

BRITISH STANDARD

**BS EN
60742 : 1996
BS 3535 :
Part 1 : 1996**

Isolating transformers and safety isolating transformers Requirements

The European Standard EN 60742 : 1995 has the status of a British Standard

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Committees responsible for this British Standard

The preparation of this British Standard was entrusted to Technical Committee PEL/96, Small transformers, upon which the following bodies were represented:

British Toy and Hobby Association
Department of Trade and Industry (Consumer Safety Unit, CA Division)
Electrical Installation Equipment Manufacturers' Association
(BEAMA Ltd.)
GAMBICA (BEAMA Ltd.)
Lighting Industry Federation Ltd.
Transmission and Distribution Association (BEAMA Ltd.)

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National foreword

This British Standard has been prepared by Technical Committee PEL/96 and is the English language version of EN 60742 : 1995 *Isolating transformers and safety isolating transformers — Requirements*, published by the European Committee for Electrotechnical Standardization (CENELEC). It was derived by CENELEC from IEC 742 : 1983 together with its amendment 1 : 1992, published by the International Electrotechnical Commission (IEC).

The CENELEC common modifications have been implemented at the appropriate places in the text and are indicated by a side line in the margin. The text of amendment 1 : 1992 to IEC 742 : 1983 is indicated by a double side line in the margin.

This standard supersedes BS 3535 : Part 1 : 1990, which remains current exclusively for use in conjunction with BS 3535 : Part 2 : 1990 in which it is extensively cross-referenced.

The foreword of the European standard refers to the 'date of withdrawal' (dow) of conflicting national standards as 1995-10-15. Certificates and marks will not be awarded after this date with respect to BS 3535 : Part 1 : 1990. However, such certificates and marks already awarded may continue to apply for production until 2000-10-15.

The material currently in BS 3535 : Part 2 : 1990 is being incorporated in IEC 1558 which is currently in preparation. When IEC 1558 is published it is envisaged that it will be adopted as a European standard and implemented in the UK by publication of a standard in the BS EN series, and BS 3535 : Part 2 : 1990 will be withdrawn. When BS 3535 : Part 2 : 1990 is withdrawn BS 3535 : Part 1 : 1990 will be withdrawn at the same time.

Cross-references

Publication referred to	Corresponding British Standard
IEC 50	BS 4727 <i>Glossary of electrotechnical, power, telecommunication, electronics, lighting and colour terms</i>
EN 60051 (IEC 51)	BS 89 <i>Direct acting indicating analogue electrical measuring instruments and their accessories</i>
EN 60065 : 1993 (IEC 65 : 1985)	BS EN 60065 : 1994 <i>Safety requirements for mains operated electronic and related apparatus for household and similar general use</i>
	BS EN 60068 <i>Environmental testing</i>
	Part 2 <i>Test methods</i>
EN 60068-2-2 : 1993 (IEC 68-2-2 : 1974)	Section 2 : 1993 <i>Tests B. Dry heat</i>
EN 60068-2-32 : 1993 (IEC 68-2-32 : 1975)	Section 32 : 1993 <i>Test Ed. Free fall</i>
EN 60127 (IEC 127)	BS EN 60117 <i>Miniature fuses</i>
HD 21.1 S2 : 1990 (IEC 227-1 : 1979)	BS 6004 : 1995 <i>Specification for PVC-insulated cables (non-armoured) for electric power and lighting</i>
HD 21.7 S1 : 1990	
HD 21.9 S1 : 1990	BS 6007 : 1993 <i>Specification for rubber-insulated cables for electric power and lighting</i>
HD 22.1 S2 : 1992 (IEC 245-1 : 1980)	
HD 22.2 S2 : 1982 (IEC 245-2 : 1980)	
HD 22.4 S2 : 1992 (IEC 245-4 : 1980)	

