Publication 68-2-2, at a temperature of $(70 \pm 2) ^\circ\text{C}$ and for a period of 7 days (168 h).

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

b) Impact test

The part is then conditioned for a period of 4 h at a temperature of $(-10 \pm 2) ^\circ\text{C}$. While still at this temperature, the coating is subjected to a blow applied to any point of the layer that is likely to be weak, from a spring-operated impact hammer (see Figure 2).

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

c) Scratch test

Finally, the part at the highest temperature attained under normal operating conditions is subjected to a scratch test. The scratches are made by means of a hardened steel pin, the end of which has the form of a cone having a top angle of 40° , its tip being rounded with a radius of $(0,25 \pm 0,02)$ mm.

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

After this test, the coating shall neither have loosened nor be pierced, and it shall withstand a dielectric strength test as specified in Clause 17, the test voltage being applied between the base material and a metal foil in contact with the layer.

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

8.2 Void.

8.3 Parts providing protection against electric shock shall have adequate mechanical strength and shall not work loose in normal use.

Compliance is checked by inspection, by manual test and by the tests of Clause 15.

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

Parts in contact with the output circuit are deemed to be live parts.

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

Wood, even impregnated, is not regarded as providing supplementary insulation.

Compliance with the requirements of Sub-clauses 8.4 and 8.5 is checked by inspection and, if necessary, by the tests specified for supplementary insulation.

- 8.6 The input and output windings for separating transformers shall be separated by a basic insulation, and the construction shall be such that there is no possibility of any connection between these windings, either directly or indirectly, through other metal parts.

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

- undue displacement of input or output windings or the turns thereof;
- undue displacement of internal wiring or wires for external connections;
- undue displacement of parts of windings or of internal wiring, in the event of rupture of wires or loosening of connections;
- wires, screws, washers and the like from bridging any part of the insulation between the input and output windings, including the connections of windings, should they loosen or become free.

It is not expected that two independent fixings will become loose at the same time.

Compliance is checked by inspection, taking Sub-clauses 8.6.1 and 8.6.3 into consideration, and by the tests of Clause 15.

- 8.6.1 For separating transformers the insulation between the input and the output winding(s) shall consist of at least basic insulation.

The insulation:

- shall comply with the electric strength test for basic insulation in Clause 17, after the humidity treatment of Clause 16;
- shall have such dimensions that creepage distances and clearances comply with the requirements for basic insulation in Clause 25;
- shall either have such dimensions that distances through the basic insulation comply with the requirements for insulation in Clause 25 (see Table XV, Item 1c)) or consist of at least two layers of insulation in thin sheet form.

Where serrated tape is used, at least one additional layer shall be applied to reduce the risk of serrations of two adjacent layers coinciding.

- 8.6.2 Each winding shall, unless this is manifestly impracticable, follow a linear sequence of layers.

This requirement does not preclude the intermixing of turns of adjacent layers.

- 8.6.3 The last turn of each winding shall be retained by a positive means, for example by tape or a suitable bonding agent.

Where cheekless bobbins are used, the end turns of each layer shall be retained by a positive means. Each layer can, for example, be interleaved with adequate insulation material projecting beyond the end turns of each layer and, moreover:

- the winding(s) is(are) impregnated with hard-baking or cold-setting material, substantially filling the intervening spaces and effectively sealing-off the end turns, or
- the winding(s) is(are) held together by means of insulation material.

It is not expected that two independent fixings will become loose at the same time.

Compliance with requirements of Sub-clauses 8.6.1, 8.6.2 and 8.6.3 is checked by inspection and by the tests of Clauses 15, 16 and 17.

- 8.7 Void.

9. Change of input voltage setting

Transformers may have a rated supply voltage range.

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.

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

10. Output voltage and output current under load

10.1 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:

- 10% for the output voltage of inherently short-circuit proof transformers with one rated output voltage;
- 10% for the highest output voltage of inherently short-circuit proof transformers with more than one rated output voltage;
- 15% for the other output voltages of inherently short-circuit proof transformers with more than one rated output voltage;
- 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 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 combined with 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 Sub-clause 7.1).

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

For transformers with tapped or multiple output windings, the load is applied to individual tapped or multiple sections, unless it is declared that all sections should be loaded simultaneously.

10.2 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.

Compliance is checked by calculation.

11. No-load output voltage

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

For transformers combined with a rectifier, the output voltages are measured on both sides of the rectifier; 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 Sub-clause 7.1).

12. 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 room temperature.

13. Heating

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

Compliance is checked by the test of Sub-clause 13.2. Moreover, the following requirements apply to the windings.

