BRITISH STANDARD

BS EN 50065-4-2:2002

Incorporating Amendment Nos. 1 and 2

Signalling on low voltage electrical installations in the frequency range 3 kHz to 148,5 kHz and 1,6 MHz to 30 MHz —

Part 4-2: Low voltage decoupling filters — Safety requirements

The European Standard EN 50065-4-2:2001, with the incorporation of amendments A1:2003 and A2:2005, has the status of a British Standard

ICS 31.160; 33.040.30

BSI British Standards

National foreword

This British Standard is the official English language version of EN 50065-4-2:2001, including amendments A1:2003 and A2:2005.

The start and finish of text introduced or altered by amendment is indicated in the text by tags ⟨A1⟩ ⟨A1⟩. Tags indicating changes to CENELEC text carry the number of the CENELEC amendment. For example, text altered by CENELEC amendment 1 is indicated by ⟨A1⟩ ⟨A1⟩.

The UK participation in its preparation was entrusted to Technical Committee PEL/205, Mains signalling, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this committee can be obtained on request to its secretary.

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the BSI Catalogue under the section entitled "International Standards Correspondence Index", or by using the "Search" facility of the *BSI Electronic Catalogue* or of British Standards Online.

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English version

Signalling on low voltage electrical installations in the frequency range 3 kHz to 148,5 kHz and 1,6 MHz to 30 MHz Part 4-2: Low voltage decoupling filters - Safety requirements

(includes amendments A1:2003 and A2:2005)

Transmission de signaux sur les réseaux électriques basse tension dans la bande de fréquences de 3 kHz à 148,5 kHz
Partie 4-2: Filtres basse tension de découplage -
Exigences de sécurité
(inclut les amendements A1:2003 et A2:2005)

Signalübertragung auf elektrischen Niederspannungsnetzen im Frequenzbereich 3 kHz bis 148,5 kHz
Teil 4-2: Niederspannungs-Entkopplungsfilter – Sicherheitsanforderungen
(enthält Änderungen A1:2003 und A2:2005)

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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, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, 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

Ref. No. EN 50065-4-2:2001 + A1:2003 + A2:2005 E

Foreword

This European Standard was prepared by SC 205A, Mains communicating systems, of Technical Committee CENELEC TC 205, Home and Building Electronic Systems (HBES).

This European Standard has been prepared under a mandate given to CENELEC by the European Commission and covers the essential requirements of the Low Voltage Directive 73/23/EEC.

The text of the draft was submitted to the Unique Acceptance Procedure and was approved by CENELEC as EN 50065-4-2 on 2000-11-01.

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—	latest date by which the national standards conflicting with the EN have to be withdrawn	(dow) 2003-11-01

EN 50065 consists of the following parts, under the general title: Signalling on low voltage electrical installations in the frequency range 3 kHz to 148,5 kHz

Part 1	General requirements, frequency bands and electromagnetic disturbances
Part 2-1	Immunity requirements for mains communications equipment and systems operating in the range of frequencies 95 kHz to 148,5 kHz and intended for use in residential, commercial and light industrial environments
Part 2-2	Immunity requirements for mains communications equipment and systems operating in the range of frequencies 95 kHz to 148,5 kHz and intended for use in industrial environments
Part 2-3	Immunity requirements for mains communications equipment and systems operating in the range of frequencies 3 kHz to 95 kHz and intended for use by electricity suppliers and distributors
Part 4-1	Low voltage decoupling filters – Generic specification
Part 4-2	Low voltage decoupling filters – Safety requirements
Part 4-3	Low voltage decoupling filters – Incoming filter
Part 4-4	Low voltage decoupling filters – Impedance filter
Part 4-5	Low voltage decoupling filters – Segmentation filter
Part 4-6	Low voltage decoupling filters – Phase coupler
Part 7	Equipment impedance

▌A2⟩ This safety standard EN 50065-4-2 has no frequency dependent content. It was originally conceived as a safety document within the EN 50065 set of standards, which have a frequency of 3 kHz to 148,5 kHz. When the scope of SC 205A was extended to 30 MHz, SC 205A agreed that the scope of the published safety standard, Part 4-2 “Low voltage decoupling filters – Safety requirements" should be amended to include the band 1,6 MHz to 30 MHz in order to cover the additional set of standards for 1,6 MHz to 30 MHz. This required no technical changes to the body of the document. In addition, it was agreed that Part 4-7 "Portable low voltage decoupling filters – Safety requirements" should also cover both frequency ranges. For this reason the title of this part of EN 50065 covers the extended frequency ranges 3 kHz to 148,5 kHz and 1,6 MHz to 30 MHz. ⟨A2▌

Foreword to amendment A1

This amendment was prepared by SC 205A, Mains communicating systems, of Technical Committee CENELEC TC 205, Home and Building Electronic Systems (HBES).

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Foreword to amendment A2

This amendment to the European Standard EN 50065-4-2:2001 was prepared by SC 205A, Mains communicating systems, of Technical Committee CENELEC TC 205, Home and Building Electronic Systems (HBES).

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— latest date by which the national standards conflicting with the amendment have to be withdrawn (dow) 2008-03-01

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1 Scope

This product safety standard applies to electrical equipment, such as decoupling filters and phase couplers in a mains communication system for a phase to neutral voltage not exceeding AC 250 V and a nominal current not exceeding 125 A, intended for household and similar fixed-electrical installations including residential, commercial and light industrial buildings

2 Normative references

This European Standard incorporated by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For updated references the latest edition of the publication referred to applies.

EN 60065		Audio, video and similar electronic apparatus – Safety requirements (IEC 60065)
EN 60068-2-75	1997	Environmental testing – Part 2-75: Tests – Test Eh Hammer tests (IEC 60068-2-75:1997)
EN 60127	series	Miniature fuses (IEC 60127 series)
EN 60417	series	Graphical symbols for use on equipment (IEC 60417 series)
EN 60529		Degrees of protection provided by enclosures (IP code) (IEC 60529)
EN 60669-1	1999	Switches for household and similar fixed electrical installations – Part 1: General requirements (IEC 60669-1:1998, mod.)
EN 60695-2-1/X	1996	Fire hazard testing- Part 2: Test methods (IEC 60695-2-1/X:1994)
EN 60721-3-3	1995	Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities – Section 3: Stationary use at weather protected locations (IEC 60721-3-3:1994)
EN 60999-1	2000	Connecting devices – Safety requirements for screw-type and screwless-type clamping units for electrical copper conductors – Part 1: General requirements and particular requirements for conductors from 0,5 mm^2 up to 35 mm^2(included) (IEC 60999-1:1999)
EN 132400	1994	Sectional Specification: Fixed capacitors for electromagnetic interference suppression and connection to the supply mains (Assessment level D)
HD 214 S2	1980	Method of determining the comparative and the proof tracking indices of solid insulating materials under moist conditions (IEC 60112:1979)
HD 384.4.442 S1	1997	Electrical installations of buildings – Part 4: Protection for safety – Chapter 44 Protection against overvoltages - Section 442: Protection of low-voltage installations against faults between high-voltage systems and earth (related to IEC 60364-4-442:1993 + A1:1995)
HD 625.1 S1	1996	Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests (IEC 60664-1:1992, mod.)
IEC 60695–10-2	1995	Fire hazard testing – Part 10: Guidance and test methods for the minimisation of the effects of abnormal heat on electrotechnical products involved in fires – Section 2 Method for testing products made from non-metallic materials for resistance to heat using the ball pressure test

IEC 60999-2 1995 Connecting devices – Safety requirements for screw-type and screw-less clamping units for electrical copper conductors – Part 2: Particular requirements for conductors from 35 mm^2 up to 300 mm^2

3 Definitions

Where the term's voltage and current are used, they imply r.m.s. values, unless otherwise specified.