Publication referred to	Corresponding British Standard
HD 22.7.S1 : 1992	BS 6141 : 1991 <i>Specification for insulated cables and flexible cords for use in high temperature zones</i>
HD 21.7 S1 : 1990	BS 5099 : 1992 <i>Specification for spark testing of electric cables</i>
HD 22.2 S2 : 1982 (IEC 245-2 : 1980)	
HD 21.2 S2 : 1990 (IEC 227-2 : 1979)	
HD 22.8 S1 : 1990	BS 6726 : 1991 <i>Specification for festoon and temporary lighting cables and cords</i>
HD 21.8 S1 : 1994	BS 6899 : 1991 <i>Specification for rubber insulation and sheath of electric cables</i>
HD 22.1 S2 : 1992 (IEC 245-1 : 1980)	BS 7211 : 1994 <i>Specification for thermosetting insulated cables (non-armoured) for electric power and lighting with low emission of smoke and corrosive gases when affected by fire</i>
HD 22.9 S1 : 1992	
EN 60309 (IEC 309)	BS EN 60309 <i>Plugs, socket-outlets and couplers for industrial purposes</i>
EN 60317 (HD 555) (IEC 317)	BS EN 60317 <i>Winding wires</i> BS 6811 <i>Winding wires</i>
	BS 4491 <i>Appliance couplers for household and similar general purposes</i>
EN 60320-1 : 1987 (IEC 320 : 1981)	Part 1 : 1989 <i>Specification of general requirements</i>
HD 384.4.41.S1 : 1980 (IEC 364.4.41 : 1977)	BS 7671 : 1992 <i>Requirements for electrical installations. IEE Wiring Regulations Sixteenth edition</i>
HD 384.5.51 S1 : 1985 (IEC 364.5.51 : 1979)	
EN 60454 (IEC 454)	BS EN 60454 <i>Specification for pressure-sensitive adhesive tapes for electrical purposes</i>
HD 446.1 S1 : 1984 (IEC 584-1 : 1977)	BS 4937 <i>International thermocouple reference tables</i>
EN 60998 (IEC 998)	BS EN 60998 <i>Connecting devices for low-voltage circuits for household and similar purposes</i>
EN 60999 : 1993 (IEC 999 : 1990)	BS EN 60999 : 1993 <i>Connecting devices — Safety requirements for screw-type and screwless-type clamping units for electrical copper conductors</i>
EN 61058-1 : 1992 (IEC 1058 : 1990)	BS EN 61058 <i>Switches for appliances</i> Part 1 : 1992 <i>General requirements</i>

IEC 85 : 1957 has been superseded by IEC 85 : 1984 which has been published as an identical British Standard BS 2757 : 1986. IEC 269-2 : 1973 has been superseded by IEC 269-2 : 1986 which has been adopted as EN 60269-2 and will be published as BS EN 60269-2. IEC 269-3 : 1973 has been superseded by IEC 269-3 : 1987 which has been adopted as EN 60269-3 and will be published as BS EN 60269-3.

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

Descriptors: Isolating transformers, safety isolating transformers, safety requirements, shaver transformers, transformers for toys, bell transformers, transformers for class III luminaires

English version

Isolating transformers and safety isolating transformers Requirements

(IEC 742 : 1983 + A1 : 1992, modified)

Transformateurs de séparation des circuits et
transformateurs de sécurité
Règles
(CEI 742 : 1983 + A1 : 1992, modifiée)

Trenntransformatoren und
Sicherheitstransformatoren
Anforderungen
(IEC 742 : 1983 + A1 : 1992, modifiziert)

This European Standard was approved by CENELEC on 1994-12-06. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

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

CENELEC members are the national electrotechnical committees of Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

Central Secretariat: rue de Stassart 35, B-1050 Brussels

Foreword

At the request of BTTF 64-1 and according to the relevant CENELEC Technical Board decision, the text of the International Standard IEC 742 : 1983 and its amendment 1 : 1992 together with common modifications prepared by BTTF 64-1 was submitted to the formal vote and was approved by CENELEC as EN 60742 on 1994-12-06.

The following dates were fixed:

- latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 1995-10-15
- latest date by which the national standards conflicting with the EN have to be withdrawn (dow) 1995-10-15

For products which have complied with EN 60742 : 1989 before 1995-10-15, as shown by the manufacturer or by a certification body, this previous standard may continue to apply for production until 2000-10-15

Appendices and annexes designated 'normative' are part of the body of the standard. Appendices and annexes designated 'informative' are given for information only. In this standard, appendices ID, II-1-A and A and annexes ZA, ZB and ZC are normative, appendices IA, IB, IC and IE are informative. Annexes ZA, ZB and ZC have been added by CENELEC.