13.1.1 *If the manufacturer has neither stated which classified material has been used, nor stated any value of t_a (see Sub-clause 2.46) and the measured temperature rise does not exceed the value given in Table I for Class A material, the tests of Sub-clause 13.3 are not made.*

However, if the measured temperature rise exceeds the value given in Table I for Class A material, the active parts of transformers (core and windings) are submitted to the tests of Sub-clause 13.3. The temperature of the heating cabinet is chosen according to Table II. The temperature rise value to be chosen in Table II is the next highest value to the measured temperature rise value.

13.1.2 *If the manufacturer has not stated which classified material has been used but has stated a value of t_a , and the measured temperature rise does not exceed the value given in Table I for Class A material, taking the value of t_a into account (see Sub-clause 13.2), the tests of Sub-clause 13.3 are not made.*

However, if the measured temperature rise, taking the value of t_a into account, exceeds the value given in Table I for Class A material, the active parts of transformers (core and windings) are submitted to the tests of Sub-clause 13.3. The temperature of the heating cabinet is chosen according to Table II, taking the value of t_a into account. The temperature rise value to be chosen in Table II is the next highest value to the calculated temperature rise value.

- 13.1.3 *If the manufacturer has stated which classified material has been used but has not stated any value of t_a , and the measured temperature rise does not exceed the relevant value given in Table I, the tests of Sub-clause 13.3 are not made.*

However, if the measured temperature rise exceeds the value given in Table I, the transformer is deemed not to comply with the requirements of this Clause 13.

- 13.1.4 *If the manufacturer has stated which classified material has been used and has stated a value of t_a , and the measured temperature rise does not exceed the relevant value given in Table I, taking the value of t_a into account, the tests of Sub-clause 13.3 are not made.*

However, if the measured temperature rise, taking the value of t_a into account, exceeds the value given in Table I, the transformer is deemed not to comply with the requirements of this Clause 13.

- 13.2 *Temperature rises 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 t_a rating of the transformer exceeds 50 °C, the room temperature during the test shall be within 5 °C of the t_a rating and shall preferably be at the t_a rating.

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 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 without enclosure.

Transformers with terminals for type M, Y and Z attachments shall have the connections subjected to the test of Item b) of Sub-clause 22.3 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.

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. If the design of the appliance or other equipment is such that the transformer can be operated without load, the test is repeated under no-load conditions.

The temperature rise of windings are determined by the resistance method. Other temperature rises are determined by means of thermocouples so chosen and positioned that they have the minimum effect on the temperature of the part under test.

When determining the temperature rise of windings, the ambient temperature is measured at such a distance from the specimen 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.

Thermocouples used for determining the temperature rise of the surface of supports are attached to the back of small blackened discs of copper or brass which are flush with the surface.

The temperature rise 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 live parts and accessible metal parts, or a reduction of creepage distances or clearances below the values specified in Clause 25.

During the test:

- *for transformers without a t_a marking, the temperature rise shall not exceed the values shown in Table I;*
- *for transformers with a t_a marking, the sum of the temperature rise and t_a shall not exceed the sum of the values shown in Table I and 25°C.*

Example: allowed temperature rise of windings for:

a) transformer $t_a = +35$ °C, Class A material

$$\Delta t + 35 \leq 75 + 25$$

$$\Delta t \leq 65 \text{ K}$$

b) transformer $t_a = -10$ °C, Class E material

$$\Delta t + (-10) \leq 90 + 25$$

$$\Delta t \leq 125 \text{ K}$$

Also, the electrical connections shall not work loose, creepage distances and clearances shall not be reduced to less than the values specified in Clause 25, sealing compound shall not flow out and overload protection devices shall not operate.

TABLE I
Values of temperature rises in normal use

Parts	Temperature rise (K)
Windings (bobblins and laminations in contact therewith), if the winding insulation is:	
- of Class A material ¹⁾	75
- of Class E material	90
- of Class B material	95
- of Class F material	115
- of Class H material	140
- of other material ²⁾	-
External enclosures ³⁾ of stationary transformers	60
External enclosures ³⁾ , handles and the like of portable transformers:	
- if, in normal use, these parts are continuously held:	
. of metal	30
. of other material	50
- if, in normal use, these parts are not continuously held:	
. of metal	35
. of other material	60
Terminals for external conductors and terminals of switches	45
Insulation of internal and external wiring ⁴⁾	
- of rubber	40
- of polyvinyl chloride	50
Parts the deterioration of which could affect safety ⁴⁾ :	
- of rubber (other than insulation of wiring)	50
- of phenol-formaldehyde	80
- of urea-formaldehyde	60
- of impregnated paper and fabric	60
- of impregnated wood	60
- of polyvinyl chloride (other than insulation of wiring), polystyrene and similar thermoplastic material	40
- of varnished cambric	50
Supports	60

1) The material classification is in accordance with IEC Publication 85.

