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Responsible committee: EPL/66 Safety of measuring, control and laboratory equipment

Interested committees:

Title: BS EN IEC 61010-1 AMD2. Safety requirements for electrical equipment for measurement, control, and laboratory use

Part 1: General requirements

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Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

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Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/Figure/ Table/Note	Type of comment	Commend (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	



66/810/CD

COMMITTEE DRAFT (CD)

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IEC TC 66 : SAFETY OF MEASURING, CONTROL AND LABORATORY EQUIPMENT

SECRETARIAT:
United Kingdom

SECRETARY:
Ms Stephanie Lavy

OF INTEREST TO THE FOLLOWING COMMITTEES:

PROPOSED HORIZONTAL STANDARD:

☐

Other TC/SCs are requested to indicate their interest, if any, in this CD to the secretary.

FUNCTIONS CONCERNED:

☐ EMC

☐ ENVIRONMENT

☐ QUALITY ASSURANCE

☒ SAFETY

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TITLE:

Amendment 2 - Safety requirements for electrical equipment for measurement, control, and laboratory use - Part 1: General requirements

NOTE FROM TC/SC OFFICERS:

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The text of this document is based on IEC 61010-1 ed3.1 and Amd2 CD2 66/455.

This red font indicates text that was modified by Amendment 1:2016

This blue font indicates text that is to be included as Amd2.

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**SAFETY REQUIREMENTS FOR ELECTRICAL EQUIPMENT FOR
MEASUREMENT, CONTROL, AND LABORATORY USE –****Part 1: General requirements****FOREWORD**

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International Standard IEC 61010-1 has been prepared by IEC technical committee 66: Safety of measuring, control and laboratory equipment.

It has the status of a group safety publication, as specified in IEC Guide 104.

541 INTRODUCTION

542 This [International](#) Standard specifies the safety requirements that are generally applicable to
543 all equipment within its scope. For certain types of equipment, these requirements will be
544 supplemented or modified by the special requirements of one, or more than one, particular part
545 2 of the standard which must be read in conjunction with the part 1 requirements.

546

SAFETY REQUIREMENTS FOR ELECTRICAL EQUIPMENT FOR MEASUREMENT, CONTROL, AND LABORATORY USE –

Part 1: General requirements

1 Scope and object

1.1 Scope

1.1.1 Equipment included in scope

This group safety publication is primarily intended to be used as a product safety standard for the products mentioned in the scope, but shall also be used by technical committees in the preparation of their publications for products similar to those mentioned in the scope of this standard, in accordance with the principles laid down in IEC Guide 104 and ISO/IEC Guide 51.

This part of IEC 61010 specifies general safety requirements for the following types of electrical equipment and their accessories, wherever they are intended to be used. It is intended to be used in conjunction of the manufacturer's process of risk assessment and risk reduction but not to replace it.

a) Electrical test and measurement equipment

This is equipment which by electromagnetic means tests, measures, indicates or records one or more electrical or physical quantities, also non-measuring equipment such as signal generators, measurement standards, power supplies for laboratory use, transducers, transmitters, etc.

NOTE 1 This includes bench-top power supplies intended to aid a testing or measuring operation on another piece of equipment. Power supplies intended to power equipment are within the scope of IEC 61558 (see 1.1.2 f)).

This standard also applies to test equipment integrated into manufacturing processes and intended for testing manufactured devices.

NOTE 2 Manufacturing test equipment is likely to be installed adjacent to and interconnected with industrial machinery in this application.

b) Electrical industrial process-control equipment

This is equipment which controls one or more output quantities to specific values, with each value determined by manual setting, by local or remote programming, or by one or more input variables.

c) Electrical laboratory equipment

This is equipment which measures, indicates, monitors, inspects or analyses materials, or is used to prepare materials. This equipment may also be used in areas other than laboratories.

1.1.2 Equipment excluded from scope

This standard does not apply to equipment within the scope of:

- a) IEC 60335 (Household and similar electrical appliances);
- b) IEC 60364 (Electrical installations of buildings);
- c) IEC 61439 (Low-voltage switchgear and control gear assemblies);
- d) IEC 60601 (Medical electrical equipment);
- e) IEC 62368-1 (Audio/video, information and communication technology equipment, except as specified in 1.1.3);
- f) IEC 61558 (Power transformers, power supply units and similar);
- g) IEC 61010-031 (Hand-held probe assemblies);
- h) IEC 61243-3 (Live working – Voltage detectors – Part 3: Two-pole low voltage type).

1.1.3 Computing equipment

This standard applies only to computers, processors, etc. which form part of equipment within the scope of this standard or are designed for use exclusively with the equipment.

1.1.4 Detectors or sensors used for Signalling or Alarms

Detectors, sensors or other devices, including controllers and analysers, which are both intended to measure, sense or detect hazardous levels of physical or electrical quantities, and are intended for signalling or safety alarm initiation, notification or release, shall be assessed to a standard providing suitable requirements for performance and reliability in addition to IEC 61010-1.

(Examples include but are not limited to products within scope of IEC 60079-29-1 and IEC 62990 series).

1.2 Object

1.2.1 Aspects included in scope

The purpose of the requirements of this standard is to ensure that HAZARDS to the OPERATOR and the surrounding area are reduced to a tolerable level.

Requirements for protection against particular types of HAZARD are given in Clauses 6 to 13, as follows:

- a) electric shock or burn (see Clause 6);
- b) mechanical HAZARDS (see Clauses 7 and 7.8);
- c) spread of fire from the equipment (see Clause 9);
- d) excessive temperature (see Clause 10);
- e) effects of fluids and fluid pressure (see Clause 11);
- f) effects of radiation, sonic and ultrasonic pressure (see Clause 12);
- g) liberated gases, explosion and implosion (see Clause 13).

Requirements for protection against HAZARDS arising from REASONABLY FORESEEABLE MISUSE and ergonomic factors are specified in Clause 16.

RISK assessment for HAZARDS or environments not fully covered above is specified in Clause 17.

NOTE Attention is drawn to the existence of additional requirements regarding the health and safety of labour forces.

1.2.2 Aspects excluded from scope

This standard does not cover:

- a) reliable function, performance, or other properties of the equipment not related to safety;
- b) transport packaging;
- c) EMC requirements (see the IEC 61326 series);
- d) protective measures for explosive atmospheres (see the IEC 60079 series).

1.3 Conformity assessment

This standard also specifies methods of checking conformity to the requirements of this standard. These are included in the conformity statements in all clauses of the document and specifically in Clause 4 Tests. The methods include inspection, testing, TYPE TESTS and ROUTINE TESTS.

1.4 Environmental conditions

1.4.1 Normal environmental conditions

This standard applies to equipment designed to be safe at least under the following conditions:

- a) indoor use;
- b) altitude up to 2 000 m;
- c) ambient temperature 5 °C to 40 °C;

d) maximum relative humidity 80 % for temperatures up to 31 °C decreasing linearly to 50 % relative humidity at 40 °C;

e) MAINS supply voltage fluctuations up to ± 10 % of the nominal voltage;

f) TRANSIENT OVERVOLTAGES up to the levels of OVERVOLTAGE CATEGORY II;

NOTE 1 These levels of transient overvoltage are typical for equipment supplied from the building wiring.

g) TEMPORARY OVERVOLTAGES occurring on the MAINS supply

h) applicable POLLUTION DEGREE of the intended environment (POLLUTION DEGREE 2 in most cases).

NOTE 2 Manufacturers may specify more restricted environmental conditions for operation; nevertheless the equipment must be safe within these normal environmental conditions.

1.4.2 Extended environmental conditions

This standard applies to equipment designed to be safe not only in the environmental conditions specified in 1.4.1, but also in any of the following conditions as RATED by the manufacturer of the equipment:

a) outdoor use;

b) altitude above 2 000 m;

c) ambient temperatures below 5 °C or above 40 °C;

d) relative humidity above the levels specified in 1.4.1;

e) MAINS supply voltage fluctuations exceeding ± 10 % of the nominal voltage;

f) WET LOCATION;

g) TRANSIENT OVERVOLTAGES up to the levels of OVERVOLTAGE CATEGORY III or IV (see Annex K).

2 Normative references

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

IEC 60027 (all parts), *Letter symbols to be used in electrical technology*

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

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

IEC 60073, *Basic and safety principles for man-machine interface, marking and identification – Coding principles for indicators and actuators*

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

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

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

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

IEC 60332-1-2, *Tests on electric and optical fibre cables under fire conditions – Part 1-2: Test for vertical flame propagation for a single insulated wire or cable – Procedure for 1 kW pre-mixed flame*

IEC 60332-2-2, *Tests on electric and optical fibre cables under fire conditions – Part 2-2: Test for vertical flame propagation for a single small insulated wire or cable – Procedure for [diffusion](#) flame*

IEC 60335-2-24, *Household and similar electrical appliances – Safety – Part 2-24: Particular requirements for refrigerating appliances, ice-cream appliances and ice-makers.*

- 686 IEC 60335-2-89, *Household and similar electrical appliances – Safety – Part 2-89: Particular*
687 *requirements for commercial refrigerating appliances with an incorporated or remote refrigerant*
688 *condensing unit or compressor*
- 689 IEC 60364-4-44:2007, *Low-voltage electrical installations – Part 4-44: Protection for safety –*
690 *Protection against voltage disturbances and electromagnetic disturbances*
691 **IEC 60364-4-44:2007/AMD1:2015**
- 692 IEC 60384-14, *Fixed capacitors for use in electronic equipment - Part 14: Sectional specification*
693 *- Fixed capacitors for electromagnetic interference suppression and connection to the supply*
694 *mains*
- 695 IEC 60417, *Graphical symbols for use on equipment*
- 696 IEC 60529, *Degrees of protection provided by enclosures (IP Code)*
- 697 IEC 60664-3, *Insulation coordination for equipment within low-voltage systems – Part 3: Use of*
698 *coating, potting or moulding for protection against pollution*
- 699 IEC 60695-11-10, *Fire hazard testing – Part 11-10: Test flames – 50 W horizontal and vertical*
700 *flame test methods*
- 701 **IEC 60695-11-3, *Fire hazard testing – Part 11-3: Test flames – 500 W flames - Apparatus and***
702 ***confirmational test methods***
- 703 IEC 60799, *Electrical accessories – Cord sets and interconnection cord sets*
- 704 IEC 60825-1, *Safety of laser products – Part 1: Equipment classification and requirements*
- 705 IEC 60947-1, *Low-voltage switchgear and controlgear – Part 1: General rules*
- 706 **IEC 60947-2, *Low-voltage switchgear and controlgear – Part 2: Circuit-breakers***
- 707 IEC 60947-3, *Low-voltage switchgear and controlgear – Part 3: Switches, disconnectors,*
708 *switch-disconnectors and fuse-combination units*
- 709 IEC 61010-031, *Safety requirements for electrical equipment for measurement, control and laboratory*
710 *use – Part 031: Safety requirements for hand-held probe assemblies for electrical measurement*
711 *and test*
- 712 IEC 61180 (all parts), *High-voltage test techniques for low-voltage equipment*
- 713 IEC 61180-1, *High-voltage test techniques for low-voltage equipment – Part 1: Definitions, test*
714 *and procedure requirements*
- 715 IEC 61180-2, *High-voltage test techniques for low-voltage equipment – Part 2: Test equipment*
- 716 IEC 61672-1, *Electroacoustics – Sound level meters – Part 1: Specifications*
- 717 IEC 61672-2, *Electroacoustics – Sound level meters – Part 2: Pattern evaluation tests*
- 718 **IEC 62061, *Safety of machinery - Functional safety of safety-related control systems***
- 719 IEC 62262, *Degrees of protection provided by enclosures for electrical equipment against*
720 *external impacts (IK code)*
- 721 **IEC 62471, *Photobiological safety of lamps and lamp systems***
- 722 **IEC TR 62471-2, *Photobiological safety of lamps and lamp systems – Part 2: Guidance on***
723 ***manufacturing requirements relating to non-laser optical radiation safety***
- 724 **IEC 62598, *Nuclear instrumentation – Constructional requirements and classification of***
725 ***radiometric gauges***
- 726 IEC Guide 104, *The preparation of safety publications and the use of basic safety publications*
727 *and group safety publications*