For the purpose of this standard, the following definitions apply:

3.1
decoupling filter
a device which attenuates incoming or outgoing signals within a specified frequency range

3.2
phase coupler
a device which transmits a signal within a specified frequency range from one phase to another in a multi-phase installation

3.3
fault conditions
abnormal conditions which may occur during normal operation

3.4
enclosed equipment
equipment which is mounted and/or applied without an additional enclosure

3.5
unenclosed equipment
equipment intended to be built into an enclosure which completely covers the equipment

3.6
partly enclosed equipment
equipment intended to be built into an appropriate enclosure which only covers the unenclosed part of the equipment

NOTE Flush-mounted equipment intended to be located in a box is an example of such equipment.

3.7
terminal
the conductive part of one pole, composed of one or more clamping unit(s) and insulation if necessary

3.8
screw-type terminal
a clamping unit for the connection and subsequent disconnection of one conductor or the interconnection and subsequent disconnection of two ore more conductors, the connection being made, directly or indirectly, by means of screws or nuts of any kind

3.9
screwless-type terminal
a clamping unit for the connection and subsequent disconnection of one conductor or the interconnection and subsequent disconnection of two ore more conductors, the connection being made, directly or indirectly, by means other than screws

3.10
nominal voltage
the voltage assigned to the equipment by the manufacturer

3.11
nominal current
the nominal maximum operating current assigned to the equipment by the manufacturer

3.12
conditional short-circuit current
a value of the AC component of a prospective current, which the equipment protected by a suitable short-circuit protective device (hereafter referred to as SCPD) in series can withstand under specified conditions of use and behaviour.

4 General requirements

Equipment and its enclosures shall be so designed and constructed that, in normal use, their performance is reliable and without danger to the user or the surroundings.

In general, compliance is checked by carrying out all the tests specified, where applicable.

5 General notes on tests

Tests according to this standard are type tests.

5.1 The samples are tested as delivered and under normal conditions of use, having regard to the classification of the equipment and to the manufacturer's installation instructions.

5.2 Unless otherwise specified, the tests are carried out in the order of the clauses at an ambient temperature of 20 °C ± 5 °C.

5.3 The required number of samples shall be 9.

Three samples are subjected to all the relevant tests, except the test of clauses 23 and 24 where three other samples are used, and the tests of clauses 25 and 26 where another three samples are used.

5.4 Equipment is deemed not to comply with this standard if any sample does not pass the tests of 21.1, 25 and 26, and if there are more failures than that of one sample in any of the other tests.

If no sample has failed during the tests of 21.1, 25 and 26, but one sample has failed in another way during any of the other tests, the test which caused the failure and those preceding which may have influenced the result of that test, are repeated on another set of samples, as specified in 5.4, all of which shall then comply with the repeated tests.

NOTE 1 In general, it will be necessary only to repeat the test that caused the failure, unless the sample fails in the mechanical strength test of clause 17, in which case the ageing test of clause 14 is repeated.

NOTE 2 The applicant may submit, together with the number of samples specified in 5.4, the additional set of samples which may be required should one sample fail. The testing laboratory will then, without further request, test the additional samples and will reject only if a further failure occurs. If the additional set of samples is not submitted at the same time, a failure of one sample will entail a rejection.

6 Rating

6.1 Standard values of nominal voltages are AC 230 V and AC 400 V.

If a different nominal voltage is applied this value shall not be less than 220 V.

6.2 Standard values of nominal currents are 10 A, 16 A, 20 A, 25 A, 32 A, 40 A, 50 A, 63 A, 80 A, 100 A and 125 A.

6.3 Standard cross-sectional areas of conductors are 1,5 mm², 2,5 mm², 4 mm², 6 mm², 10 mm², 16 mm², 25 mm², 35 mm² and 50 mm²

Compliance with the requirements of 6.1 to 6.3 is checked by inspection of the marking.

7 Classification

7.1 Equipment is classified as follows:

7.1.1 According to protection against direct contact and external influences:

- enclosed equipment (minimum IP2X) for separate mounting;
- unenclosed equipment for mounting in an adequate enclosure.

NOTE 1 The degrees of protection are based on EN 60529.

NOTE 2 For unenclosed the protection against electric shock is given by the enclosure in which the equipment is intended to be mounted. For enclosed equipment, the protection against electric shock is provided by compliance with the requirements of clause 10.

7.1.2 According to the degree of protection against ingress of water:

The degrees of protection are based on EN 60529.

7.1.3 According to the method of mounting

- surface-type equipment;
- flush-type equipment;
- panel board equipment.

7.1.4 According to environmental temperature conditions

The classifications are based on EN 60721-3-3.

– class 3K4	+ 5 °C to + 40 °C	for indoor locations
– class 3K5	- 5 °C to + 45 °C	for unprotected indoor locations
– class 3K6	- 25 °C to + 55 °C	for outdoor locations
– class 3K8H	- 25 °C to + 70 °C	for severe environments

7.1.5 According to the rated impulse withstand voltage

The rated impulse withstand voltages are based on HD 625.1.

- 4000 V according to overvoltage category III;
- 6000 V according to overvoltage category IV.

8 Marking

8.1 As a minimum the equipment shall be marked with:

a) nominal voltage(s) in volts ~;
b) nominal current in amperes;
c) manufacturer's or responsible vendor's name, trade mark or identification mark;
d) type of filter or phase coupler and reference or catalogue number;
e) symbol for temperature range, if different from class 3K4;
f) symbol for degree of protection, if higher than IP2X;

g) symbol for degree of protection against ingress of water, if higher than IPX0. In such case the symbol for degree of protection against harmful ingress of solid foreign bodies shall also be marked, even if not higher than IP2X.

h) marking with conditional short-circuit current and suitable SCPD shall be given in the manufacturer's catalogues

8.2 Symbols for marking shall be used as follows:

Amperes	A
Volt	V
Alternating current	~
Degree of protection against moisture	IPX4 or IPX5 The letter "X" shall be replaced by the relevant number.

The figure for the current rating shall be placed before or above that for the nominal voltage and separated from the latter by an oblique line or a dash.

NOTE The marking for current, voltage and nature of supply may be, for instance, as follows: 16 A 230 V~or 16/230~.

8.3 The manufacturer's or responsible vendor's name, trademark or identification mark, type reference and nominal current shall be on the main part of the equipment.

Parts such as cover plates, which are necessary for safety purposes and are intended to be sold separately, shall be marked with the manufacturer's or responsible vendor's name, trade mark or identification mark and type reference.

The symbol for degree of protection, if applicable, shall be marked on the outside of its associated enclosure so as to be easily discernible when the equipment is mounted and wired as in normal use.

NOTE 1 Additional type references may be marked on the main part, or on the outside or the inside of the associated enclosure.

NOTE 2 The term "main" part means the part carrying the terminals and any part integral with them; it does not include parts intended to be sold separately.

8.4 Terminals

The side name (Input side, output side) and the respective termination shall be marked, when appropriate, in such a way that they are clearly distinguished (e.g. using a different colour for each side).

These indications shall not be placed on screws or any other easily removable parts.

NOTE "Easily removable parts" are those parts, which can be removed during the normal installation of the equipment.

For example a typical marking scheme is given in Table 1.