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GENERAL PLAN OF THE STANDARD

The following standard has several chapters:

- Chapter I gives general requirements for all isolating and safety isolating transformers, whatever their use.
- Chapter II gives supplementary requirements applicable to isolating transformers.

It is divided into sections applicable to various kinds of transformers¹⁾:

- Section One: Isolating transformers for general use, shaver transformers and shaver supply units.

Each section is independent of the other sections and the supplements (or modifications) which are indicated all refer back to Chapter I: General Requirements.

- Chapter III gives supplementary requirements applicable to safety isolating transformers.

It is divided into sections applicable to various kinds of transformers¹⁾:

- Section One: Transformers for general use;
- Section Two: Transformers for toys;
- Section Three: Bell transformers;
- Section Four: Transformers for Class III luminaires incorporating incandescent lamps.

Each section is independent of the other sections and the supplements (or modifications) which are indicated all refer back to Chapter I: General Requirements.

¹⁾ The subdivision of Chapters II and III is intended to allow the further insertion of requirements for other kinds of transformers.

ISOLATING TRANSFORMERS AND SAFETY ISOLATING TRANSFORMERS

Requirements

CHAPTER I: GENERAL REQUIREMENTS

1. Scope and object

1.1. Scope

This standard is applicable to stationary or portable, single-phase or polyphase, air-cooled isolating and safety isolating transformers, associated or otherwise, having a rated supply voltage not exceeding 1 000 V alternating current and rated frequency not exceeding 500 Hz, the rated output not exceeding:

— for isolating transformers:

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

— for safety isolating transformers:

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

The no-load and rated output voltages do not exceed:

— for isolating transformers 1 000 V a.c. and $1\,000\sqrt{2}$ V unsmoothed d.c.;

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

Rated values are indicated in supplementary parts, Chapters II and III, appropriate to each type of transformer.

This standard is applicable to those isolating transformers used when the installation rules call for the separation of circuits for the supply of certain parts of the circuit or of equipment (shavers, portable tools, lawn mowers, etc.).

This standard is applicable to safety isolating transformers used for the supply of circuits for safety extra-low voltage equipment (toys, bells, portable tools, handlamps, etc.).

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

This standard is applicable to dry type or encapsulated transformers. It is not applicable to transformers filled with liquid dielectrics or pulverised materials.

In locations where special environmental conditions prevail, particular requirements may be necessary in accordance with IEC Publication 364-5-51: Electrical Installations of Buildings, Part 5: Selection and Erection of Electrical Equipment. Chapter 51: Common Rules.

1.2 Object

The main object of this standard is to establish safety requirements for isolating transformers and safety isolating transformers.

2. Definitions

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

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.

- 2.1 *Safety extra-low voltage (SELV)* denotes a voltage which does not exceed 50 V a.c. r.m.s. or 120 V ripple free d.c. between conductors or between any conductor and earth in a circuit which is isolated from the supply mains by means such as a safety isolating transformer.

Maximum voltage lower than 50 V a.c. r.m.s. or 120 V ripple free d.c. may be specified in particular requirements especially when direct contact with live parts is allowed.

The voltage limit should not be exceeded either at full load or no-load.

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

- 2.3 *Isolating transformer* denotes a transformer with protective separation between the input and output windings.

- 2.4 *Safety isolating transformer* denotes an isolating transformer designed to supply SELV circuits.

Definitions of transformers intended for particular use are indicated in the relevant sections. The replacement of the expression "Safety isolating transformer" is under consideration by ACOS.

- 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 not incorporated in, but specially designed to be used only with the specific appliance(s) or equipment.

These types of transformer may be either:

- incorporated transformers;
- transformers for specific use.

- 2.7 *Incorporated transformer* denotes an associated transformer which is designed to be built into a specific appliance or equipment, the enclosure of which provides protection against electric shock.

- 2.8 *Transformer for specific use* denotes an associated transformer which, without being incorporated in an appliance or equipment, is fixed to or delivered with the 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 line 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 line 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 as 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:

- **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 only be removed 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 within 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 the requirements of this standard, after the overload or short-circuit has been removed.

- 2.32 *Non-inherently short-circuit proof transformer* denotes a short-circuit proof transformer which is equipped with a protective device, which opens the input circuit or the output circuit or reduces the current in the input or output circuit when the transformer is overloaded or short-circuited, and which continues to meet all requirements of this standard, after the overload or short-circuit has been removed.