- 728 ISO/IEC Guide 51, *Safety aspects – Guidelines for their inclusion in standards*
- 729 ISO 306:2013, *Plastics – Thermoplastic materials – Determination of Vicat softening*
730 *temperature (VST)*
- 731 ISO 361, *Basic ionizing radiation symbol*
- 732 ISO 11228-1, *Ergonomics – Manual Handling – Part 1: Lifting and carrying*
- 733 ISO 3746, *Acoustics – Determination of sound power levels of noise sources using sound*
734 *pressure – Survey method using an enveloping measurement surface over a reflecting plane*
- 735 ISO 5349-1, *Mechanical vibration – Measurement and evaluation of human exposure to hand*
736 *transmitted vibration – Part 1: General requirements*
- 737 ISO 7000, *Graphical symbols for use on equipment*
- 738 ISO 9614-1, *Acoustics – Determination of sound power levels of noise sources using sound*
739 *intensity – Part 1: Measurement at discrete points*
- 740 ISO 13849-1, *Safety of machinery – Safety-related parts of control systems – Part 1: General*
741 *principles for design*
- 742 ISO 13849-2, *Safety of machinery – Safety-related parts of control systems – Part 2: Validation*
- 743 ISO 13857, *Safety of machinery – Safety distances to prevent hazard zones being reached by*
744 *upper and lower limbs*
- 745 EN 378-2, *Refrigerating systems and heat pumps. - Safety and environmental requirements.*
746 *Design, construction, testing, marking and documentation*
- 747 EN 1005-2, *Safety of machinery – Human physical performance – Part 2: Manual handling of*
748 *machinery and component parts of machinery*

749 **3 Terms and definitions**

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

751 **3.1 Equipment and states of equipment**

752 **3.1.1 FIXED EQUIPMENT**

753 equipment fastened to a support, or otherwise secured in a specific location

754 [IEC 60050-826:2004, 826-16-07, modified]

755 **3.1.2 PERMANENTLY CONNECTED EQUIPMENT**

756 equipment that is electrically connected to a supply by means of a permanent connection which
757 can be detached only by the use of a TOOL

758 **3.1.3 PORTABLE EQUIPMENT**

759 equipment intended to be carried by hand

760 **3.1.4 HAND-HELD EQUIPMENT**

761 PORTABLE EQUIPMENT intended to be supported by one hand during NORMAL USE

762 **3.1.5 TOOL**

763 external device, including keys and coins, used to aid a person to perform a mechanical function

764 **3.1.6 DIRECT PLUG-IN EQUIPMENT**

765 equipment with a MAINS plug that is attached to the equipment housing without the use of a
766 MAINS supply cord so that the equipment is supported by the MAINS socket-outlet

3.1.7 MOBILE EQUIPMENT

equipment that, once installed and placed into service, is intended to be moved from one location to another while supported by its own wheels or equivalent means

[IEC 60050-826:2022, 826-16-04, modified]

3.2 Parts and accessories**3.2.1 TERMINAL**

component provided for the connection of a device to external conductors

[IEC 60050-151:2001, 151-12-12, modified]

NOTE TERMINALS can contain one or several contacts and the term therefore includes sockets, connectors, etc.

3.2.2 FUNCTIONAL EARTH TERMINAL

TERMINAL by which electrical connection is made directly to a point of a measuring or control circuit or to a screening part and which is intended to be earthed for any functional purpose other than safety

NOTE For measuring equipment, this TERMINAL is often called the measuring earth TERMINAL.

3.2.3 PROTECTIVE CONDUCTOR TERMINAL

TERMINAL which is bonded to conductive parts of equipment for safety purposes and is intended to be connected to an external protective earthing system

3.2.4 ENCLOSURE

part providing protection of equipment against certain external influences and, in any direction, protection against direct contact

NOTE ENCLOSURES may also provide protection against the spread of fire (see 9.3.2 c)).

3.2.5 PROTECTIVE BARRIER

part providing protection against direct contact from any usual direction of access

[IEC 60050-195:1998, 195-06-15]

NOTE Depending on its construction, a PROTECTIVE BARRIER can be called a casing, cover, screen, door, guard, etc.

A PROTECTIVE BARRIER can act alone; it is then only effective when it is in place. A PROTECTIVE BARRIER can also act in conjunction with an interlocking device with or without guard locking; in this case, protection is ensured whatever the position of the PROTECTIVE BARRIER.

3.3 Quantities**3.3.1 RATED (value)**

quantity value assigned, generally by a manufacturer, for a specified operating condition of a component, device or equipment

[IEC 60050-151:2001, 151-16-08, modified]

3.3.2 RATING

set of RATED values and operating conditions

[IEC 60050-151:2001, 151-16-11]

3.3.3 WORKING VOLTAGE

highest r.m.s. value of the a.c. or d.c. voltage across any particular insulation which can occur when the equipment is supplied at RATED voltage

NOTE 1 Transients and voltage fluctuations are not considered to be part of the WORKING VOLTAGE.

NOTE 2 Both open-circuit conditions and normal operating conditions are taken into account.

3.4 Tests

3.4.1 TYPE TEST

test of one or more samples of equipment (or parts of equipment) made to a particular design, to show that the design and construction meet one or more requirements of this standard

NOTE This is an amplification of the IEC 60050-151:2001, 151-16-16 definition to cover design as well as construction.

3.4.2 ROUTINE TEST

conformity test made on each individual item during or after manufacture

[IEC 60050-151:2001, 151-16-17]

3.5 Safety terms

3.5.1 ACCESSIBLE (of a part)

able to be touched with a standard test finger or test pin, when used as specified in 6.2

3.5.2 HARM

injury or damage to the health of people, or damage to property or the environment

[SOURCE: ISO/IEC Guide 51:2014, 3.1]

3.5.3 HAZARD

potential source of HARM

[SOURCE: ISO/IEC Guide 51:2014, 3.2]

3.5.4 HAZARDOUS SITUATION

circumstance in which people, property or the environment is/are exposed to one or more HAZARDS

[SOURCE: ISO/IEC Guide 51:2014, 3.4]

3.5.5 HAZARDOUS LIVE

capable of rendering an electric shock or electric burn

3.5.6 MAINS

low-voltage electricity supply system to which the equipment concerned is designed to be connected for the purpose of powering the equipment

3.5.7 MAINS CIRCUIT

circuit which is intended to be directly connected to the MAINS for the purpose of powering the equipment

3.5.8 PROTECTIVE IMPEDANCE

component or assembly of components whose impedance, construction and reliability are suitable to provide protection against electric shock

3.5.9 PROTECTIVE BONDING

electrical connection of ACCESSIBLE conductive parts or protective screening to provide electrical continuity to the means for connection of an external protective conductor

3.5.10 NORMAL USE

operation, including stand-by, according to the instructions for use or for the obvious intended purpose

3.5.11 NORMAL CONDITION

condition in which all means for protection against HAZARDS are intact

3.5.12 SINGLE FAULT CONDITION

condition in which one means for protection against HAZARD is defective or one fault is present which could cause a HAZARD

NOTE If a SINGLE FAULT CONDITION results unavoidably in one or more other fault conditions, all the failures are considered as one SINGLE FAULT CONDITION [IEC Guide 104].

3.5.13 OPERATOR

person operating equipment for its intended purpose

3.5.14 RESPONSIBLE BODY

individual or group responsible for the safe use and maintenance of equipment

3.5.15 WET LOCATION

location where water or another conductive liquid may be present and is likely to cause reduced human body impedance due to wetting of the contact between the human body and the equipment, or wetting of the contact between the human body and the environment

3.5.16 REASONABLY FORESEEABLE MISUSE

use of a product in a way not intended by the supplier, but which may result from readily predictable human behaviour

3.5.17 RISK

combination of the probability of occurrence of HARM and the severity of that HARM

3.5.18 TOLERABLE RISK

RISK which is accepted in a given context based on the current values of society

[ISO/IEC Guide 51:1999, 3.7]

3.5.19 OVERVOLTAGE CATEGORY

numeral defining a TRANSIENT OVERVOLTAGE condition (see Annex K)

3.5.20 TRANSIENT OVERVOLTAGE

short duration overvoltage of a few milliseconds or less, oscillatory or non-oscillatory, usually highly damped

[SOURCE: IEC 60664-1:2020, 3.1.13]

3.5.21 TEMPORARY OVERVOLTAGE

power frequency overvoltage of relatively long duration

[SOURCE: IEC 60664-1:2020, 3.1.12]

3.6 Insulation**3.6.1 BASIC INSULATION**

insulation of HAZARDOUS LIVE parts which provides basic protection

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

NOTE BASIC INSULATION may serve also for functional purposes.

3.6.2 SUPPLEMENTARY INSULATION

independent insulation applied in addition to BASIC INSULATION in order to provide protection against electric shock in the event of a failure of BASIC INSULATION

[IEC 60050-195:1998, 195-06-07, modified]

3.6.3 DOUBLE INSULATION

insulation comprising both BASIC INSULATION and SUPPLEMENTARY INSULATION

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

892 **3.6.4 REINFORCED INSULATION**

893 insulation which provides protection against electric shock not less than that provided by
894 DOUBLE INSULATION

895 NOTE REINFORCED INSULATION may be composed of several layers which cannot be tested singly as
896 SUPPLEMENTARY INSULATION or BASIC INSULATION.

897 [IEC 60050-195:1998, 195-06-09, modified]

898 **3.6.5 POLLUTION**

899 addition of foreign matter, solid, liquid or gaseous (ionized gases), that may produce a reduction
900 of dielectric strength or surface resistivity

901 **3.6.6 POLLUTION DEGREE**

902 numeral indicating the level of POLLUTION that may be present in the environment

903 **3.6.7 POLLUTION DEGREE 1**

904 no POLLUTION or only dry, non-conductive POLLUTION occurs, which has no influence

905 **3.6.8 POLLUTION DEGREE 2**

906 only non-conductive POLLUTION occurs except that occasionally a temporary conductivity
907 caused by condensation is expected

908 **3.6.9 POLLUTION DEGREE 3**

909 conductive POLLUTION occurs, or dry, non-conductive POLLUTION occurs which becomes
910 conductive due to condensation which is expected

911 NOTE In such conditions, equipment is normally protected against exposure to direct sunlight, precipitation, and
912 full wind pressure, but neither temperature nor humidity is controlled.