Table 1 - Symbols for identification of the termination

Single phase		Three phase	
Point of connection	**Identification**	**Point of connection**	**Identification**
Line	L	1st Phase 2nd Phase 3rd Phase	L1, L2, L3
Neutral	N	Neutral	N
Earth	EN 60417 Symbols 5019	Earth	EN 60417 Symbols 5019
Communication 1 Communication 2	C1 C2	Communication 1 Communication 2	C1 C2

Terminals associated with any one pole shall have similar identification differing from that of the terminals associated with the other poles, unless the relationship is self-evident.

8.5 Terminals shall additionally be marked in accordance with 7.4 in EN 60999-1.

Compliance is checked by inspection.

8.6 Marking shall be durable and easily legible.

Compliance is checked by inspection and by the following test.

The test is made by rubbing the marking 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.

NOTE 1 The petroleum spirit used should consist of a solvent hexane with a content of aromatics of maximum 0,1 % by volume, a value of 29 % for kauri-butanol, an initial boiling-point of approximately 65 °C, a dry-point of approximately 69 °C and a density of approximately 0,68 g/cm³.

NOTE 2 The type reference may be marked with paint or ink, protected, if necessary, by vanish.

8.7 The correct installation and use of the equipment shall be indicated in an installation instruction delivered with the equipment. A phase coupler shall be delivered with a marking plate with the following text:

Phase Coupler !
Must be disconnected while working on the installation.

The marking plate shall be fastened to the panel board in which the phase coupler is installed.

The installation instruction and the text of the marking plate shall be written in the official language(s) of the country in which the equipment is to be sold.

Compliance is checked by inspection.

NOTE In the following country the marking plate is not necessary: Germany.

9 Dimensions

Equipment shall comply with the appropriate standard sheets.

Compliance is checked by inspection and by measurement.

10 Protection against electric shock

10.1 Equipment shall be so designed that live parts are not accessible when the equipment is mounted and wired as for normal use, even after removal of parts which can be removed without the aid of a tool.

Compliance is checked by inspection and, if necessary, by the following test.

The sample is mounted as in normal use and fitted with conductors of the smallest cross-sectional area specified in clause 12. The test is repeated using conductors of the largest cross-sectional area specified in clause 12.

The standard test finger specified in EN 60529 is applied to the sample in every possible position, an electrical indicator, with a voltage not less than 40 V and not more than 50 V, being used to show contact with the relevant part.

Equipment, having enclosures or covers in thermoplastic or elastomeric material, is subjected to the following additional test, which is carried out at an ambient temperature according to the maximal temperature specified under the environmental classification ± 2 °C.

The equipment shall be installed as in normal use at this temperature and preheated with the nominal current and voltage connected for at least one hour.

During this additional test, the equipment is subjected for 1 min to a force of 75 N, applied through the tip of a straight unjointed test finger of the same dimensions as the standard test finger.

This test finger, with an electrical indicator as described above, is applied to all places where yielding of insulating material could impair the safety of the equipment. The test is not made on membranes. A force of only 10 N is applied to thin-walled knock-outs.

During this test, the equipment with its associated mounting means shall not deform to such an extent that live parts can be touched by the unjointed test finger.

NOTE Membranes are tested according to 14.4.1 only.

10.2 Accessible parts shall be of insulating material with the exception of small screws and the like which are isolated from live parts and which are used for fixing bases or cover plates.

However accessible parts may be made of metal if the requirements of either 10.2.1 or 10.2.2 are fulfilled.

10.2.1 Covers or cover plates shall be separated from live parts by supplementary insulation, made by insulating linings or insulating barriers fixed to the covers or cover plates, or to the body of the equipment in such a way that this supplementary insulation

- cannot be removed without being permanently damaged, or
- is so designed that it cannot be replaced in an incorrect position and that, if they omitted, the equipment is rendered inoperable or manifestly incomplete. There shall be no:
  - risk of accidental connection between live parts and metal covers or cover plates, for example through their fixing screws, even if a conductor should come away from its terminal,
  - risk of a reduction of creepage distances or clearances below the values specified in clause 20.

10.2.2 Accessible conductive parts, which are not separated from live parts by supplementary insulation, made by insulating linings or insulating barriers, shall be permanently and reliably connected to the protective earth terminal.

Compliance with 10.2.1 and 10.2.2 is checked by inspection and by the tests of clauses 15 and 20. For 10.2.2 the additional requirements in clause 11 shall be tested.

NOTE Insulating coating sprayed on the inside or on the outside of the metal covers or cover plates is not deemed to be an insulating lining or barrier for the purpose of this subclause.

〖A2〗 **10.2.3** If the filter contains capacitors in excess of 0,1 µF connected between line conductors, the voltage resulting from static charges shall fall below DC 120 V in less than 5 s after disconnection from the power supply. 〖A2〗

11 Provision for protective earthing

11.1 Earthing terminals shall be terminals with screw clamping or with other means of comparable effectiveness and shall comply with the appropriate requirements of clause 12.

They shall be of the same size as the corresponding terminals for the supply conductors except that any additional external earthing terminal shall be of a size suitable for conductors of at least 6 mm².

11.2 Decoupling filters having more than one cable inlet shall be provided with an internal earthing terminal allowing the connection of an incoming and outgoing conductor for the continuity of the earthing circuit.

Compliance with the requirements of 11.1and 11.2 are checked by inspection and the tests of clause 12.

11.3 The connection between the earthing terminal and accessible metal parts to be connected thereto shall be of low resistance.

Compliance is checked by the following test:

A current derived from a.c. source having a no-load voltage not exceeding 12 V and equal to 1,5 times rated current or 25 A, whichever is greater, is passed between the earthing terminal and each of the accessible metal parts in turn

The voltage drop between the earthing terminal and the accessible metal part is measured, and the resistance calculated from the current and this voltage drop.

In no case the resistance shall exceed 0,05 Ω.

12 Terminals

The requirements in 1.1 and 0.0 are only for clamping units connected to power circuits.

1.1 General

12.1.1 Equipment shall be provided with terminals having screw-type or screwless-type clamping units.

12.1.2 Clamping units shall allow the conductor to be connected without special preparation.

12.1.3 The means for clamping the conductors in the clamping units shall not serve to fix any other component, although they may hold the clamping units in place or prevent them from turning.

Compliance is checked by inspection and by the test of 1.2 as applicable.

1.2 Screw-type and screwless-type clamping units with clamping for external copper conductors

12.2.1 Screw-type and screwless-type clamping units shall comply with EN 60999-1 or IEC 60999-2.

All the tests shall be with the clamping units mounted in the equipment.

The clamping units shall be tested with the cross-sectional area of conductors given in Table 2.

Table 2 - Connectable cross-sections of copper conductors

Ranges of nominal current In (A)	Type of conductor and cross-sectional area (mm^2)	
	Rigid (solid or stranded)	Flexible
In ≤ 10	1 to 2,5	1 to 1,5
10 < In ≤ 16	1,5 to 4	1 to 2,5
16 < In ≤ 25	2,5 to 6	1,5 to 4
25 < In ≤ 32	4 to 10	2,5 to 6
32 < In ≤ 40	6 to 16	-
40 < In ≤ 63	10 to 25	-
63 < In ≤ 80	16 to 35	-
80 < In ≤ 125	25 to 50	-

In addition to 9.5 and 9.6 in EN 60999-1: “During the test the clamping units shall not work loose from their fixings to the equipment.”

Subclauses 8.16 and 9.9 in EN 60999-1 are not applicable.

The test current in 9.10 in EN 60999-1 shall be according to Table 3 in clause 16 of this standard.

13 Construction

13.1 Insulating linings and barriers shall have adequate mechanical strength and shall be secured in a reliable manner.

Compliance is checked by inspection after the tests of clause 0.