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 requirements of this standard, after the overload or short-circuit has been removed.

- 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 designed to be protected against excessive temperature by means of a protective device which is not provided with 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 having a mass exceeding 18 kg and not provided with one or more carrying handle(s).

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 interruption 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 in contact with 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 (Figure 3, page 196).

- 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 (Figure 3).

Note to Sub-clauses 2.47 and 2.48

Creepage distances and clearances are measured through the joint between two parts of an insulating barrier except when:

- either the two parts forming the joint are bonded together by heat sealing or other similar means at the place where this is of importance;
- or the joint is completely filled with adhesive at the necessary places and the adhesive bonds to the surfaces of the insulating barrier so that moisture cannot be absorbed into the joint;

- 2.49 *Working voltage*, the highest r.m.s. value of the a.c. or d.c. voltage which may occur (locally) across any insulation at the rated supply voltage, transients being disregarded, in open-circuit conditions or under normal operating conditions.

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 (see IEC 664 – subclause 3.12).

- 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 *Protective separation* denotes separation between circuits by means of basic and supplementary protection (basic insulation plus either supplementary insulation or protective screening) or by an equivalent protective provision (e.g. reinforced insulation), (see 64(CO)196).

- 2.54 *Protective screening* denotes separation from live parts by means of an interposed conductive screen, connected to the means of connection for an external protective conductor, (see 64(CO)196).

3. General requirement

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 1A 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 required. A further three specimens are required if the tests have to be repeated.

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

For testing a series of transformers see Annex ZA.

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.

If the test of 15.4 on transformers integrated with a plug has to be made, it is carried out on three additional specimens.

For testing purposes it may, in some cases, be necessary to provide specially prepared samples.

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 $20 \pm 5^\circ\text{C}$. 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 $23 \pm 2^\circ\text{C}$.

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

4.5 For a.c., test voltages are of substantially sine-wave 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 an earthing terminal or earthing contact, and which 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 of 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, page 194, 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 standard for the appliance or equipment.*

Consequently, the following clauses, subclauses or parts thereof do not apply and any reference to these is replaced, where applicable, by a reference to the corresponding clauses or subclauses 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, table I, starting with the line “External enclosures of stationary transformers” up to and including “Supports ... 60.” – 14.1, table III, second box, 14.2 – 14.3 – 14.4 – 14.5 – 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 – 18.14 – 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 – Appendix IA.

Attention is drawn to the fact that if the appliance or equipment standard does not include tests for short-circuit or overload protection of the transformer, relevant tests of clause 14 may have to be made.

- 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.

For IP 00 transformers the temperature rises of supports reported on Tables I and III are not necessarily applicable as maximum values, but shall be complying with the value declared by the manufacturer.

- 4.14 *Transformers with a protection index IP 00 the application of which is known are tested according to the manufacturer's mounting instructions.*

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 are taken from the R 10 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 will be determined by the way in which the transformer is incorporated.

|| 6.2 According to the 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: Classification of Degrees of Protection Provided by Enclosures (*IP system*).

6.4 According to the 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;

|| 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.

- rated output in voltamperes or kilovoltamperes;

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

- rated output current(s) in amperes as an alternative to the marking of the rated output;

- rated frequency(ies) in hertz;

- | — rated power factor, if other than unity; not required for transformers rated below 25 VA;

- symbol for nature of output current for transformers combined with a rectifier;

- || — symbol indicating the electrical function of the transformer, i.e. isolating transformer or safety isolating transformer;

- manufacturer's name or trade mark;

- manufacturer's model or type reference;

- 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 $t_a < 50$ °C and in steps of 10 °C for $t_a > 50$ °C.

- 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.

If the transformer has more than one output winding, the short-circuit voltage to be marked is the lowest value for the various windings. It is recommended that three-phase transformers are marked with a symbol for the connection group, according to IEC Publication 76: Power Transformers.

|| Additional markings are allowed provided they do not give rise to misunderstanding.

- 7.2 For transformers with protection index IP00, or for associated transformers, it is permitted to mark 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.

|| This information shall be such that a replacement transformer, which will be fully interchangeable with the original transformer, electrically, mechanically, dimensionally and functionally, can be supplied.