913 **3.6.10 POLLUTION DEGREE 4**

914 continuous conductivity occurs due to conductive dust, rain or other wet conditions

915 **3.6.11 CLEARANCE**

916 shortest distance in air between two conductive parts

917 **3.6.12 CREEPAGE DISTANCE**

918 shortest distance along the surface of a solid insulating material between two conductive parts

919 [IEC 60050-151:2001, 151-15-50]

920 **4 Tests**

921 **4.1 General**

922 Tests in this standard are TYPE TESTS to be carried out on samples of equipment or parts. Their
923 only purpose is to check that the design and construction ensure conformity with this standard.
924 In addition, manufacturers shall perform the ROUTINE TESTS of Annex F on 100 % of equipment
925 produced which has both HAZARDOUS LIVE parts and ACCESSIBLE conductive parts.

926 The equipment shall at least meet the requirements of this standard. It is permissible to exceed
927 the requirements. If, in this standard, a lower limit is specified for a conformity value, then the
928 equipment may demonstrate a larger value. If an upper limit is specified for a conformity value,
929 the equipment may demonstrate a lower value.

930 Tests on subassemblies that meet the requirements of the relevant standards specified in this
931 standard, and used in accordance with them, need not be repeated during TYPE TESTS of the
932 whole equipment.

933 *Conformity with the requirements of this standard is checked by carrying out all applicable tests,*
934 *except that a test may be omitted if examination of the equipment and design documentation*

demonstrates conclusively that the equipment would pass the test. Tests are carried out both under reference test conditions (see 4.3) and under fault conditions (see 4.4).

Where conformity statements in this standard require inspection, this may include examination of the equipment by measurement, examination of the markings on the equipment, examination of the instructions supplied with the equipment, examination of the data sheets of the materials or components from which the equipment is manufactured, etc. In each case, the inspection will either demonstrate that the equipment meets the applicable requirements, or will indicate that further testing is required.

Where the intended use or equipment functions present RISKS other than those mitigated through the means and requirements in clauses 6 to 16 to the OPERATOR or to the surrounding area, the manufacturers' RISK management (see Clause 17 and Annex J) can be consulted to determine tests and operating conditions to verify that such RISKS are reduced to a tolerable level.

If, when carrying out a conformity test, there is any uncertainty about the exact value of an applied or measured quantity (for example voltage) due to the tolerance:

a) manufacturers should ensure that at least the specified test value is applied;

b) test houses should ensure that no more than the specified test value is applied.

TRANSIENT OVERVOLTAGES, TEMPORARY OVERVOLTAGES, and POLLUTION DEGREE need not be considered (i. e. these conditions need not be applied during the conformity tests of this standard unless otherwise specified).

4.2 Sequence of tests

The sequence of tests is optional unless otherwise specified. The equipment under test shall be carefully inspected after each test. If the result of a test causes doubt whether any earlier tests would have been passed if the sequence had been reversed, these earlier tests shall be repeated.

4.3 Reference test conditions

4.3.1 Environmental conditions

Unless otherwise specified in this standard, the following environmental conditions shall exist in the test location:

a) a temperature of 15 °C to 35 °C;

b) a relative humidity of not more than 75 %, but not exceeding the limits of 1.4.1 d);

c) an atmospheric pressure of 75 kPa to 106 kPa;

d) no hoar-frost, dew, percolating water, rain, solar radiation, etc.

4.3.2 State of equipment

4.3.2.1 General

If dimensions or mass make it unsuitable to carry out particular tests on completely assembled equipment, tests on sub-assemblies are allowed, provided it is verified that the assembled equipment will meet the requirements of this standard.

These combinations of test conditions may be different for each individual test and they shall be recorded together with any measurements for each test. In case of doubt, tests shall be performed in more than one combination of conditions. If testing at the least favourable RATED environmental conditions is necessary to allow realistic assessment of conformity criteria, the tests shall be conducted under these conditions.

4.3.2.2 Position of equipment

The equipment shall be placed in any position of NORMAL USE as specified in the manufacturer's instructions. Equipment intended to be built into a wall, recess, cabinet, etc., shall be installed as specified in the manufacturer's instructions. For HAND-HELD EQUIPMENT, all possible orientations are considered to be positions of NORMAL USE.

NOTE - see also requirements for equipment installation in 5.4.3.

Where no information related to the positioning of equipment, or where no ventilation requirements are given in the manufacturer's instructions, the equipment shall, for the tests in NORMAL CONDITION, be placed in a corner, in any orientation, while still allowing for any connected cables to bend freely. On equipment sides without external connections the equipment shall be as close to the corner walls as practicable.

Equipment which can be oriented in more than one position, shall be assessed in every position. If an examination of the equipment shows that the worst-case conditions can be found in one position, a single test is sufficient in that case.

4.3.2.3 Accessories

Accessories and OPERATOR-interchangeable parts available from, or recommended by, the manufacturer for use with the equipment under test shall be either connected or not connected.

4.3.2.4 Covers and removable parts

Covers or parts which can be removed without using a TOOL shall be removed or not removed.

4.3.2.5 Electrical supply source

The following requirements apply.

- a) The supply voltage shall be between 90 % and 110 % of any RATED supply voltage for which the equipment can be set or, if the equipment is RATED for a greater fluctuation, at any supply voltage within the fluctuation range.
- b) The frequency shall be any RATED frequency.
- c) Equipment for both a.c. and d.c. shall be connected to an a.c. or d.c. supply.
- d) Equipment for single-phase a.c. supply shall be connected both with normal and reverse polarity.
- e) If the means of connection permits reversal, battery-operated and d.c. equipment shall be connected with both reverse and normal polarity.
- f) Equipment powered by other external means (for example: USB, 4-20 mA loop, PoE, wireless power transfer, etc.) shall be operated at RATED voltage or according to the specifications of the specific interface.
- g) batteries shall be at whichever state of charge that represents the least favourable condition.

4.3.2.6 Input and output voltages

Input and output voltages, including floating voltages but excluding the electrical supply source voltage (see 4.3.2.5), shall be set to any voltage within the RATED voltage range.

4.3.2.7 Earth terminals

PROTECTIVE CONDUCTOR TERMINALS, if any, shall be connected to earth.

FUNCTIONAL EARTH TERMINALS shall be connected or not connected to earth.

4.3.2.8 Controls

Controls which an OPERATOR can adjust without the use of a TOOL shall be set to any position except that:

- a) MAINS selection devices shall be set to the correct value;
- b) combinations of settings shall not be made if they are prohibited by the manufacturer's marking on the equipment.

4.3.2.9 Connections

The equipment shall be connected for NORMAL USE, or not connected.

4.3.2.10 Load on motors

Load conditions of motor-driven parts of equipment shall be in accordance with the NORMAL USE.

4.3.2.11 Output

For equipment giving an electrical output:

- a) the equipment shall be operated in such a way as to provide the RATED output power to the RATED load;
- b) the RATED load impedance of any output shall be connected or not connected.

4.3.2.12 Duty cycle

Equipment for short-term or intermittent operation shall be operated for the longest RATED period and shall have the shortest RATED recovery period consistent with the manufacturer's instructions.

Equipment for short-term or intermittent operation that develops significant heat during the startup phase, and that relies on continued operation to dissipate that heat, shall also be operated for the shortest RATED period followed by the shortest RATED recovery period.

4.3.2.13 Loading and filling

Equipment intended to be loaded with a specific material in NORMAL USE shall be loaded with the least favourable quantity of the materials specified in the instructions for use, including not loaded (empty) if the instructions for use permit this in NORMAL USE.

NOTE If the specified material could cause a HAZARD during test, another material may be used provided that it can be shown that the result of the test is not affected.

4.3.2.14 External Services

External services such as air, coolant, etc. shall be supplied at the least favourable temperature, pressure, flow rate etc. allowed by the equipment instructions.

4.4 Testing in single fault condition**4.4.1 General**

The following requirements apply.

- a) The equipment design, specifications, and operating instructions shall be examined to identify the fault conditions which are liable to result in HAZARDOUS SITUATIONS and which, therefore, shall be applied.
- b) Fault tests shall be made as specified for checking conformity, unless it can be demonstrated that no HAZARD could arise from a particular fault condition.
- c) The equipment shall be operated under the least favourable combination of reference test conditions (see 4.3). These combinations may be different for different faults and they shall be recorded for each test. If the environmental limits of the reference test conditions (see 4.3) do not allow realistic assessment of SINGLE FAULT CONDITIONS, the test shall be conducted at the least favourable RATED environmental conditions of the equipment.
- d) Software used in a protective function shall not be considered to provide protection during fault condition testing unless the software complies with requirements of 14.1 and 14.10. An error in a single software providing a protective function shall be considered together with the single faults identified in 4.4.1 a).

NOTE - Reliability can typically be increased by redundancy, diversity, or fail-safe states

4.4.2 Application of fault conditions**4.4.2.1 General**

Fault conditions shall include:

- 1) Any fault conditions determined as applicable through the examination of the equipment as required in clause 4.4.1.
- 2) Applicable fault conditions specified in 4.4.2.2 to 4.4.2.15.
- 3) Any fault condition specified in clauses 6 to 16 dealing with the protection against each hazard.

1076 The fault conditions shall be applied only one at a time and shall be applied in turn in any
1077 convenient order. Multiple simultaneous faults shall not be applied unless they are a
1078 consequence of an applied fault.

1079 NOTE For example, fans may be stopped one fan at a time unless they share a common power or control source.
1080 In that case, the common fans should be stopped simultaneously by interrupting the power or control source.

1081 After each application of a fault condition, the equipment or part shall pass the applicable tests
1082 of 4.4.4.

1083 **4.4.2.2 Protective impedance**

1084 The following requirements apply.

1085 a) If a PROTECTIVE IMPEDANCE is formed by a combination of components, each component
1086 shall be short-circuited or disconnected, whichever is less favourable.

1087 b) If a PROTECTIVE IMPEDANCE is formed with a single component that meets the requirements
1088 of 6.5.4, it need not be short-circuited or disconnected.

1089 **4.4.2.3 Protective conductor**

1090 The protective conductor shall be interrupted, except for PERMANENTLY CONNECTED EQUIPMENT
1091 and equipment utilizing a connector meeting the requirements of IEC 60309.

1092 **4.4.2.4 Equipment or parts for short-term or intermittent operation**

1093 These shall be operated continuously if continuous operation could occur in a SINGLE FAULT
1094 CONDITION. Individual parts may include motors, relays, other electromagnetic devices and
1095 heaters.

1096 **4.4.2.5 Motors**

1097 Motors shall be stopped while fully energized or prevented from starting, whichever is less
1098 favourable.

1099 One supply phase of any multi-phase motor shall be interrupted while the motor is operating at
1100 its intended full load.