13.2 Equipment shall be constructed so as to permit:

- easy introduction and connection of the conductors in to the terminals;
- correct positioning of the conductors;
- easy fixing of the equipment;
- equipment intended for walls or boxes shall have adequate space between the underside of the base and the enclosure (cover or box) so that, after installation of the equipment, the insulation of the conductors is not pressed against live parts of different polarity.

Surface-type equipment shall be constructed so that the fixing means do not damage the insulation of the cables during the installation.

NOTE 1 This requirement does not imply that the metal parts of the terminals are necessarily protected by insulation barriers or insulating shoulders, to avoid contact, due to incorrect installation of the terminal metal parts, with the insulation of the conductor.

NOTE 2 For surface-type equipment, mounted on a mounting plate, a wiring channel may be needed to comply with this requirement.

Compliance is checked by inspection and by an installation test using conductors of the largest cross-sectional area specified in Table 2 - Connectable cross-sections of copper conductors.

13.3 Covers and cover plates shall be held in place at two or more points by effective fixings such that their removal requires the use of a tool.

NOTE 1 It is recommended that the screws for fixing covers or cover plates be captive.

NOTE 2 The use of tight fitting washers of cardboard or the like is deemed to be an adequate method for securing screws which must be captive.

If the fixings of covers or cover plates serve also to fix the base, there shall be sufficient means to ensure the correct position of the base after removal of the cover or cover plate.

Means for fixing covers or cover plates shall not serve to fix any other part.

NOTE 3 Decorative covers, cover plates or parts thereof, not providing protection against electric shock, are not considered as covers or cover plates in the meaning of this subclause.

Compliance is checked by inspection and by an installation test.

13.4 Enclosed or partly enclosed equipment with the degree of protection IPX0 shall be so constructed that, when the equipment is fixed and wired as in normal use, there are no free openings in the enclosure.

Compliance is checked by inspection and by an installation test with conductors of the smallest cross-sectional area specified in Table 2.

NOTE Small gaps between enclosures and conduits or cables are neglected.

13.5 In equipment with a degree of protection higher than IPX0, membranes, screwed glands and similar provisions shall be so designed that the part forming the tight inlet for the cable is replaceable.

Compliance is checked by inspection.

14 Resistance to ageing, to harmful ingress of water and to humidity

The following requirements are based on EN 60669-1.

1.1 Resistance to ageing

Equipment shall be resistant to ageing.

Compliance is checked by the following test:

Equipment, complete with enclosure, and mounted as for normal use, is subjected to at test in a heating cabinet with an atmosphere having the composition and pressure of the ambient air and ventilated by natural circulation.

Equipment which is required to be marked with degree of protection shall be tested after having been mounted and assembled as specified in 14.2.1.

The temperature of the cabinet is 70 °C ± 2 °C.

The samples are kept in the cabinet for 7 days (168 h).

The use of an electrically heated cabinet is recommended.

Natural circulation may be provided by holes in the walls of the cabinet.

After the treatment, the samples are removed from the cabinet and kept at room temperature and relative humidity between 45 % and 55 % for at least 4 days (96 h).

The samples shall show no crack visible to the naked eye, nor shall the material have become sticky or greasy, this being judged as follows:

With the forefinger wrapped in a dry piece of rough cloth the sample is pressed with a force of 5 N.

No traces of the cloth shall remain on the sample and the material of the sample shall not stick to the cloth.

After the test the samples shall show no damage which could impair compliance with this standard.

NOTE The force of 5 N can be obtained in the following way:
The sample is placed on one of the pans of a balance and the other pan is loaded with a mass equal to the mass of the sample plus 500 g. Equilibrium is then restored by pressing the sample with the forefinger wrapped in a dry piece of rough cloth.

1.2 Resistance to harmful ingress of water

The enclosure of equipment, which is required to be marked with degree of protection, shall provide a degree of protection against harmful ingress of water in accordance with the classification of the equipment.

Compliance is checked by the appropriate test specified below.

NOTE The tests are based on EN 60529.

14.2.1 Surface-type equipment is mounted on a vertical surface with the open drain hole in the lowest position.

Flush-type equipment is fixed vertically in an appropriate enclosure which is placed in a recess in a block of hardwood.

Unclosed equipment is tested under simulation of conditions of normal use, taking into account the manufacturer's instructions. Fixing screws for enclosures are tightened with a torque equal to two-thirds of the values specified in Table 4 of EN 60999-1.

Glands are tightened with a torque equal to two-thirds of that applied during the test of 17.3. Parts which can be removed without the aid of a tool are removed.

NOTE Glands are not filled with any form of sealing compound.

14.2.2 Equipment with the degree of protection IPX4 is subjected to the test specified for equipment with the degree of protection IPX4 according to the requirements of EN 60529.

14.2.3 Equipment with the degree of protection IPX5 is subjected to the test specified for equipment with the degree of protection IPX5 according to the requirements of EN 60529.

Immediately after the tests specified in 14.2.2 and 14.2.3, the samples shall withstand an electric strength test as specified in 15.2 and inspection shall show that water has not entered the samples to any appreciable extent and has not reached live parts.

1.3 Resistance to humidity

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

Compliance is checked by the humidity test described in this subclause, followed immediately by the measurement of the insulation resistance and by the electric strength test specified in clause 15.

Inlet openings, if any, are left open; if knock-outs are provided, one of them is opened.

Parts which can be removed without the aid of a tool, are removed and subjected to the humidity treatment with the main part; spring lids are open during this treatment.

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 in which the samples are placed is maintained within ± 1 °C of any convenient value between 20 °C and 30 °C.

Before being placed in the humidity cabinet, the samples are brought to a temperature between T(ambient temperature) and T + 4 °C.

The samples are kept in the cabinet for:

2 days (48 h)	For equipment with degree of protection IP20;
7 days (168 h)	For equipment other than IP20.

NOTE 1 In most cases, the samples may be brought to the specified temperature by keeping them at this temperature for at least 4 h before the humidity treatment.

NOTE 2 A relative humidity between 91 % and 95 % can be obtained by placing in the humidity cabinet a saturated solution of sodium sulphate (Na2SO4) or potassium nitrate (KNO3) in water having a sufficiently large contact surface with the air.

NOTE 3 In order to achieve the specified conditions within the cabinet, it is necessary to ensure constant circulation of the air within and, in general, to use a thermally insulated cabinet.

After this test, the samples shall show no damage within the meaning of this standard.

1.4 Requirements for membranes in inlet openings

14.4.1 Membranes shall be reliably fixed and shall not be displaced by the mechanical and the thermal stresses occurring in normal use.

Membranes shall be replaceable.

Compliance is checked by inspection and by the following test:

After the treatment specified in 14.1, membranes are tested when assembled in the equipment.

The equipment is then placed for 2 h in a heating cabinet as described in 14.1, the temperature being maintained at Tmax ± 2 °C, where Tmax is the maximal ambient temperature according to the temperature classification in 7.1.4.

Immediately after this period, a force of 30 N is applied for 5 s to various parts of the membranes by means of the tip of a straight standard test finger as specified in EN 60529.

During these tests, the membranes shall not deform to such an extent that live parts become accessible.

After the tests, the membranes shall show no harmful deformation which would lead to non-compliance with the requirements of protection according to 14.2.

For membranes likely to be subjected to an axial pull during normal use, an axial pull of 30 N is applied for 5 s.

During this test, the membranes shall not come out.

The test is then repeated with membranes, which have not been subjected to any treatment.