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

Non-inherently short-circuit proof transformers with incorporated fuses and non short-circuit proof transformers designed to be protected by fuses shall, in addition, be marked with the rated current of the protecting fuse-link, in amperes or milliamperes, 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 and non short-circuit proof transformers designed to be protected by 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 devices need no additional marking regarding the protective device.

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

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

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

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:

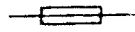
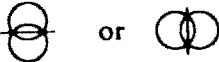
“if the supply cord of this transformer is damaged the transformer must be returned to the manufacturer or his agent for the cord to be replaced”;

— 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	voltamperes
kVA	kilovoltamperes
W	watts
Hz	hertz
PRI	input
SEC	output
— — —	direct current
N	neutral
~	single phase
3 ~	three phase
3N ~	three phase + neutral

$\cos \varphi$	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)
 or 	isolating transformer
	safety isolating transformer
 or 	fail-safe transformer
 or 	non-short-circuit proof transformer
 or 	short-circuit proof transformer (inherently or non-inherently)

The three last symbols may be arranged with symbols for isolating transformers or for safety isolating transformers.

For example:



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 does not exceed 15 cm, 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 so 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 a 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 rubbing the marking by hand for 15 s with a piece of cotton cloth soaked with water and again for 15 s with a piece of cotton cloth soaked with petroleum spirit. The petroleum spirit to be used for the test is an aliphatic hexane solvent (with an aromatics content of maximum 0,1 % by volume, 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 0,68 g/cm³).

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

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

8. Protection against electric shock

8.1 Enclosures of transformers shall have no openings other than openings necessary for the correct operation of the transformer such openings shall 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:

- parts giving access to live parts which are normally connected to an output circuit, which because of the nature of its use, is accessible, provided that, for no-load output voltages exceeding 33 V a.c. or 80 V ripple free d.c., one of the poles remains inaccessible;
- lamps with caps other than E10;
- type D fuse-carriers.

Covering is not necessary for live parts normally connected to accessible output circuits.

Live parts at a no-load output voltage not exceeding 33 V a.c. or 80 V ripple free d.c. may be accessible in all cases.

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.

When protection of live parts against accidental contact is ensured by an insulating coating, it 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: Basic Environmental Testing Procedures, Part 2: Tests – Tests B: Dry Heat, 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 layer 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 layer is subjected to a blow applied to any point of the layer that is likely to be weak, from a spring-operated impact hammer (Figure 2, page 195).

After this test, the layer 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 $0.25 \pm 0.02\text{ mm}$.

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 $10 \pm 0.5\text{ N}$. The scratches are at least 5 mm apart and at least 5 mm from the edge of the specimen.

After this test, the layer 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.

Compliance shall be 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, page 197.

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 then the apertures are 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, contact with bare live parts is shown by means of an electrical contact indicator, the voltage being not less than 40 V.

The more stringent tests which are necessary for insulating layers on the outside of metal parts are under consideration.

- 8.2 There shall be no connection between the output winding and the body or the protective earthing circuit, if any, unless this is allowed by the relevant equipment standard for associated transformers.

Compliance is checked by inspection.

- 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 either of insulating material or 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 if 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 shall be electrically separated from each other, 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. The term "windings" also covers other internal circuits of the transformer, if any.

In particular, 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 to be expected that two independent fixings will become loose at the same time. See also the explanation to subclause 18.6.

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

8.6.1 The insulation between the input and output winding(s) shall consist of double or reinforced insulation, unless the requirements of subclause 8.6.4 are complied with.

In addition the following applies:

- for class I transformers, the insulation between the input windings and the body shall consist of basic insulation, and the insulation between the output windings and the body shall consist of supplementary insulation.
- for class II transformers, the insulation between the input windings and the body, and between the output windings and the body, shall consist of double or reinforced insulation.

8.6.2 Where an intermediate metal part (e.g. the iron core) not connected to the body is located between the input and output windings, the insulation between the input and output windings via the intermediate metal part shall consist of double or reinforced insulation, and, for class II transformers, the insulation between the input windings and the body and between the output windings and the body via the intermediate metal part shall consist of double or reinforced insulation. The insulation between the intermediate metal part and the input or output windings shall in both cases consist of at least basic insulation rated for the relevant circuit voltage.

An intermediate part which is separated from one of the windings by double or reinforced insulation is considered as being connected to the other winding.