1101 **4.4.2.6 Capacitors**

1102 Capacitors (except for self-healing capacitors) in the auxiliary winding circuits of motors shall
1103 be short-circuited.

1104 **4.4.2.7 Transformers relied upon for safety**

1105 **4.4.2.7.1 General**

1106 The [output](#) windings of transformers shall be short-circuited as specified in 4.4.2.7.2, and
1107 overloaded as specified in 4.4.2.7.3.

1108 A transformer damaged during one test may be repaired or replaced before the next test.

1109 Tests for transformers tested as separate components are specified in 14.6.

1110 [Switch mode transformers and other pulse driven transformers shall be tested in the circuitry,](#)
1111 [by short-circuiting an applicable component or connecting a load in parallel with the component.](#)

1112 **4.4.2.7.2 Short circuit**

1113 Each untapped output winding, and each section of a tapped output winding, which is loaded in
1114 NORMAL USE, shall be tested in turn, one at a time, to simulate short circuits in the load.
1115 Overcurrent protection devices remain fitted during the test. All other windings are loaded or
1116 not loaded, whichever load condition of NORMAL USE is less favourable.

1117 NOTE – The least favourable load conditions for other windings may vary for each test depending on the winding
1118 subjected to short circuit conditions.

1119 **4.4.2.7.3 Overload**

1120 Each untapped output winding, and each section of a tapped output winding, is overloaded in
1121 turn one at a time. [During each test any other windings shall be loaded or not loaded, to achieve](#)

1122 the highest current through primary or secondary overcurrent protection without them activating,
1123 whichever load condition of NORMAL USE is less favourable.

1124 NOTE – This test is to achieve the highest winding temperature of the transformer without exceeding the 1 hour
1125 characteristic of any overcurrent protection.

1126 If any overloads arise from testing in the fault conditions of 4.4, secondary windings shall be
1127 subjected to those overloads.

1128 Overloading is carried out by connecting a variable resistor across the winding or, in the case
1129 of a switch mode transformer after the output rectifier. The resistor is adjusted as quickly as
1130 possible and readjusted, if necessary, after 1 min to maintain the applicable overload. No
1131 further readjustments are then permitted.

1132 If overcurrent protection is provided by a current-breaking device, the overload test current is
1133 the maximum current which the overcurrent protection device is just capable of passing for 1 h.
1134 Before the test, the device is replaced by a link with negligible impedance. If this value cannot
1135 be derived from the specification, it is to be established by test.

1136 For equipment in which the output voltage is designed to collapse when a specified overload
1137 current is reached, the overload is slowly increased to a point just before the point which causes
1138 the output voltage to collapse.

1139 In all other cases, the loading is the maximum current obtainable from the secondary winding
1140 under test, with any other windings loaded or not loaded, whichever represents the least
1141 favourable condition.

1142 Transformers with overtemperature protection which meets the requirements of 14.3 during the
1143 short-circuit test of 4.4.2.7.2 need not be subjected to overload tests.

1144 4.4.2.8 Outputs

1145 Outputs shall be short-circuited and overloaded one at a time (see 4.4.2.7.3 for description of
1146 overload conditions).

1147 4.4.2.9 Equipment for more than one supply

1148 Equipment which is designed to be operated from more than one type of supply shall be
1149 simultaneously connected to these supplies, unless this is prevented by the construction.

1150 4.4.2.10 Cooling

1151 Equipment cooling shall be restricted as follows, one fault at a time:

- 1152 a) air-holes with filters shall be closed;
- 1153 b) forced cooling by motor-driven fans shall be stopped;
- 1154 c) cooling by circulation of water or other coolant shall be stopped;
- 1155 d) loss of cooling liquid shall be simulated.

1156 4.4.2.11 Heating devices

1157 In equipment incorporating heating devices, the following faults shall be applied one at a time:

- 1158 a) timers which limit the heating period shall be overridden to energize the heating circuit
1159 continuously;
- 1160 b) temperature controllers, except for overtemperature protection devices meeting the
1161 requirements of 14.3, shall be overridden to energize the heating circuit continuously.

1162 4.4.2.12 Insulation between circuits and parts

1163 Insulation between circuits and parts which is below the level specified for BASIC INSULATION
1164 shall be bridged to check against the spread of fire if the method of 9.1 a) is used.

1165 4.4.2.13 Interlocks

1166 Each part of an interlock system for the protection of the OPERATOR shall be short-circuited or
1167 open-circuited in turn if the system prevents access to HAZARDS when a cover, etc. is removed
1168 without the use of a TOOL.

4.4.2.14 Voltage selectors

Voltage selectors which an OPERATOR can set for different RATED supply voltages shall be set for each possible setting with the equipment connected to each of its RATED supply circuits.

4.4.2.15 Interruption of external electrical supply and other energy sources

Each of the required electrical supply or other energy supply sources shall be removed and restored. Consideration shall be given for equipment with automatic restart function such that it shall resume in a safe state.

4.4.3 Duration of tests

4.4.3.1 General

The equipment shall be operated until further change as a result of the applied fault is unlikely. If there is an indication that a HAZARD of electric shock, spread of fire or injury to persons may eventually occur, the test shall be continued until the HAZARD occurs or until it becomes clear that a HAZARD will not occur.

4.4.3.2 Current limiting devices

If a device which interrupts or limits the current during operation is included to limit the temperature of parts which can easily be touched, the maximum temperature attained by those parts shall be measured, whether the device operates or not.

4.4.3.3 Fuses

If a fault is terminated by the opening of a fuse and if the fuse does not operate within approximately 1 s, the current through the fuse under the relevant fault condition shall be measured. The pre-arcing time/current characteristics of the fuse shall be evaluated to find out whether the minimum operating current is reached and what is the maximum time before the fuse operates. The current through the fuse may vary as a function of time.

If the minimum operating current of the fuse is not reached in the test, the equipment shall be operated for a period corresponding to the maximum fusing time or continuously for the duration specified in 4.4.3.1, with the fuse replaced with a short-circuit.

4.4.4 Conformity after application of fault conditions

4.4.4.1 General

Conformity with requirements for protection against electric shock after the application of single faults is checked as follows:

- a) by making the measurements of 6.3.2 to check that no ACCESSIBLE conductive parts have become HAZARDOUS LIVE;*
- b) by performing a voltage test on DOUBLE INSULATION or REINFORCED INSULATION to check that the protection is still at least at the level of BASIC INSULATION. The voltage tests are made as specified in 6.7 and 6.8 (without humidity preconditioning) with the test voltage for BASIC INSULATION;*
- c) by measuring the temperature of transformer windings if the protection against electrical HAZARDS is achieved by DOUBLE INSULATION or REINFORCED INSULATION within the transformer. The temperatures of Table 20 shall not be exceeded.*

4.4.4.2 Touch temperature

Conformity with requirements for temperature protection is checked by determining the temperature of the outer surface of the ENCLOSURE and of parts which can easily be touched (See Clause 10).

4.4.4.3 Spread of fire

Conformity with requirements for protection against the spread of fire is checked by placing the equipment on white tissue-paper covering a softwood surface and covering the equipment with cheesecloth. No molten metal, burning insulation, flaming particles, etc. shall fall on the surface on which the equipment stands and there shall be no charring, glowing, or flaming of the tissue paper or cheesecloth. Melting of insulation material shall be ignored if no HAZARD could arise.

4.4.4.4 Other hazards

Conformity with other requirements for protection against HAZARDS is checked as specified in Clauses 7 to 16.

5 Marking and documentation**5.1 Marking****5.1.1 General**

Equipment shall bear markings as specified in 5.1.2 to 5.2. Except for marking of internal parts, these markings shall be visible from the exterior, or be visible after removing a cover or opening a door without the aid of a TOOL, if the cover or door is intended to be removed or opened by an OPERATOR. Markings applying to the equipment as a whole shall not be put on parts which can be removed by an OPERATOR without the use of a TOOL.

For rack- or panel-mounted equipment, markings are permitted to be on a surface that becomes visible after removal of the equipment from the rack or panel.

Letter symbols for quantities and units shall be as specified in IEC 60027. Graphic symbols shall be in accordance with Table 1 if applicable. There are no colour requirements for symbols. Graphic symbols shall be explained in the documentation.

NOTE 1 IEC or ISO symbols should be used if available.

NOTE 2 Markings should not be on the bottom of the equipment, except on HAND-HELD EQUIPMENT or where space is limited.

Conformity is checked by inspection.

5.1.2 Identification

The equipment shall, as a minimum, be marked with:

- a) the name or trade mark of the manufacturer or supplier;
- b) a model number, name or other means to identify the equipment. If equipment bearing the same distinctive designation (model number) is manufactured at more than one location, equipment from each manufacturing location shall be marked so that the location can be identified.

NOTE The marking of factory location may be in code and need not be on the equipment exterior.

Conformity is checked by inspection.

5.1.3 External electrical supply sources

The equipment shall be marked with the following information, [except where electrical power is only supplied from specific equipment through either a dedicated connector or specified through marking. Where space is limited, Symbols 1 or 2 of Table 1 or DC or AC shall be marked as close as possible to the supply terminal with information as required in 5.1.3 a\) to e\) included in the equipment documentation.](#)

- a) Nature of supply:

- 1) a.c.: RATED MAINS frequency or range of frequencies;
- 2) d.c.: symbol 1 of Table 1 or DC.

NOTE 1 For information purposes it may be useful to mark

- equipment intended for a.c. with symbol 2 of Table 1;
- equipment suitable for both a.c. and d.c. with symbol 3 of Table 1;
- equipment for three-phase supply with symbol 4 of Table 1.

- b) The RATED supply voltage(s) or the RATED range of supply voltages.

NOTE 2 RATED voltage fluctuations may also be marked.

- c) The maximum RATED power in watts (active power) or volt-amperes (apparent power), or the maximum RATED input current, with all accessories or plug-in modules connected. If the equipment can be used on more than one voltage range, separate values shall be marked for each voltage range unless the maximum and minimum values do not differ by more than

1266 20 % of the mean value. The measured value shall not exceed the marked value by more
1267 than 10 %.

1268 d) Equipment which can be manually set for different RATED supply voltages shall be provided
1269 with means for the indication of the voltage for which the equipment is set. Except for
1270 PERMANENTLY CONNECTED EQUIPMENT the indication shall be visible from the exterior. If the
1271 equipment is so constructed that the supply voltage setting can be altered without the use
1272 of a TOOL, the action of changing the setting shall also change the indication.

1273 e) Accessory MAINS socket-outlets accepting standard MAINS plugs shall be marked with the
1274 voltage if it is different from the MAINS supply voltage. If the outlet is for use only with specific
1275 equipment, it shall be marked to identify the equipment for which it is intended. If not, the
1276 maximum RATED current or power shall be marked, or symbol 14 of Table 1 placed beside
1277 the outlet with the full details included in the documentation.