14.4.2 Membranes shall be so designed and made of such material that the introduction of the cables into the equipment is permitted when the ambient temperature is low.

Compliance is checked by the following test:

The equipment is fitted with membranes, which have not been subjected to any ageing treatment, those without any opening being suitably pierced.

The equipment is then kept, for 2 h, in a refrigerator in which the temperature is maintained at Tmin ± 2 °C, where Tmin is the minimal ambient temperature according to the temperature classification in 7.1.4, but it shall be lower or equal to – 15 °C.

After this period, the equipment is removed from the refrigerator and immediately afterwards, while the equipment is still cold, it shall be possible to introduce, without undue force, cables of the heaviest type through the membranes.

After the tests of 14.4.1 and 14.4.2, the membranes shall show no harmful deformation, cracks or similar deformation which would lead to non-compliance with this standard.

15 Insulation resistance and dielectric strength

15.1 The insulation resistance of the equipment shall be adequate.

Compliance is checked by the following tests which are made immediately after the test of 14.3, in the humidity cabinet or in the room in which the samples were brought to the prescribed temperature, after reassembly of those parts which have been removed without the aid of a tool.

The insulation resistance is measured with a voltage of approximately DC 500 V applied, the measurement being made 1 min after application of the voltage [A2] , electronic components connected between live parts of different polarity being disconnected for the test. [A2]

[A2] The insulation resistance measured shall not be less than 5 MΩ: [A2]

- between all terminals connected together and metal foil in contact with the outer surface of accessible parts;
- for equipment having a metal enclosure, between the outer surface and metal foil in contact with the inner surface of the internal enclosure or the insulating lining;
- between live parts and terminals for looping-in of external conductors;
- between live parts and the mounting surface of the equipment, including the means for fixing and parts of protective conductor circuit.

[A2] The insulation resistance measured shall not be less than 2 MΩ between live parts of different polarity. [A2]

NOTE While wrapping the metal foil around the outer surface or placing it in contact with the inner surface of parts of insulating material, it is pressed against holes or grooves by means of a straight test finger of the same dimensions as the standard test finger.

15.2 The dielectric strength of the equipment shall be adequate.

15.2.1 The insulation is subjected for 5 s to a sinusoidal voltage, having a frequency of 50 Hz or 60 Hz. The value of the test voltage and the points of application are:

- 3 kV between all terminals and metal foil in contact with the outer surface of accessible parts;
- 1,5 kV between the outer metal surface and a metal foil in contact with the inner surface of the internal enclosure or the insulated lining;

– 1,5 kV between live parts and terminals for looping-in of external conductors;

– 1,5 kV between live parts and the surface on which they are mounted, including the means for fixing and parts of protective conductor circuit.

Initially, not more than half the prescribed voltage is applied; then it is raised in less than 1 s to the full value.

No flashover or breakdown shall occur during the test.

NOTE 1 The values are based on HD 384.4.442 S1. The following formula is used: U_0 + 1200 V and rounded, where U_0 is the voltage between line and neutral.

NOTE 2 While wrapping the metal foil around the outer surface or placing it in contact with the inner surface of parts of insulating material, it is pressed against holes or grooves by means of a straight unjointed test finger of the same dimensions as the standard test finger.

NOTE 3 The high-voltage transformer used for the test shall be so designed that, when the output terminals are short-circuited after the output voltage has been adjusted to the appropriate test voltage, the output current is at least 200 mA.

NOTE 4 The overcurrent relay should not trip when the output current is less than 100 mA.

NOTE 5 Care is taken that the r.m.s. value of the test voltage applied is measured within ± 3 %.

NOTE 6 Glow discharges without drop in voltage are neglected.

15.2.2 The insulation shall withstand an impulse voltage according to HD 625.1. The value of the test voltage and the points of application are:

For overvoltage category III according to 7.1.5:

– 6 kV between all terminals and metal foil in contact with the outer surface of accessible parts;

– 4 kV between the outer metal surface and a metal foil in contact with the inner surface of the internal enclosure or the insulated lining;

– 4 kV between live parts and the surface on which they are mounted, including the means for fixing and parts of protective conductor circuit.

For overvoltage category IV according to 7.1.5:

– 8 kV between all terminals and metal foil in contact with the outer surface of accessible parts;

– 6 kV between the outer metal surface and a metal foil in contact with the inner surface of the internal enclosure or the insulated lining;

– 6 kV between live parts and the surface on which they are mounted, including the means for fixing and parts of protective conductor circuit.

No flashover or breakdown shall occur during the test.

〈A2〉 *Note 1 deleted* 〈A2〉

NOTE 2 While wrapping the metal foil around the outer surface or placing it in contact with the inner surface of parts of insulating material, it is pressed against holes or grooves by means of a straight unjointed test finger of the same dimensions as the standard test finger.

16 Temperature rise

Equipment shall be so constructed that the temperature rise in normal and abnormal use is not excessive.

Compliance is checked by inspection and by the following test.

The equipment is mounted as in normal use as specified in the installation instructions with PVC-insulated rigid copper conductors as specified in Table 3, the terminal screws or nuts being tightened with a torque equal to two-thirds of that specified in Table 4 of EN 60999-1.

The conductors connected to the terminals shall have a length of at least 1 m.

NOTE 1 The rigid conductors may be solid or stranded, as applicable.

Parts of the equipment, through which the load current is passing, are loaded with alternating current having the value shown in Table 3. Parts with no load current passing are loaded with 1,1 times the rated voltage for the relevant part.

In normal use the temperature rise is measured when the steady-state temperature has been reached, but not later than within 4 h of operation.

Table 3 - Test current

Cross-sectional area of rigid conductors (mm^2)	Nominal current (A)	Test current (A)
1,5	10-13	15
2,5	16	20
2,5	20	25
4	25	31,25
6	32	40
10	40	50
10	50	62,5
16	63	78,75
25	80	100
35	100	125
50	125	156

NOTE 2 The test currents for equipment having other nominal currents are determined by interpolation between the next lower and higher ratings.

Unenclosed equipment is mounted in the smallest enclosure for which the equipment is designed.

The temperature is determined by means of melting particles, colour changing indicators or thermocouples, so chosen and positioned that they have negligible effect on the temperature being determined.

The temperature rise under normal use and abnormal conditions according clause 24 shall not exceed the values given in Table 4 - Permissible temperature rise, where Tmax is the maximum ambient temperature according to 7.1.4.

The temperature rise measured on components and insulating material added to Tmax shall not exceed the limits for their maximum working temperature.

During the test the temperature rises necessary to perform the tests of 18.3 and 18.4 shall be determined.

Table 4 - Permissible temperature rise

Parts of the equipment	Permissible temperature rise (K)	
	Normal	Abnormal (clause 24)
Terminals and parts which may come into contact with cable insulation when installed	100 °C – Tmax	135 °C – Tmax
Accessible metallic parts	80 °C - Tmax	90 °C - Tmax
Accessible non-metallic parts	90 °C – Tmax	90 °C – Tmax

17 Mechanical strength

17.1 Equipment shall have adequate mechanical strength so as to withstand the stresses imposed during installation and use.

For enclosed and partly enclosed equipment compliance is checked by the tests 17.2 and 17.3.

17.2 Equipment shall have adequate impact resistance.

Compliance is checked by applying blows to the equipment by means of the spring-operated impact-test apparatus or the pendulum hammer described in EN 60068-2-75.

The samples are mounted on a sheet of plywood, 8 mm nominal thickness and approximately 175 mm², secured at its top and bottom edges to a rigid bracket which is part of the mounting support.