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

8.6.4 For class I transformers, the insulation between the input and output windings may consist of basic insulation plus protective screening instead of double or reinforced insulation, provided the following conditions are complied with:

- transformers intended for connection to the supply by means of a plug shall be marked with the essence of the following wording: “Only for connection to an earthed socket-outlet.”;
- the insulation between the input winding and the protective screen shall comply with the requirements for basic insulation (rated for the input voltage);
- the insulation between the protective screen and the output winding shall comply with the requirements for basic insulation (rated for the output voltage);
- the protective screen shall, unless otherwise specified, consist of a metal foil or of a wire wound screen extending at least to the full width of one of the windings adjacent to the screen; a wire wound screen shall be wound tight without space between the turns;
- the protective screen shall, in order to prevent eddy current losses due to creation of a shorted turn, be so arranged that both edges cannot simultaneously touch each other nor touch an iron core;
- the protective screen and its lead-out wire shall have a cross-section sufficient to ensure that, if a breakdown of insulation should occur, an overload device will open the circuit before the screen is destroyed;
- the lead-out wire shall be soldered to the protective screen or fixed in an equally reliable manner.

For the purpose of this subclause, the term “windings” does not include internal circuits.

Examples of construction of windings are given in appendix IB.

8.6.5 Each winding shall follow a linear sequence of layers.

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

8.6.6 The last turn of each winding shall be retained by a positive means for example, by tape or 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:

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

It is not expected that two independent fixings will become loose at the same time. See also the explanations to subclause 18.6.

Compliance with the requirements of subclauses 8.6.1 up to and including 8.6.6 is checked by inspection and by the tests of clauses 15, 16 and 17.

8.7 Transformers shall not be provided with capacitors which electrically connect input and output circuits.

Compliance is checked by inspection.

9. Change of input voltage setting

Stationary transformers may have a rated supply voltage range.

Stationary 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.

Portable transformers shall have only one rated supply voltage unless the transformer is not capable of producing a voltage in excess of the limits allowed in the scope if the higher marked voltage is accidentally connected to the lower voltage winding.

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 ready for use.

Compliance is checked by inspection.

The requirement for stationary transformers is met if a tool has to be used to remove a cover before the voltage setting can be changed.

For the purpose of this requirement, a portable transformer provided with a device for adjusting the input connections to suit supply voltages over a range of not more than 10% of the value corresponding with the midpoint of that range, is not considered to be a transformer with more than one supply voltage.

10. Output voltage and output current under load

10.1 When the transformer is connected to rated supply voltage, at rated frequency, and loaded with an impedance which would give rated output at rated output voltage and full load 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 are intended to 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 13.2 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 higher 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 higher 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 requirement of subclause 13.1.

- 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 requirement of subclause 13.1.

- 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. No other adjustment is made, except that the supply voltage is increased by 6 %.

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

Temperature rises of winding 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 that it does not 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 cause a short circuit, 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 temperatures rises in normal use

Parts	Temperature rise (K)
Windings (bobbins 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 (which may be touched with the standard test finger) of stationary transformers, if of:	
— metal	45
— other material	55
External enclosures ³⁾ , handles and the like of portable transformers:	
— if, in normal use, these parts are continuously held:	
• of metal	30
• or other material	50
— if, in normal use, these parts are not continuously held:	
• of metal	35
• of other material	55

TABLE I (Continued)

Parts	Temperature rise (K)
Terminals for external conductors and terminals of switches.	45
Insulation of internal and external wiring ¹⁾ :	
— 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: Recommendations for the classification of Materials for the Insulation of Electrical Machinery and Apparatus in relation to their Stability in Service. 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 forms a 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: Polyvinyl Chloride Insulated Cables of Rated Voltages up to and including 450/750 V, and 245: Rubber insulated Cables of Rated Voltages up to and including 450/750 V, 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.	

If the temperature rise exceeds 45K at terminals for external conductors, another insulating material for wiring or a sleeve with a higher resistance to high temperatures shall be used according to the relevant harmonized standards. The use of such cable, cord or sleeve shall be required in the instruction sheet.

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 sample 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.

For transformers having other than continuous working conditions, the test conditions may be found in the relevant chapters.

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 must 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 shall be as indicated in Sub-clause 4.2 (three additional specimens). The specimens shall be subjected to ten test cycles.