1278 *Conformity is checked by inspection and by measurement of power or input current to check*
1279 *the requirements of 5.1.3 c) have been met. The measurement is made at each RATED voltage*
1280 *range with the equipment in the condition of maximum power or current consumption as*
1281 *applicable with all accessories or plug-in modules connected. If the input current varies during*
1282 *the normal operating cycle, the steady-state current is taken as the mean indication of the*
1283 *highest measured r.m.s. value during a 10 s period of the normal operation cycle. To exclude*
1284 *any initial inrush current the measurement is not made until the current has stabilized (usually*
1285 *after 1 min). Transients are ignored.*

1286

Table 1 – Symbols

Number	Symbol	Reference	Description
1		IEC 60417-5031 (2002-10)	Direct current
2		IEC 60417-5032 (2002-10)	Alternating current
3		IEC 60417-5033 (2002-10)	Both direct and alternating current
4		IEC 60417-5032-1 (2002-10)	Three-phase alternating current
5		IEC 60417-5017 (2006-08)	Earth (ground) TERMINAL
6		IEC 60417-5019 (2006-08)	PROTECTIVE CONDUCTOR TERMINAL
7		IEC 60417-5020 (2002-10)	Frame or chassis TERMINAL
8			Not used
9		IEC 60417-5007 (2009-02)	On (Power)
10		IEC 60417-5008 (2009-02)	Off (Power)
11		IEC 60417-5172 (2003-02)	Equipment protected throughout by DOUBLE INSULATION or REINFORCED INSULATION
12		IEC 60417-6042 (2010-11)	Caution, possibility of electric shock
13		IEC 60417-5041 (2002-10)	Caution, hot surface
14		ISO 7000-0434B (2004-01)	Caution ^a
15		IEC 60417-5268 (2002-10)	In position of a bi-stable push control
16		IEC 60417-5269 (2002-10)	Out position of a bi-stable push control
17		ISO 361	Ionizing radiation
18		ISO 7010 – W010 (modified)	Caution, risk of frostbite
19		ISO 7010 W021	Flammable material
20			Mass of equipment

^a See 5.4.1 which requires manufacturers to state that documentation must be consulted in all cases where this symbol is marked.

5.1.4 Fuses

For any fuse which may be replaced by an OPERATOR, there shall be a marking beside the fuse-holder, which will enable the OPERATOR to identify the correct replacement fuse (see 5.4.5).

Conformity is checked by inspection.

5.1.5 TERMINALS, connections and operating devices

5.1.5.1 General

If necessary for safety, an indication shall be given of the purpose of TERMINALS, connectors, controls, and indicators, including any connections for fluids such as gas, water and drainage. Where there is insufficient space, symbol 14 of Table 1 may be used.

NOTE 1 For additional information, see IEC 60445 and IEC 60447.

NOTE 2 Individual pins of multi-pin connectors need not be marked.

Push-buttons and actuators of emergency stop devices, and indicators used only to indicate a warning of danger or the need for urgent action, shall be coloured red and coded as specified in IEC 60073. If the meaning of colour relates to the safety of persons or the environment, supplementary means of coding shall be provided (see IEC 60073).

NOTE 3 National authorities may require that equipment used in certain environments meet the man-machine interface requirements pertinent to that environment.

Conformity is checked by inspection.

5.1.5.2 Terminals

TERMINALS for connection to the MAINS supply shall be identifiable.

The following TERMINALS shall be marked as follows:

- a) FUNCTIONAL EARTH TERMINALS with symbol 5 of Table 1;
- b) PROTECTIVE CONDUCTOR TERMINALS with symbol 6 of Table 1, except when the PROTECTIVE CONDUCTOR TERMINAL is part of an approved MAINS appliance inlet. The symbol shall be placed on the TERMINAL or close to it;
- c) TERMINALS of circuits which are permitted by 6.6.3 to be connected to ACCESSIBLE conductive parts, with symbol 7 of Table 1 unless connection is self-evident;
NOTE This symbol may also be considered as a warning symbol in that it indicates that a HAZARDOUS LIVE voltage must not be connected to the TERMINAL. The symbol should also be used if it is likely that an OPERATOR could make such a connection inadvertently.
- d) TERMINALS supplied from the interior of the equipment and which are HAZARDOUS LIVE, with the voltage, current, charge or energy value or range, or with symbol 12 (preferred) or symbol 14 of Table 1. This requirement does not apply to MAINS supply outlets where a standard MAINS socket outlet is used.

Conformity is checked by inspection.

5.1.6 Switches and circuit-breakers

If the power supply switch or circuit-breaker is used as the disconnecting device, it shall be marked as specified in 6.11.4.2.

If a push-button switch is used as the power supply switch, symbols 9 and 15 of Table 1 may be used to indicate the on-position, or symbols 10 and 16 to indicate the off-position, with the pair of symbols (9 and 15, or 10 and 16) close together.

Conformity is checked by inspection.

5.1.7 Equipment protected by double insulation or reinforced insulation

Equipment which is only partially protected by DOUBLE INSULATION or REINFORCED INSULATION shall not be marked with symbol 11 of Table 1.

NOTE Equipment protected throughout by DOUBLE INSULATION or REINFORCED INSULATION may be marked with symbol 11 of Table 1.

Conformity is checked by inspection.

5.1.8 Field-wiring TERMINAL boxes

If the temperature of the TERMINALS or the ENCLOSURE of a field-wiring TERMINAL box or compartment exceeds 60 °C in NORMAL CONDITION at an ambient temperature of 40 °C, or at the maximum RATED ambient temperature if higher, there shall be a marking to warn the installer.

1339 consult the installation instructions before determining the temperature RATING of the cable to
1340 be connected to the TERMINALS. The marking shall be visible before and during connection, or
1341 be beside the TERMINALS. Symbol 14 is an acceptable marking.

1342 *Conformity, in case of doubt, is checked by measurement as specified in 10.3 a) and, if*
1343 *applicable, by inspection of markings.*

1344 **5.1.9 Other marking requirements**

1345 The equipment shall have the following markings as applicable:

1346 a) Protection against ingress of solid foreign objects and water as specified in 11.6.1;

1347 b) Markings as specified for lifting and carrying of equipment in 7.5.1

1348 *Conformity is checked by inspection.*

1349 **5.2 Warning markings**

1350 Warning markings specified in this standard shall meet the following requirements.

1351 Warning markings shall be visible and legible when the equipment is ready for NORMAL USE. If
1352 a warning applies to a particular part of the equipment, the marking shall be placed on or near
1353 that part.

1354 The size of warning markings shall be as follows:

1355 a) symbols shall be at least 2,75 mm high. Text shall be at least 1,5 mm high and contrast in
1356 colour with the background;

1357 b) symbols or text moulded, stamped or engraved in a material shall be at least 2,0 mm high.
1358 If not contrasting in colour, they shall have a depth or raised height of at least 0,5 mm.

1359 If it is necessary for the RESPONSIBLE BODY or OPERATOR to refer to the documentation to
1360 preserve the protection afforded by the equipment, the equipment shall be marked with symbol
1361 14 of Table 1. Symbol 14 is not required to be used if other symbols which address the safety
1362 aspects are used and explained in the documentation.

1363 If the instructions for use state that an OPERATOR is permitted to gain access, using a TOOL, to
1364 a part or location which in NORMAL USE may present a HAZARD, there shall be a warning marking
1365 indicating that the equipment must be placed in safe state before access. Symbol 14 shall be
1366 used for this purpose with the warning text included in the documentation. Additional symbols
1367 may be marked to indicate the nature of the HAZARD such as symbol 12, 13, or 17 as appropriate.

1368 Symbols are the preferred marking method over text warnings. Supplemental text may be
1369 provided adjacent to the symbol.

1370 *Conformity is checked by inspection.*

1371 **5.3 Durability of markings**

1372 Required markings shall remain clear and legible under conditions of NORMAL USE and shall
1373 resist the effects of the cleaning agents specified by the manufacturer.

1374 *Conformity is checked by performing the following test for durability of markings on the outside*
1375 *of the equipment. The markings are rubbed by hand, without undue pressure, for 30 s with a*
1376 *cloth soaked with each specified cleaning agent (or, if not specified, with 70 % isopropyl*
1377 *alcohol).*

1378 *After the above treatment the markings shall be clearly legible and adhesive labels shall not*
1379 *have worked loose or become curled at the edges.*

1380 **5.4 Documentation**

1381 **5.4.1 General**

1382 The following information necessary for safety purposes, as needed by the OPERATOR or the
1383 RESPONSIBLE BODY, shall be contained in the documentation provided with the equipment. Safety
1384 documentation for service personnel authorized by the manufacturer shall be made available
1385 to such personnel:

- a) intended use of the equipment;
- b) technical specification;
- c) name and address of the manufacturer or supplier from whom technical assistance may be obtained;
- d) the information specified in 5.4.2 to 5.4.6;
- e) information about the residual RISKS and how to mitigate residual RISKS (see Clause 17);
- f) for equipment which for safety reasons requires specific accessories (for example probe assemblies) with specific characteristics, the documentation shall indicate that only accessories which meet the manufacturer's specifications shall be used;
- g) if a HAZARD could be caused by an incorrect reading when measuring, indicating or detecting harmful or corrosive substances, or HAZARDOUS LIVE electrical quantities, the instructions shall provide guidance on how to determine that the equipment is functioning correctly;
- h) instructions for lifting and carrying (see 7.5.1).
- i) instructions for transport, handling and storage.
- j) instructions related to IP rating (see 11.6)

Warning symbols and warning statements that are marked on the equipment shall be explained in the documentation. In particular, the documentation shall include a statement that it must be consulted in all cases where symbol 14 of Table 1 is marked, in order to find out the nature of the potential HAZARDS and any actions which have to be taken to avoid them.

NOTE 1 Markings and text on equipment are considered equivalent to the documentation.

NOTE 2 If NORMAL USE involves the handling of harmful or corrosive substances, instruction should be given on correct use and safety provisions. If any harmful or corrosive substance is specified or supplied by the equipment manufacturer, the necessary information on its constituents and the correct disposal procedure should also be given.

Documentation may be provided on printed or electronic media, however printed information is required for all information necessary for safety that might not be available in electronic form at the time it is needed. The documentation shall be delivered with the equipment. Consideration shall be given to the ability of the RESPONSIBLE BODY to read the media.

Conformity is checked by inspection.

5.4.2 Equipment RATINGS

Documentation shall include the following:

- a) the supply voltage or voltage range, frequency or frequency range, and power or current RATING;
- b) a description of all input and output connections as required by 6.6.1 a);
- c) the RATING of the insulation of external circuits as required by 6.6.1 b);
- d) a statement of the range of environmental conditions for which the equipment is designed including:
 - 1) indoor or outdoor use
 - 2) altitude
 - 3) temperature
 - 4) relative humidity
 - 5) MAINS supply voltage fluctuations
 - 6) OVERVOLTAGE CATEGORY, except for cord/plug-connected equipment
 - 7) WET LOCATION, if applicable
 - 8) POLLUTION DEGREE of the intended environment,
- e) for equipment RATED for ingress protection according to IEC 60529 the information required in 11.6.1;
- f) for equipment with an impact RATING less than 5 J, the information specified in 8.1 d)

Conformity is checked by inspection.