The mounting support shall have a mass of 10 kg ± 1 kg and shall be mounted on a rigid frame by means of pivots. The frame is fixed to a solid wall.

The equipment is mounted on the plywood as in normal use.

Before applying the blows, fixing screws of bases and covers are tightened with a torque equal to two-thirds of that specified in Table 4 of EN 60999-1.

Three blows are applied to every point of the enclosure that is likely to be weak, with an impact energy of 0,5 J ± 0,04 J.

NOTE For partly enclosed equipment, the test is made only on the enclosed part of the equipment.

After the test, screwed glands and enclosures of the samples shall show no damage within the meaning of this standard.

17.3 Screwed glands are fitted with a cylindrical metal rod having a diameter, in millimetres, equal to the nearest whole number below the internal diameter, in millimetres, of the packing.

The glands are then tightened by means of a suitable spanner, the torque shown in Table 5 being applied to the spanner for 1 min.

Table 5 - Related torque

Diameter of test rod D (mm)	Torque (Nm)	
	Metal glands	Glands of moulded material
D ≤ 14	6,25	3,75
14 < D ≤ 20	7,5	5,0
20 < D	10,0	7,5

After the test, the glands and the enclosures of the samples shall show no damage within the meaning of this standard.

18 Resistance to heat

18.1 Equipment shall be sufficiently resistant to heat

Compliance is checked by the tests of 18.2, 18.3 and 18.4.

18.2 The equipment shall be kept for 1 h in a heating cabinet at a temperature of 100 °C.

During the test the temperature shall be 100 °C ± 2 °C and the equipment shall not undergo any change impairing the further use and sealing compound, if any, shall not flow to such an extent that live parts are exposed.

After the test and after the samples have been allowed to cool down to approximately room temperature, there shall be no access to live parts which are normally not accessible when the samples are mounted as in normal use, even if the standard test finger is applied with a force not exceeding 5 N.

After the test, markings shall still be legible.

Discoloration, blisters or slight displacement of the sealing compound is disregarded provided that safety is not impaired within the meaning of this standard.

18.3 Parts of insulating material necessary to retain current-carrying parts and parts of the earthing circuit in position are subjected to a ball-pressure test by means of the apparatus according to IEC 60695-10-2 except the insulating parts necessary to retain the earthing terminals in a box shall be tested as specified in 18.4.

NOTE When it is not possible to carry out the test on the sample, the test should be carried out on a specimen according to IEC 60695-10-2.

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

The test is made in a heating cabinet at a temperature of 125 °C ± 2 °C, or 40 °C ± 2 °C plus the highest temperature rise determined for the relevant part during the test of clause 16, whichever is the higher.

After 1 h, the ball is removed from the sample, which is then cooled down within 10 s to approximately room temperature by immersion in cold water.

The diameter of the impression caused by the ball is measured and shall not exceed 2 mm.

18.4 Parts of insulating material not necessary to retain current-carrying parts and parts of the earthing circuit in position, even though they are in contact with them, are subjected to a ball-pressure test in accordance with 18.3, but the test is made at a temperature of 75 °C ± 2 °C, or 40 °C ± 2 °C plus the highest temperature rise determined for the relevant part during the test of clause 16, whichever is the higher.

19 Screws, current-carrying parts and connections

19.1 Connections, electrical or mechanical, shall withstand the mechanical stresses occurring in normal use.

Screws or nuts which transmit contact pressure shall be in engagement with a metal thread.

Compliance is checked by inspection and for screws and nuts that are operated when connecting the external conductors and mounting the equipment by the following test.

NOTE 1 The requirements for the verification of terminals are given in clause 12.

The screws or nuts are tightened or loosened:

- 10 times for screws in engagement with a thread of insulating material;
- 5 times in all other cases.

Screws in engagement with a thread of insulating material are completely removed and reinserted each time.

The test is made by means of a suitable screwdriver or a suitable tool, applying a torque as specified in Table 5 in EN 60999-1.

The conductor is moved each time that the screw or nut is loosened.

During the test, no damage impairing the further use of the screwed connections shall occur, such as breakage of screws or damage to the head slots, threads, washers or stirrups.

NOTE 2 Screws or nuts which are operated when assembling the equipment include screws for fixing covers or cover plates, etc., but not connecting means for screwed conduits and screws for fixing the base of the equipment.

NOTE 3 The shape of the blade of the test screwdriver is to fit the head of the screw to be tested. The screws and nuts shall not be tightened in jerks. Damage to covers is neglected.

19.2 For screws in engagement with a thread of insulating material which are operated when mounting the equipment during installation, their correct introduction into the screw hole or nut shall be ensured.

Compliance is checked by inspection.

NOTE The requirement with regard to correct introduction is met if introduction of the screw in a slanting manner is prevented, for example by guiding the screw by the part to be fixed, by a recess in the female thread or by the use of a screw with the leading thread removed.

19.3 Electrical connections shall be so designed that contact pressure is not transmitted through insulating material other than ceramic, pure mica or other material with characteristics no less suitable, unless there is sufficient resiliency in the metallic parts to compensate for any possible shrinkage or yielding of the insulating material.

Compliance is checked by inspection.

NOTE The suitability of the material is considered in respect of the stability of the dimensions.

19.4 Screws and rivets, which serve as electrical as well as mechanical connections, shall be locked against loosening.

Compliance is checked by inspection and by manual test.

NOTE 1 Spring washers may provide satisfactory locking.

NOTE 2 For rivets, a non-circular shank or an appropriate notch may be sufficient.

NOTE 3 Sealing compound which softens on heating provides satisfactory locking only for screw connections not subjected to torsion in normal use.

19.5 Current-carrying parts shall be of:

– copper;

– an alloy containing at least 58 % copper for parts made from cold-rolled sheet or at least 50 % copper for other parts;

– stainless steel containing at least 13 % chromium and not more than 0,09 % carbon;

– steel provided with an electroplated coating of zinc according to ISO 2081, the coating having a thickness of at least:

  - 5 µm, service condition ISO No. 1, for ordinary equipment (IPX0);
  - 12 µm, service condition ISO No. 2, for splash-proof equipment (IPX4);
  - 25 µm, service condition ISO No. 3, for jet-proof equipment (IPX5);

– steel provided with an electroplated coating of nickel and chromium according to ISO 1456, the coating having a thickness of at least:

  - 20 µm, service condition ISO No. 2, for ordinary equipment (IPX0);
  - 30 µm, service condition ISO No. 3, for splash-proof equipment (IPX4);
  - 40 µm, service condition ISO No. 4, for jet-proof equipment (IPX5);

– steel provided with an electroplated coating of tin according to ISO 2093, the coating having a thickness of at least:

  - 12 µm, service condition ISO No. 2, for ordinary equipment (IPX0);
  - 20 µm, service condition ISO No. 3, for splash-proof equipment (IPX4);
  - 30 µm, service condition ISO No. 4, for jet-proof equipment (IPX5).

Current-carrying parts which may be subjected to mechanical wear shall not be made of steel provided with an electroplated coating.

Under moist conditions metals showing a great difference of electrochemical potential with respect to each other shall not be used in contact with each other.

Compliance is checked by a test which is under consideration.

NOTE The requirement of this subclause does not apply to screws, nuts, washers, clamping plates and similar parts of terminals.

19.6 Thread-forming screws and thread-cutting screws shall not be used for the connection of current-carrying parts. Thread-forming screws and thread-cutting screws may be used to provide earthing continuity, provided that it is not necessary to disturb the connection in normal use and at least two screws are used for each connection.

Compliance is checked by inspection.

20 Creepage distances, clearances and distances through sealing compound

20.1 Creepage distances, clearances and distances through sealing compound shall not be less than the values shown in Table 6.