13.3.1 Heat run

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

The temperatures in the heating cabinet shall be maintained to within a tolerance of $\pm 3^\circ\text{C}$.

TABLE II

Test temperature and testing time (in days) per cycle

Test temperature ($^\circ\text{C}$)	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					4
210					7
200					14
190				4	
180				7	
170				14	
160			4		
150		4	7		
140		7			
130	4				
120	7				
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-clause 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 shall be 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.

All windings which are intended to be loaded at the same time are loaded at rated output and then the short-circuit or overload, as specified, is made on the chosen output winding.

For the tests of Sub-clauses 14.2, 14.3 and 14.4, temperature rise 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:	Maximum temperature rise (K)				
– winding protected inherently	125	140	150	165	185
– winding protected by protective device:					
● during first hour or, for fuses having a rated current exceeding 63A, during the first 2 h (a)	175	190	200	215	235
● after first hour, peak 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)				80	
Rubber insulation of wiring				60	
P.V.C. insulation of wiring				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 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:

14.3.1 The output terminals are short-circuited. The incorporated overload protection device shall operate before the temperature rise exceeds the values shown in Table III for any value of the supply voltage between 0.94 and 1.06 times rated supply voltage.

14.3.2 If protected by a fuse in accordance with either IEC 269-2 or IEC 269-3, or a technically equivalent fuse, the transformer is loaded for a time T and with a current equal to k times the current marked on the transformer as the rated current of the protection fuse-link, where k and T have the values shown in table IV.

TABLE IV

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

For cylindric fuses gG type B for use by unskilled persons (IEC 269-3-1) and for fuses for use by authorized persons with fuse-links for bolted connections (IEC 269-2-1), the value of k is 1,6 for $I_n < 16$ A.

For D-type fuses for use by unskilled persons (IEC 269-3-1) for a rated current of 16 A, the value of k is 1,9.

14.3.3 *If protected by miniature fuses in accordance with IEC Publication 127: Cartridge Fuse-links for Miniature Fuses, or by a technically equivalent fuse, the transformer is loaded for 30 min with a current equal to 2.1 times the value of the rated current of the fuse.*

14.3.4 *If protected by an overload protection device other than a fuse, the transformer is loaded by a current equal to 0.95 times the value of the lowest current which causes the device to operate, until steady-state conditions are reached.*

14.3.5 *For the tests of Sub-clauses 14.3.2 and 14.3.3, the fuse-link is replaced by link of negligible impedance.*

For the tests of Sub-clause 14.3.4, the test current is obtained at ambient temperature, commencing at 1.1 times the rated tripping current, which is slowly decreased in steps of 2% until the current value is obtained for which the overload protection device does not operate.

If thermal fuses are used, the test current of one specimen shall be increased in steps of 5%. After each step, the transformer shall reach steady-state conditions. This is continued until the thermal fuse-link fails. This current value is noted. The test is repeated with the other specimen using 0.95 times the noted value.

14.4 *Non-short-circuit proof transformers are loaded as indicated in Sub-clause 14.3. The correct protective device specified by the manufacturer is fitted to the relevant input or output circuit.*

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

14.5 Fail-safe transformers

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

Each of the three specimens is mounted as for normal use on a 20 mm thick dull black painted plywood surface. Each transformer is operated at 1.06 times the rated primary voltage, the output winding which produced the highest temperature rise during the test of Sub-clause 13.2 being initially loaded with 1.5 rated output current (or if this is not possible, the maximum value of the output current obtainable) until steady-state conditions are reached or the transformer fails (whichever occurs first).

If the transformer fails, it shall comply during and after the tests with the criteria given in Sub-clause 14.5.2.

If the transformer does not fail, the time to reach steady-state conditions is noted and the chosen output winding is then short-circuited. The test is continued until the transformer fails. Each specimen shall do so within a time, for this part of the test, of not longer than that necessary to attain steady-state conditions, but not exceeding 5 h.

The transformers shall fail safely and comply during and after the tests with criteria given in Sub-clause 14.5.2.