5.4.3 Equipment installation

The documentation shall include installation and specific commissioning instructions and, if necessary for safety, warnings against HAZARDS which could arise during installation or commissioning or as a result of improper installation or commissioning of the equipment. Such information includes, if applicable:

- a) instructions for protective earthing;
- b) connections to the supply;
- c) for PERMANENTLY CONNECTED EQUIPMENT:
 - 1) supply wiring requirements;
 - 2) requirements for any external switch or circuit-breaker (see 6.11.3.1) and external overcurrent protection devices (see 9.6.2) and a recommendation that the switch or circuit-breaker be near the equipment;
- d) the required field wiring temperature RATING (see 5.1.8)
- e) ventilation requirements;
- f) requirements and safety characteristics for special external services, for example: maximum and minimum pressure, flow rate, temperature etc. allowed by the equipment instructions or cooling liquid;
- g) instructions relating to sound level (see 12.5.1).
- h) instructions related to verification of equipment connection to potentially hazardous substances (see 13.1).

NOTE It is recommended to add a statement in the documentation for the installation that the safety of any system incorporating the equipment is the responsibility of the assembler of the system.

Conformity is checked by inspection.

5.4.4 Equipment operation

Instructions for use shall include, if applicable:

- a) identification and description of operating controls and their use in all operating modes;
- b) instructions not to position the equipment so that it is difficult to operate the disconnecting device;
- c) instructions for interconnection to accessories and other equipment, including indication of suitable accessories, detachable parts and any special materials;
- d) specifications of limits for intermittent operation;
- e) explanations of symbols related to safety which are used on the equipment;
- f) instructions for replacement of consumable materials;
- g) instructions for cleaning and decontamination;
- h) a statement listing potentially poisonous or injurious substances that can be liberated from the equipment, and possible quantities;
- i) detailed instructions about RISK reduction procedures relating to flammable liquids (see 9.5 c));
- j) details of methods of reducing the RISKS of burns from surfaces permitted to exceed the temperature limits of 10.1.
- k) additional precautions necessary related to HAZARDS associated with moisture or liquids when accessories or sub-assemblies compliant with other product safety standards are used with equipment within the scope of this standard.

There shall be a statement in the instructions that, if the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

Conformity is checked by inspection.

5.4.5 Equipment maintenance and service

Instructions shall be provided to the RESPONSIBLE BODY in sufficient detail to permit safe maintenance, inspection and testing of the equipment, and to ensure continued safety of the equipment after the maintenance, inspection and test procedure.

If applicable, manufacturer's documentation shall instruct against replacing detachable MAINS supply cords by inadequately RATED cords.

For equipment using replaceable batteries, the specific battery type shall be stated.

The manufacturer shall specify any parts which are required to be examined or supplied only by the manufacturer or his agent.

The RATING and characteristics of replaceable fuses shall be stated.

Instructions on the following subjects shall be provided for service personnel, as necessary to permit safe servicing and continued safety of the equipment after servicing if the equipment is suitable to be serviced:

a) product-specific RISKS that may affect the service personnel;

b) protective measures for these RISKS;

c) verification of the safe state of the equipment after repair.

d) a list of specifications of all the special equipment, TOOLS and accessories essential to enable it to be safely adjusted and maintained.

e) guidance on verification of connections to hazardous substances (see 13.1)

Instructions for service personnel need not be supplied to the RESPONSIBLE BODY, but shall be made available to service personnel.

Conformity is checked by inspection.

5.4.6 Integration into systems or effects resulting from special conditions

Aspects resulting from integration into systems or effects resulting from special ambient or application conditions shall be described in the documentation.

Conformity is checked by inspection of the documentation.

6 Protection against electric shock

6.1 General

6.1.1 Requirements

Protection against electric shock shall be maintained in NORMAL CONDITION and SINGLE FAULT CONDITION (see 6.4 and 6.5). ACCESSIBLE parts (see 6.2) shall not be HAZARDOUS LIVE (see 6.3). Voltage, current, charge or energy between an ACCESSIBLE part and earth, or between any two ACCESSIBLE parts on the same piece of equipment within a distance of 1,8 m (over a surface or through air), shall not exceed the levels of 6.3.1 in NORMAL CONDITION nor of 6.3.2 in SINGLE FAULT CONDITION.

Conformity is checked by the determination of ACCESSIBLE parts as specified in 6.2 and by the measurements of 6.3 to establish that the levels of 6.3.1 and 6.3.2 are not exceeded, and as specified in 6.4 to 6.11.

6.1.2 Exceptions

If it is not feasible for operating reasons to prevent the following parts being both ACCESSIBLE and HAZARDOUS LIVE, they are permitted to be ACCESSIBLE to an OPERATOR during NORMAL USE while they are HAZARDOUS LIVE:

a) parts of lamps and lamp sockets after lamp removal;

b) parts intended to be replaced by an OPERATOR (for example, batteries) and which may be HAZARDOUS LIVE during the replacement or other OPERATOR action, but only if they are ACCESSIBLE only by means of a TOOL and have a warning marking (see 5.2);

1527 If any of the parts in a) and b) receives a charge from an internal capacitor, they shall not be
 1528 HAZARDOUS LIVE 10 s after interruption of the supply.

1529 *If a charge is received from an internal capacitor, conformity is checked by the measurements*
 1530 *of 6.3 to establish that the levels of 6.3.1 c) are not exceeded.*

1531 6.2 Determination of ACCESSIBLE parts

1532 6.2.1 General

1533 *Unless obvious, determination of whether a part is ACCESSIBLE is made as specified in 6.2.2*
 1534 *to 6.2.4 in all positions of NORMAL USE. Test fingers (see Annex B) and pins are applied without*
 1535 *force unless a force is specified. Parts are considered to be ACCESSIBLE if they can be touched*
 1536 *with any part of a test finger or test pin, or if they could be touched in the absence of a covering*
 1537 *which is not considered to provide suitable insulation (see 6.9.2).*

1538 *ACCESSIBLE parts do not include those that become ACCESSIBLE when equipment having a mass*
 1539 *exceeding 40 kg is tilted. If, in NORMAL USE, an OPERATOR is intended to perform any actions*
 1540 *(with or without a TOOL) that could increase the accessibility of parts, such actions are taken*
 1541 *before performing the examinations of 6.2.2 to 6.2.4.*

1542 NOTE Examples of such actions include:

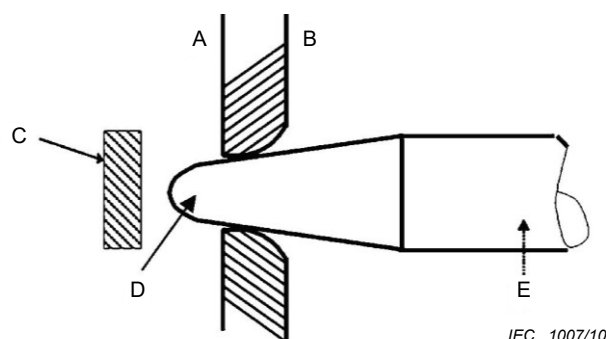
- 1543 a) removing covers;
- 1544 b) opening doors;
- 1545 c) adjusting controls;
- 1546 d) replacing consumable material;
- 1547 e) removing parts.

1548 *Rack-mounted and panel-mounted equipment is installed as specified in the manufacturer's*
 1549 *instructions before making the examinations of 6.2.2 to 6.2.4. For such equipment, the*
 1550 *OPERATOR is assumed to be in front of the panel.*

1551 6.2.2 Examination

1552 *The jointed test finger (see Figure B.2) is applied in every possible position. If a part could*
 1553 *become ACCESSIBLE by applying a force, the rigid test finger (see Figure B.1) is applied with a*
 1554 *force of 10 N. The force is exerted by the tip of the test finger so as to avoid wedge and lever*
 1555 *action. The test is applied to all outer surfaces, including the bottom. However, on equipment*
 1556 *accepting plug-in modules the tip of the jointed test finger is inserted only to a depth of 180 mm*
 1557 *from the opening in the equipment.*

1558 *The test finger is likewise applied to all openings in the ENCLOSURE, including holes and*
 1559 *TERMINALS. In these cases, the ACCESSIBLE parts of the ENCLOSURE are considered to include*
 1560 *any part of the test finger which can be inserted into the hole or TERMINAL (see Figure 1).*



1561

1562 Key

- 1563 A inside of equipment
- 1564 B outside of equipment
- 1565 C HAZARDOUS LIVE part
- 1566 D tip of test finger is considered to be ACCESSIBLE
- 1567 E test finger

Figure 1 – Measurements through openings in ENCLOSURES**6.2.3 Openings above parts that are HAZARDOUS LIVE**

A metal test pin 100 mm long and 4 mm in diameter is inserted into any openings above parts which are HAZARDOUS LIVE. The test pin is suspended freely and allowed to penetrate up to 100 mm.

The additional safety measures of 6.5.1 for protection in SINGLE FAULT CONDITION are not required solely because a part is ACCESSIBLE only by this test.

NOTE This exception is permitted because the insertion of an object similar to this test pin is considered to be a SINGLE FAULT CONDITION and one means of protection is sufficient.

This test is not applied to TERMINALS.

6.2.4 Openings for pre-set controls

A metal test pin 3 mm in diameter is inserted through holes intended to give access to pre-set controls which require the use of a screwdriver or other TOOL. The test pin is applied in every possible direction through the hole. Penetration shall not exceed three times the distance from the ENCLOSURE surface to the control shaft or 100 mm, whichever is smaller.

6.3 Limit values for ACCESSIBLE parts**6.3.1 Levels in normal condition**

Voltages above the levels of a) are deemed to be HAZARDOUS LIVE if any of the levels of b) or c) are exceeded.

a) The a.c. voltage levels are 30 V r.m.s., 42,4 V peak and the d.c. voltage level is 60 V. For equipment intended for use in WET LOCATIONS, the a.c. voltage levels are 16 V r.m.s., 22,6 V peak and the d.c. voltage level is 35 V.

b) The current levels are:

1) 0,5 mA r.m.s. for sinusoidal waveforms, 0,7 mA peak for non-sinusoidal waveforms or mixed frequencies, or 2 mA d.c., when measured with the measuring circuit of Figure A.1a up to 1 MHz. If the frequency does not exceed 100 Hz, the measuring circuit of Figure A.2 can be used. The measuring circuit of Figure A.4 is used for equipment intended for use in WET LOCATIONS.

2) 70 mA r.m.s. when measured with the measuring circuit of Figure A.3. This relates to possible burns at higher frequencies (above 30 kHz).

c) The levels of capacitive charge or energy are:

1) 45 µC charge for voltages up to 15 kV peak or d.c.; line A of Figure 3 shows the capacitance versus voltage where the charge is 45 µC.

2) 350 mJ stored energy for voltages above 15 kV peak or d.c.