2) If other materials than those specified in IEC Publication 85 under A, E, B, F and H are used, they shall withstand the test of Sub-clause 13.3.

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

4) The grades of rubber and polyvinyl chloride insulation are those covered by IEC Publications 227 and 245, 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.

The values in the table are based on an ambient temperature not normally exceeding 25 °C, but occasionally reaching 35 °C.

The winding temperatures are based on IEC Publication 85, but have been adjusted to take into account the fact that, in these tests, the temperatures are mean and not hot-spot values.

Immediately after the test, the specimen shall withstand an electric strength test as specified in Sub-clause 17.3, the test voltage being applied between input and output windings only.

For Class I transformers, care is taken that other insulation is not stressed by a voltage exceeding the relevant value specified in Sub-clause 17.3.

It is recommended that the measurements be made on each winding separately and that the resistance of windings at the end of the test be determined 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.

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

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

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

with:

x = 234,5 for copper
x = 225 for aluminium

and where:

Δt is the temperature rise, above 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 room temperature at the beginning of the test

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

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

13.3 When applicable (see Sub-clause 13.1), the active 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 are made after each cycle.

The number of specimens is as indicated in Sub-clause 4.2 (three additional specimens). The specimens are subjected to ten test cycles.

13.3.1 Heat run

Depending on the type of insulation, the specimens are kept in a heating cabinet for the time and the temperature specified in Table II.

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

TABLE II
Test temperature and testing time (In days) per cycle

Test temperature °C	Temperature rise (K) for the insulation system (based on an ambient temperature of 25 °C, occasionally reaching 35 °C)				
	75	90	95	115	140
220 210 200 190 180 170 160 150 140 130 120				4 7 14	4 7 14
Temporary classification assigned for the tests of Clause 14 only	A	E	B	F	H

13.3.2 Moisture treatment

The specimens are submitted for two days (48 h) to a moisture treatment according to Sub-clause 16.2.

13.3.3 Vibration test

With the axis of the windings vertical, the specimens are submitted for 1 h to a vibration test, exerting a maximum acceleration of 1.5 g at rated frequency.

13.3.4 Measurements

After each cycle the insulation resistance is measured according to Sub-clauses 17.1 and 17.2. An electric strength test according to Sub-clauses 17.3 and 17.4 is made. After the heat runs, 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 17 are, however, reduced to 35% of the specified values and the testing times doubled, except that the windings test according to Sub-clause 17.4 shall be made with a test voltage of at least 1,2 times rated supply voltage. A specimen is considered not to comply with the windings 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.

In the case of one specimen failing due to breakdown between the turns of a winding, this is not considered to be a failure of the endurance test. The test can be continued with the remaining two specimens.

14. Short-circuit and overload protection

14.1 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 made immediately after the test according to Sub-clause 13.2 without the position of the transformer being changed, at 1,06 times rated supply voltage, or, for non-inherently short-circuit proof transformers, at any value of the supply voltage between 0,94 and 1,06 times rated supply voltage:

- for inherently short-circuit proof transformers, by the tests of Sub-clause 14.2;*
- for non-inherently short-circuit proof transformers, by the tests of Sub-clause 14.3;*
- for transformers provided with non-self-resetting thermal cut-outs which can be neither reset nor replaced, by the tests of Sub-clause 14.5, as if they were of the fail-safe type;*
- for non-short-circuit proof transformers, by the tests of Sub-clause 14.4;*
- for fail-safe transformers, by the tests of Sub-clause 14.5;*

- for transformers combined with a rectifier, the tests of Sub-clause 14.2 or 14.3 are made twice, once with the short-circuit applied on one side of the rectifier and again with the short-circuit applied at 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 greatest temperature rise. In the first case all windings which are intended to be loaded at the same time are loaded at rated output and then the short-circuit is made on the chosen output winding.

For the tests of Sub-clauses 14.2, 14.3 and 14.4, the temperature rises shall not exceed the values given in Table III.

TABLE III
*Maximum values of temperature rises
under short-circuit or overload conditions*

Insulation classification	A	E	B	F	H
Type of protection: - winding protected inherently - winding protected by protective device:	Maximum temperature rise (K)				
. during first hour or, for fuses having a rated current exceeding 63 A, during the first 2 h a)	125	140	150	165	185
. after first hour, peak value b)	175	190	200	215	235
. after first hour, arithmetic mean value b)	150	165	175	190	210
. after first hour, arithmetic mean value b)	125	140	150	165	185
External enclosures (which may be touched with the standard test finger) Rubber insulation of wiring PVC insulation of wiring			80 60 60		
Supports (i.e. any area on the pine plywood surface covered by the transformer)			80		

a) After the tests of Sub-clause 14.3.3 these values may be exceeded due to the thermal inertia of the transformer.

b) Does not apply to the tests of Sub-clause 14.3.3

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

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