14.5.2 *At any time during the tests of Sub-clause 14.5.1:*

- the temperature rise of any part of the enclosure of the transformers which may be touched with the standard test finger shall not exceed 150 K;*
- the temperature rise of the plywood support shall nowhere exceed 100 K;*
- the transformers shall not emit flames, molten material, glowing particles or burning drops of insulating material.*

After the tests of Sub-clause 14.5.1 and after cooling down to ambient temperature:

- the transformers shall withstand a dielectric strength test, the test voltage being 35% of the values according to Clause 17, Table VI, for primary-to-secondary and primary-to-body only;*
- enclosures, if any, shall show no holes allowing the standard test finger (Figure 3, page 196) to touch bare live parts. In case of doubt, contact with bare live parts is shown by means of an electrical contact indicator, the voltage being not less than 40 V.*

If one specimen does not pass the test, the complete test is failed.

15. Mechanical strength

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

|| *Compliance is checked by the test of subclause 15.2 for stationary transformers, and by the tests of subclauses 15.2 and 15.3 or 15.4, as appropriate, for portable transformers.*

After the tests, the transformer shall show no damage within the meaning of this standard; in particular, live parts shall not have become accessible, when tested with the standard test pin (Figure 4, page 197), insulating barriers shall not have been damaged and handles, levers, knobs and the like shall not have moved on their shafts.

|| *In addition, as regards the test of subclause 15.4, bending of the pins during the test is ignored.*

Damage to the finish, small dents which do not reduce creepage distances or clearances below the values specified in Clause 25, and small chips which do not adversely affect the protection against electric shock or moisture, are neglected.

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

- 15.2 *The transformer, with covers and the like fitted, is held firmly against a rigid support and is subjected to three blows from a spring-operated impact hammer as shown in Figure 2, page 195, applied to every point of the exterior that protects live parts and is likely to be weak, including handles, levers, switch knobs and the like, by pressing the hammer nose perpendicularly to the surface. Before applying the blows, the fixing screws of bases and covers are tightened with a torque equal to two-thirds of that specified in Table XIV.*

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

- 15.3 *Portable transformers are held in their normal position of use and are then allowed to fall from a height of 40 mm on to a smooth steel plate, at least 5 mm thick, placed on a flat concrete support. 100 such falls are made at a rate not exceeding one fall per 5 s.*

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

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

- 15.4 Transformers which are provided with integrated pins, intended to be introduced into fixed socket-outlets, shall have adequate mechanical strength. The following test is made instead of the test of subclause 15.3:

Compliance is checked by the following test, which is made on three samples in a tumbling barrel as described in IEC 68-2-32. The barrel is turned at a rate of five revolutions per minute, ten falls per minute thus taking place, the number of falls being:

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

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

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

Distortion of pins and damage to the finish and small dents which do not reduce the creepage distances or clearances below the values specified in subclause 29.1 of IEC 884-1 are disregarded.

All three samples shall withstand the test.

16. Protection against harmful ingress of water and moisture

- 16.1 The enclosure of transformers shall provide the degree of protection against ingress of water in accordance with the relevant protection index of the transformer.

Transformers not provided with a power supply cord are fitted with external wiring as specified in Sub-clause 21.4 of the smallest appropriate cross-sectional area, specified in Sub-clause 22.5.

Compliance is checked by the relevant test laid down in IEC Publication 529: Classification of Degrees of Protection Provided by Enclosures, the transformer being mounted as in normal use, with plugs for the output circuit, if any, inserted.

Immediately after this treatment, the transformer shall withstand an electric strength test as specified in Clause 17, and inspection shall show that water has not entered the transformer to any appreciable extent.

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

Compliance is checked by the humidity treatment described in this sub-clause followed immediately by the tests of Clause 17.

Transformers intended to be fixed connected to the supply are tested with the cable fitted but with cable entries open. If knock-outs are provided, one of them is opened. Transformers intended to be used with a power supply cord are tested with the cord and cord entries correctly fitted.

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

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

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

The specimen is kept in the cabinet for:

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

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

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

After this treatment and tests of Clause 17, the transformer shall show no damage within the meaning of this standard.

17. Insulation resistance and electric strength

17.1 The insulation resistance and the electric strength of transformers shall be adequate.

Compliance is checked by the tests of Sub-clauses 17.2 to 17.4, which are made immediately after the test of Sub-clause 16.2, in the humidity cabinet or in the room in which the specimen was brought to the prescribed temperature, after reassembly of those parts which may have been removed.

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

The insulation resistance shall be not less than that shown in Table 1.