The values in Table 6 are in accordance with HD 625.1.

Table 6 - Creepage distances and clearances

Description	Rated impulse voltage 4 kV (mm)	Rated impulse voltage 6 kV (mm)
Creepage distances		
1. Between live parts of different polarity, including parts for looping-in of external conductors	4[1)]	5,5
2. Between live parts, including parts for looping-in of external conductors, and:		
- accessible metal parts,	5,5	8
- earthed metal parts, including the earthing circuits	3	5,5
- screws or other devices for fixing bases, covers or cover plates	3	5,5
Clearances		
3. Between live parts of different polarity, including parts for looping-in of external conductors	3	5,5
4. Between live parts, including parts for looping-in of external conductors, and		
- accessible metal parts,	5,5	8
- earthed metal parts, including the earthing circuits	3	5,5
- screws or other devices for fixing bases, covers or cover plates	3	5,5
5. Between live parts, including parts for looping-in of external conductors, and the surface on which the base of surface-type equipment is mounted	5,5	8
Distances through insulating sealing compound		
6. Between live parts covered with at least 2 mm of sealing compound and the surface on which the base of surface-type equipment is mounted	4	5,5

1) The value is reduced to 3 mm for nominal voltage up to and including 250 V

For printed wiring materials the following tables substitute the values given in items 1), and 3) of Table 6:

- creepage distances: Table 7;

Table 7 - Creepage distances for printed circuit board

Working voltage V (r.m.s.)	Minimum creepage distances for printed wiring materials mm
50	0,04
63	0,063
80	0,1
100	0,16
125	0,25
160	0,4
200	0,63
250	1
320	1,6
400	2

The creepage distances shall not be less than the clearances.

- clearances: Table 8

Table 8 - Minimum clearances for printed circuit board

Required impulse withstand voltage kV	Minimum clearances for printed wiring materials mm
0,5	0,04
0,6	0,06
0,8	0,1
1	0,15
1,2	0,25
1,5	0,5
2	1
2,5	1,5
3	2
4	3
6	5,5

The required impulse withstand voltage is the maximum calculated or measured impulse voltage expected to occur across the clearance taking into account the rated impulse voltage of the equipment.

For decoupling filters and phasecouplers the rated impulse voltage is according to the classification either 4 kV or 6 kV.

Table 7 and Table 8 are only valid for pollution degree 1 and 2 according to HD 625.1 and cannot be applied to the means to connect the external wiring to the printed wiring material. Material according to material group I, II or IIIa may be used.

Materials are separated into three groups according to their proof-tracking index (PTI). The PTI values are as follows:

– material group I $600 \geq PTI$

– material group II $400 \leq PTI < 600$

– material group III $175 \leq PTI < 400$

The PTI values above refer to values obtained in accordance with HD 214 S2, on specimens specifically made for the purpose and tested with solution A.

NOTE 1 The proof-tracking index (PTI) is also used to identify the tracking characteristics of materials. A material may be included in one of the three groups given above on the basis that its PTI, established by the methods of HD 214 S2 using solution A, is equal to or greater than the lower value specified for the group.

The values given in Table 7 and Table 8 need not be complied with if the requirements of clause 24 are fulfilled.

An accessible surface of insulating material is to be compared with an accessible metal part according to items 2 and 4 in Table 6.

Compliance is checked by measurement.

The measurements are made on the equipment fitted with conductors of the largest cross-sectional area specified in clause 12, and also without conductors.

Distances through slots or openings in external parts of insulating material are measured to metal foil in contact with the accessible surface; the foil is pushed into corners and the like by means of a straight unjointed test finger having the same dimension as the standard test finger specified in EN 60529, but is not pressed into openings.

NOTE 2 The contribution to the creepage distance of any groove less than 1 mm wide is limited to its width.

NOTE 3 Any air-gap less than 1 mm is ignored in computing the total clearance.

NOTE 4 The surface on which the base of surface-type equipment is mounted includes any surface in contact with the base when the equipment is installed. If the base is provided with a metal plate at the back, this plate is not regarded as the mounting surface.

20.2 Insulating sealing compound shall not protrude above the edge of the cavity in which it is contained.

20.3 Enclosed or partly enclosed equipment shall not have bare current-carrying strips at the back.

Compliance with the requirements of 20.2 and 20.3 is checked by inspection.

21 Resistance to abnormal heat, to fire and to tracking

〈A1〉 21.1 Resistance to abnormal heat and to fire

Parts made of insulating material which might be exposed to thermal stresses due to electric effects and whose deterioration might impair safety shall not be unduly affected by heat and fire generated within the equipment.

Compliance is checked by the glow-wire test according to clauses 3 to 11 of EN 60695-2-1/X under the following conditions:

- 650 °C for parts made of insulating material not retaining current-carrying parts and parts of the earthing circuit in position, even though they may be in contact with them.
- 850 °C for parts made of insulating material retaining current-carrying parts and parts of the earthing circuit in position, when the equipment according to 7.1.5 is classified to overvoltage category III.
- 960 °C for parts made of insulating material retaining current-carrying parts and parts of the earthing circuit in position, when the equipment according to 7.1.5 is classified to overvoltage category IV.

Small parts such as washers are not subjected to the test of this subclause.

The tests are not made on parts of ceramic material.

If the test cannot be made on the complete specimen, a suitable part may be cut from it for the purpose of the test.

The test is made on one specimen only. In case of doubt, the test will be repeated on two further specimens.

The specimen shall be positioned during the test in the most unfavourable position of its intended use (with the surface tested in a vertical position).

The tip of the glow-wire shall be applied to the specified surface of the test specimen, taking into account the conditions of the intended use under which a hot part may come into contact with the specimen.

The specimen is regarded as having passed the glow-wire test if:

- there is no visible flame and no sustained glowing, or if
- flames and glowing on the specimen extinguish within 30 s after removal of the glow-wire.

There shall be no ignition of the tissue paper or scorching of the board. 〈A1〉

1.2 Resistance to tracking

Parts of insulating material for which a creepage path is specified between live parts of different polarity, between live parts and earthed metal and between live parts and accessible surfaces shall have resistance to tracking.

Compliance is checked according to HD 214 S2.

Ceramic parts are not tested.

The material under test shall pass a proof-tracking-index (PTI) of minimum 175 V using test solution A with the interval between drops 30 s $\pm$ 5 s.

No flashover over or breakdown between electrodes shall occur before a total of 50 drops has fallen.

22 Resistance to rusting

Ferrous parts, including covers and boxes, shall be adequately protected against rusting.

Compliance is checked by the following test:

All grease is removed from the parts to be tested, by immersion in carbontetra-chloride, trichloroethane or an equivalent degreasing agent, for 10 min.

The parts are then immersed for 10 min in a 10 % solution of ammonium chloride in water at a temperature of 20 °C ± 5 °C.

Without drying, but after shaking off any drops, the parts are placed for 10 min in a box containing air saturated with moisture at a temperature of 20 °C ± 5 °C.

After the parts have been dried for 10 min in a heating cabinet at a temperature of 100 °C ± 5 °C, their surfaces shall show no signs of rust.

NOTE 1 Traces of rust on sharp edges and any yellowish film removable by rubbing is ignored.

NOTE 2 For small springs and the like, and for inaccessible parts exposed to abrasion, a layer of grease may provide sufficient protection against rusting. Such parts are subjected to the test only if there is doubt about the effectiveness of the grease film, and the test is then made without previous removal of the grease.