6.3.2 Levels in single fault condition

Voltages above the levels of a) are deemed to be HAZARDOUS LIVE if any of the levels of b) or c) are exceeded at the same time.

a) The a.c. voltage levels are 50 V r.m.s., 70 V peak and the d.c. voltage level is 120 V. For equipment intended for use in WET LOCATIONS, the a.c. voltage levels are 33 V r.m.s., 46,7 V peak and the d.c. voltage level is 70 V.

b) The current levels are:

1) 5,0 mA r.m.s. for sinusoidal waveforms, 7,07 mA peak for non-sinusoidal waveforms or mixed frequencies, or 25 mA d.c., when measured with the measuring circuit of Figure A.1b up to 1 MHz. If the frequency does not exceed 100 Hz, the measuring circuit of Figure A.2 can be used. The measuring circuit of Figure A.4 is used for equipment intended for use in wet locations;

2) 500 mA r.m.s. when measured with the measuring circuit of Figure A.3. This relates to possible burns at higher frequencies (above 30 kHz). For currents with a duration less than 1 sec. the measuring circuit of Figure A.3 shall be used.

1617 For short-term currents, the maximum duration versus current is defined by Figure 2. For
1618 durations of less than 0,1 ms, the maximum current is 2,5 A peak.

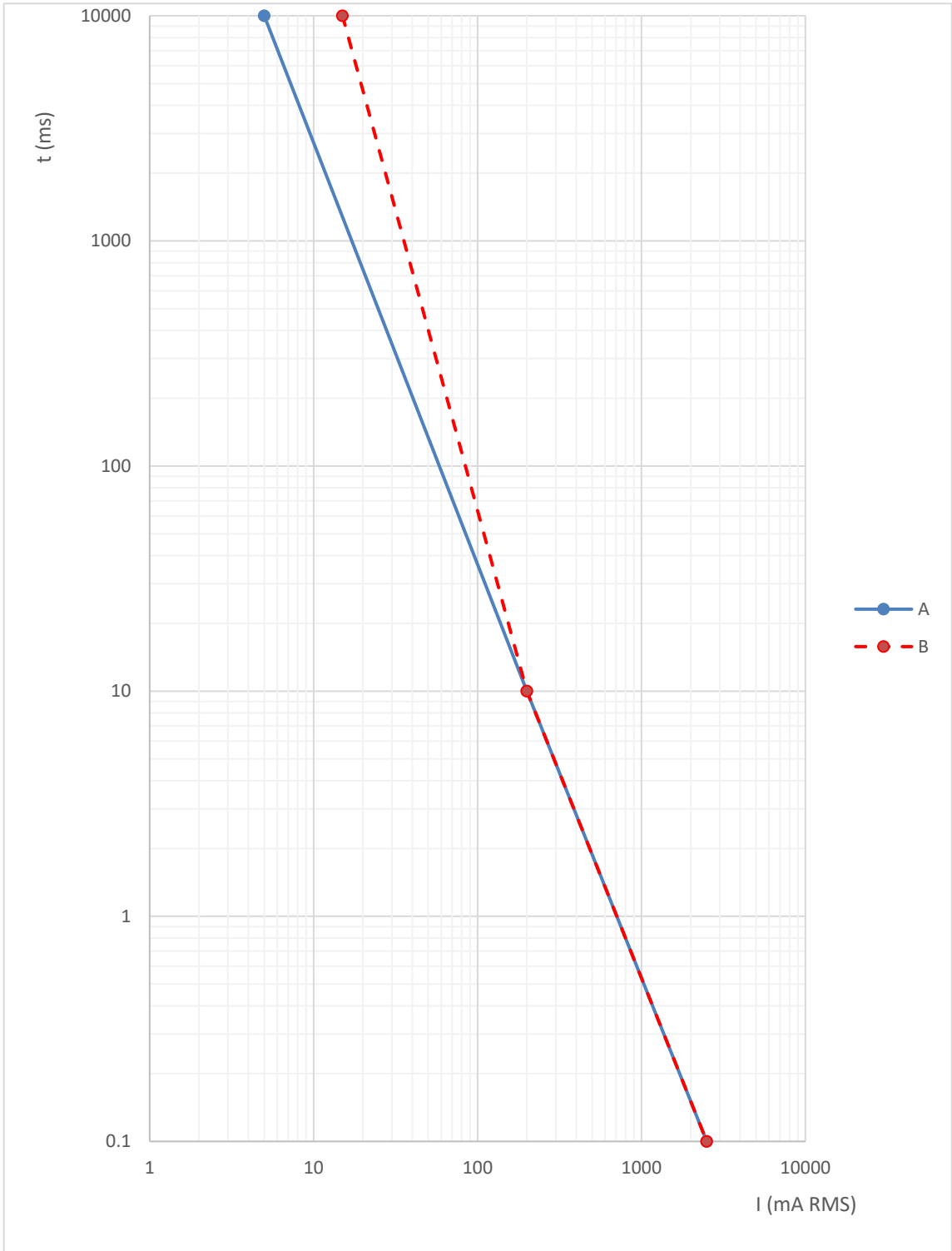
1619 c) The levels of capacitance or energy are:

1620 1) line B of Figure 3 or

1621 2) 1,6 J stored energy for voltages above 40 kV peak or DC.

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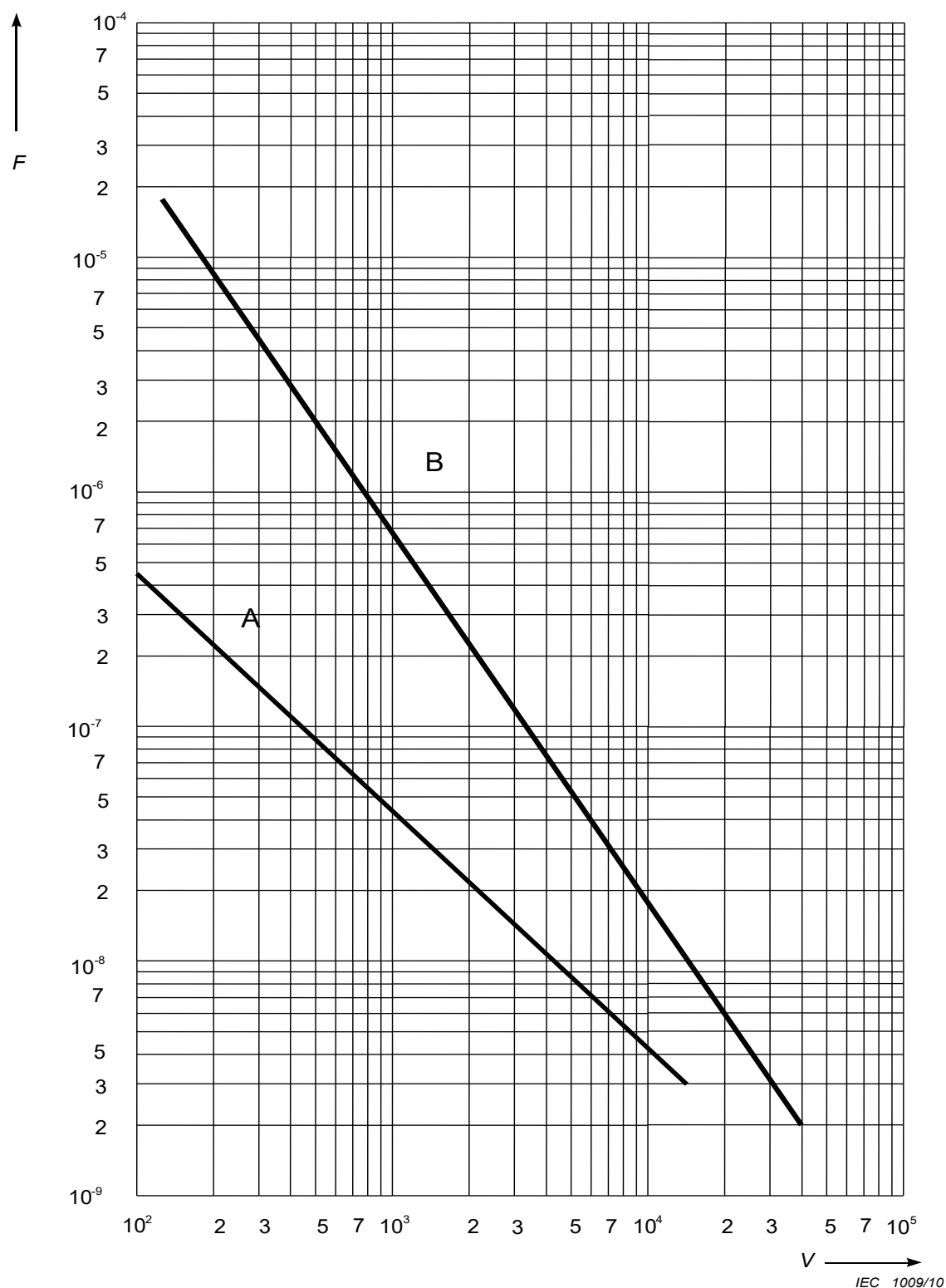
Key

A Current AC RMS

B Current DC

NOTE this figure is based on IEC 60479-1:2018 Figures 20 and 22, and IEC TS 60479-2:2007 Figure 20

**Figure 2 – Maximum duration of short-term current
in SINGLE FAULT CONDITION (see 6.3.2 b))**



1630

1631 **Key**

1632 A NORMAL CONDITION

1633 B SINGLE FAULT CONDITION

1634 **Figure 3 – Capacitance level versus voltage in NORMAL CONDITION and SINGLE FAULT**
 1635 **CONDITION (see 6.3.1 c) and 6.3.2 c))**

1636

6.4 Primary means of protection

6.4.1 General

Access to HAZARDOUS LIVE parts shall be prevented by ENCLOSURES or PROTECTIVE BARRIERS (see 6.4.2) and ACCESSIBLE parts shall be prevented from becoming HAZARDOUS LIVE by one or both of the following means (see Annex D):

a) BASIC INSULATION (see 6.4.3);

b) impedance (see 6.4.4).

Conformity is checked by inspection and as specified in 6.4.2. to 6.4.4.

6.4.2 ENCLOSURES and PROTECTIVE BARRIERS

ENCLOSURES and PROTECTIVE BARRIERS shall meet the rigidity requirements of 8.1.

If ENCLOSURES or PROTECTIVE BARRIERS provide protection by insulation, they shall meet the requirements of BASIC INSULATION.

If ENCLOSURES or PROTECTIVE BARRIERS provide protection by limiting access, CLEARANCES and CREEPAGE DISTANCES between ACCESSIBLE parts and HAZARDOUS LIVE parts shall meet the requirements of 6.7 and the applicable requirements for BASIC INSULATION.

Conformity is checked as specified in 6.7 and 8.1. Rack-mounted and panel-mounted equipment are to be installed as specified in the manufacturer's instructions before checking.

6.4.3 BASIC INSULATION

CLEARANCES, CREEPAGE DISTANCES and solid insulation forming BASIC INSULATION between ACCESSIBLE parts and HAZARDOUS LIVE parts shall meet the requirements of 6.7.

Conformity is checked as specified in 6.7.

6.4.4 Impedance

An impedance used as a primary means of protection shall meet all the following requirements:

a) it shall limit the current or voltage to not more than the applicable level of 6.3.2;

b) it shall be RATED for the maximum WORKING VOLTAGE and for the amount of power that it will dissipate;

c) CLEARANCE and CREEPAGE DISTANCE between terminations of the impedance shall meet the applicable requirements of 6.7 for BASIC INSULATION.