23 Components

Where safety is involved, components shall be used in accordance with their specified ratings for i.e. working voltage, transient voltage and working temperature unless a specific exception is made in this standard.

Fuses, capacitors and resistors the short-circuiting or interruption of which would cause an infringement of the requirements under fault conditions with regard to electric shock or fire hazards shall comply with the requirements of 1.1 to 1.3.

1.1 Fuses

Fuses, if any, shall comply with EN 60127 and have as a minimum a rated breaking capacity of 1500 A.

The nominal current of the fuse shall be of the lowest possible value taking into account the operation of the equipment.

[A2] It is proposed to consider for filters with rated currents equal to or higher than 40 A a minimum prospective fault current of 6 000 A. [A2]

NOTE It may be necessary to apply a fuse with a higher nominal current than that necessary for the overload protection due to the fact that the resistance of the fuse may lead to such a high voltage drop that the operation of the equipment is influenced.

1.2 Capacitors

Capacitors shall have a dielectric strength to withstand the required impulse voltage.

Capacitors shall comply with the requirements of EN 132400.

The nominal voltage of such capacitors shall be in accordance with the nominal voltage of the equipment.

1.3 Resistors

Resistors shall maintain an adequately constant value under the abnormal condition in clause 24.

These resistors shall comply with the requirements of EN 60065.

23.4 Components used for reducing the required impulse voltage and clearance according to Table 8 shall have adequate dielectric strength.

Components shall be design to withstand the impulse voltage that calculated or measured will be over the component when the dielectric test specified in clause 26 is applied to the equipment.

Conformity is check by inspection or by measurement

24 Abnormal conditions

24.1 Abnormal conditions mean either an overload or a single fault condition.

The equipment shall not create hazard such as danger of fire or electric shock under abnormal conditions

A single fault condition shall not cause the current protective device of the installation to operate.

Compliance is checked by the tests specified in 24.2 and 24.3.

24.2 When the equipment is operated under abnormal conditions no part shall reach such a temperature that there is danger of fire to the surroundings of the equipment.

Compliance is checked by subjecting the equipment to a heating test under abnormal conditions, as described in 24.2.1.

During the tests any flame inside the apparatus shall extinguish within a period of 10 s.

During the test, the temperature rises shall not exceed the value given in clause 16.

24.2.1 Unless otherwise specified, the tests are made on the equipment while it is mounted, connected and loaded as specified in clause 16.

Each of the abnormal conditions indicated in 24.2.1.1 and 24.2.1.2 is applied in turn.

The abnormal conditions are applied in the order, which is the most convenient for testing.

24.2.1.1 The following fault conditions shall be simulated:

– short circuit across creepage distances and clearances, other than those complying with the requirements in clause 20;

– short circuit across insulating coatings consisting, for example, of lacquer or enamel;

– short circuit or interruption of semiconductor devices;

– short circuit of electrolytic capacitors;

– short circuit or interruption of components which do not comply with the requirements of clause 23.

When a specified fault condition test is carried out, it can cause consequential faults, which either interrupt or short-circuit other components. In case of doubt, the fault condition test shall be repeated up to two more times with replacement components in order to check that the same result is always obtained. Should this not be the case, the most unfavourable consequential fault, whether interruption or short circuit, shall be applied together with the specified fault condition.

If the temperature of the equipment is limited by the operation of temperature protective devices (including fuses), the temperature is measured 2 min after the operation of the device.

If no temperature-limiting device operates, the temperature is measured after a steady state has been reached or after 4 h, whichever is the shorter time.

If the temperature is limited by a fuse the following additional test is carried out:

The fuse is short-circuited and the current under the relevant fault condition is measured. The equipment is then loaded for a duration corresponding to the maximum fusing time of the type of fuse as specified by EN 60127 at the fault current measured above. The temperature is measured 2 min after the end of the period.

24.2.1.2 The following overload test is carried out, where applicable.

The equipment without incorporated temperature-limiting devices and without incorporated fuses are loaded for 1 h with the conventional tripping current for the protective device which in the installation will protect the equipment. The manufacture shall in the installation instructions declare the type of the protective device together with the related maximum nominal value of the protective device.

The maximum temperature is measured during the test.

The equipment protected by temperature protective devices (including fuses) are loaded in such a way that the current through the equipment is 95 % of the current with which the protecting device releases after 1 h.

The temperature rise is measured after a steady state has been reached or after 4 h, whichever is the shorter time.

The equipment protected by incorporated fuses complying with EN 60127 shall have those fuses replaced by links of negligible impedance and shall be loaded in such a manner that the current through the links shall be 2,1 times the nominal current of the fuse.

The temperature rise is measured after the current has been applied for 30 min.

24.3 Protection against electric shock is required, even though the equipment is being used or has been used during fault conditions.

Compliance is checked by carrying out the tests described in 24.2.

The equipment, having been subjected to the test, shall comply with the requirements of clause 10.

25 Protection against short-circuit

The equipment shall be able to withstand the conditional short-circuit current assigned by the manufacturer.

The manufacturer shall state the type and value of the SCPD see definition clause 8.

Compliance is checked by the following test:

The test current shall be within - 0 % and + 5 % of the rated conditional short-circuit current. The test voltage and frequency shall be with ± 5 % of the rated value.

The equipment shall be tested in free air mounted on a metal support unless they are designed for a specific enclosure or intended for use in enclosures, which are designed to accept only one device. In this case the test shall be carried out with the equipment in the smallest of such enclosures stated by the manufacturer.

The test circuit shall consist of the SCPD, an auxiliary switch, and an impedance in series with the equipment.

The auxiliary switch shall make all phases simultaneously. The impedance shall be in series (one in each phase) with the equipment and shall be adjustable to satisfy the specified test conditions. All parts of the equipment normally earthed in service, including the metal support or the enclosure, shall be insulated from earth and connected through a fusible element to neutral of the supply. The fusible element shall consist of a copper wire 0,8 mm in diameter and at least 50 mm long, or of an equivalent fusible element for the detection of the fault current.

The prospective fault current in the fusible element circuit shall be 1500 A ± 10 %. If necessary, a resistor in series with the fusible element limiting the current to that value shall be used.

The test is made on three new samples with the conditional short-circuit current assigned by the manufacturer. The type and value of the SCPD, the conditional short-circuit current and the test circuit shall be stated in the test report.

During the test there shall be no flashover between poles or between poles and enclosure/support and no melting of the fusible element.

After the test the equipment shall show no damage impairing the further use and shall be capable of withstanding a dielectric test according to clause 15. The dielectric test shall not be carried out later than 24 h after the conditional short-circuits test.

〚A2〛 It is proposed to consider for filters with rated currents equal to or higher than 40 A a minimum prospective fault current of 6 000 A. 〚A2〛

26 Resistance to transients

Equipment shall withstand transients that may occur in normal use without causing hazard of electric shock or fire.

Compliance is checked by the following test:

The impulse dielectric test specified in HD 625.1 subclause 4.1.1.2 shall be applied on the mains terminals of the equipment with the following specifications:

- the output impedance of the impulse generator shall not be higher than 2 Ω;
- a rated impulse test voltage of 4 kV for overvoltage category III or 6 kV for overvoltage category IV;
- an AC voltage of 1,1 Un shall be applied on the mains terminal of the equipment during the test.

The sample is subjected to 10 positive impulses followed by 10 negative impulses. An interval of 10 s shall elapse between two consecutive impulses. During the test no sustained arcing, ignition, bursting of the enclosure or other damages causing electric shock or fire hazard shall occur.

After the test the equipment shall show no damage impairing the further use and shall be capable of withstanding a dielectric test according to clause 15.

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