Conformity is checked by inspection, by measuring the voltage or current to confirm that they do not exceed the levels of 6.3.2, and by measuring CLEARANCE and CREEPAGE DISTANCE as specified in 6.7.

6.5 Additional means of protection in case of SINGLE FAULT CONDITIONS

6.5.1 General

ACCESSIBLE parts shall be prevented from becoming HAZARDOUS LIVE in SINGLE FAULT CONDITION. The primary means of protection (see 6.4) shall be supplemented by one of a), b), c) or d). Alternatively one of the single means of protection e) or f) shall be used. See Figure 4 and Annex D.

a) PROTECTIVE BONDING (see 6.5.2);

b) SUPPLEMENTARY INSULATION (see 6.5.3);

c) automatic disconnection of the supply (see 6.5.5);

d) current- or voltage-limiting device (see 6.5.6);

e) REINFORCED INSULATION (see 6.5.3);

f) PROTECTIVE IMPEDANCE (see 6.5.4).

Conformity is checked by inspection and as specified in 6.5.2 to 6.5.6.

1681

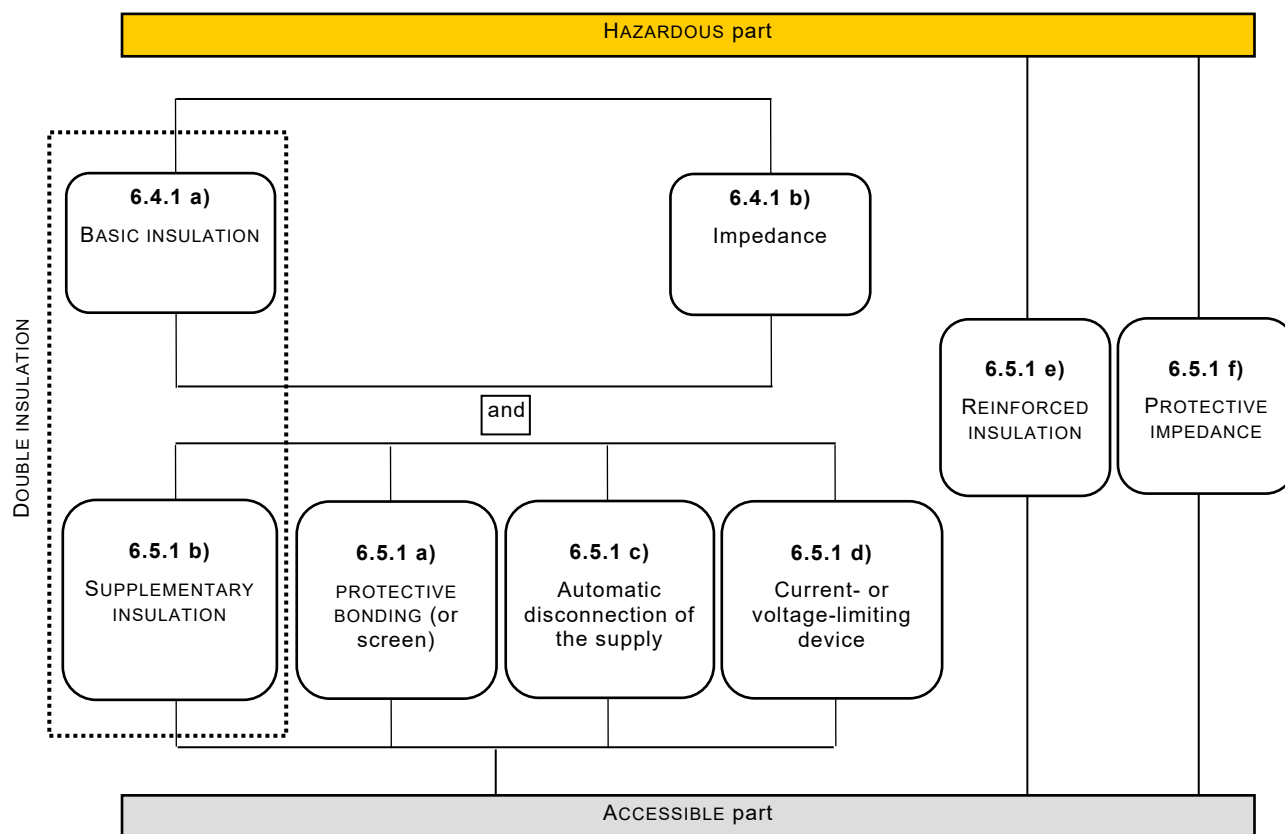


Figure 4 – Acceptable arrangement of protective means against electric shock

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1682

1683 6.5.2 Protective bonding

1684 6.5.2.1 General

1685 ACCESSIBLE conductive parts shall be bonded to the PROTECTIVE CONDUCTOR TERMINAL if they
 1686 could become HAZARDOUS LIVE in case of a single fault of the primary means of protection
 1687 specified in 0. Alternatively, such ACCESSIBLE parts shall be separated from parts which are
 1688 HAZARDOUS LIVE by a conductive protective screen bonded to the PROTECTIVE CONDUCTOR
 1689 TERMINAL.

1690 *Conformity is checked as specified in 6.5.2.2 to 6.5.2.6.*

1691 6.5.2.2 Integrity of protective bonding

1692 The integrity of PROTECTIVE BONDING shall be assured as specified below.

- 1693 a) PROTECTIVE BONDING shall consist of directly connected structural parts or discrete
 1694 conductors, or both. It shall withstand all thermal and dynamic stresses to which it could be
 1695 subjected before one of the overcurrent protective means specified in 9.6 disconnects the
 1696 equipment from the supply.
- 1697 b) Soldered connections subject to mechanical stress shall be mechanically secured
 1698 independently from the soldering. Such connections shall not be used for other purposes
 1699 such as fixing constructional parts.
- 1700 c) Screw connections shall be secured against loosening.
- 1701 d) If a part of the equipment is removable by an OPERATOR, the PROTECTIVE BONDING for the
 1702 remainder of the equipment shall not be interrupted (except for a part that also carries the
 1703 MAINS input connection to the whole equipment).
- 1704 e) Unless they are specifically designed for electrical inter-connection and meet the
 1705 requirements of 6.5.2.4, movable conductive connections, for example, hinges, slides, etc.,
 1706 shall not be the sole PROTECTIVE BONDING path.
- 1707 f) The exterior metal braid of cables shall not be regarded as PROTECTIVE BONDING, even if
 1708 connected to the PROTECTIVE CONDUCTOR TERMINAL.

g) If power from the MAINS supply is passed through equipment for use by other equipment, means shall also be provided for passing the protective conductor through the equipment to protect the other equipment. The impedance of the protective conductor path through the equipment shall not exceed that specified in 6.5.2.4.

h) Protective conductors may be bare or insulated. Insulation shall be green-and-yellow, except in the following cases:

1) for earthing braids, either green-and-yellow or colourless-transparent;

2) for internal protective conductors, and other conductors connected to the PROTECTIVE CONDUCTOR TERMINAL in assemblies such as ribbon cables, busbars, flexible printed wiring, etc., any colour may be used provided that no HAZARD is likely to arise from non-identification of the protective conductor.

Equipment using PROTECTIVE BONDING shall be provided with a TERMINAL that is suitable for connection to a protective conductor and meets the requirements of 6.5.2.3.

Conformity is checked by inspection.

6.5.2.3 Protective conductor terminal

PROTECTIVE CONDUCTOR TERMINALS shall meet the following requirements.

a) The contact surfaces shall be metal.

NOTE 1 Materials of PROTECTIVE BONDING systems should be chosen to minimize electro-chemical corrosion between the TERMINAL and the protective conductor, or any other metal in contact with them.

b) The integral protective conductor connection of an appliance inlet shall be regarded as the PROTECTIVE CONDUCTOR TERMINAL.

c) For equipment provided with a rewirable flexible cord and for PERMANENTLY CONNECTED EQUIPMENT, the PROTECTIVE CONDUCTOR TERMINAL shall be located near the MAINS supply TERMINALS.

d) If the equipment does not require connection to a MAINS supply, but nevertheless has a circuit or part which is required to be protectively earthed, the PROTECTIVE CONDUCTOR TERMINAL shall be located near the TERMINALS of that circuit for which protective earthing is necessary. If this circuit has external TERMINALS, the PROTECTIVE CONDUCTOR TERMINAL shall also be external.

e) PROTECTIVE CONDUCTOR TERMINALS for MAINS CIRCUITS shall be at least equivalent in current-carrying capacity to the MAINS supply TERMINALS.

f) Plug-in type PROTECTIVE CONDUCTOR TERMINALS combined with other TERMINALS and intended to be connected and disconnected without the use of a TOOL, shall be designed so that the protective conductor connection makes first and breaks last with respect to the other connections. Examples include plugs and appliance couplers for MAINS cords and connector assemblies of plug-in units.

g) If the PROTECTIVE CONDUCTOR TERMINAL is also used for other bonding purposes, the protective conductor shall be applied first and secured independently of other connections. The protective conductor shall be connected in such a way that it is unlikely to be removed during servicing that does not require disconnection of the protective conductor.

h) For equipment in which the protective conductor is required for protection against a single fault in a measuring circuit, the following shall apply:

1) the PROTECTIVE CONDUCTOR TERMINAL and protective conductor shall have at least the current RATING of the measuring TERMINALS;

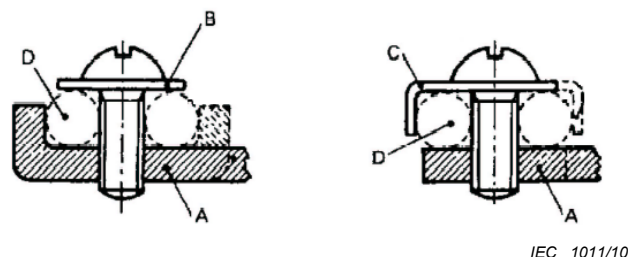
2) the PROTECTIVE BONDING shall not be interrupted by any switching or interrupting device.

i) FUNCTIONAL EARTH TERMINALS (for example, measuring earth TERMINALS) shall allow a connection which is independent from the connection of the protective conductor.

NOTE 2 Equipment may be equipped with FUNCTIONAL EARTH TERMINALS, irrespective of the protective means taken.

j) If the PROTECTIVE CONDUCTOR TERMINAL is a binding screw assembly (see Figure 5), it shall be of a suitable size for the bond wire, but with a thread size no smaller than 4,0 mm, with at least three turns of the screw engaged.

- k) The contact pressure required for a bonding connection shall not be capable of being reduced by deformation of materials forming part of the connection.



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Key

- A fixed part
B washer or clamping plate
C anti-spread device
D conductor space

Figure 5 – Examples of binding screw assemblies

Conformity is checked by inspection. Conformity for j) is also checked by the following test.

The binding screw assembly is to be tightened and loosened three times, together with the least favourable conductor to be secured, using the tightening torques specified in Table 2. All parts of the binding screw assembly shall withstand this test without mechanical failure.

Table 2 – Tightening torque for binding screw assemblies

Thread size mm	4,0	5,0	6,0	8,0	10,0
Tightening torque N·m	1,2	2,0	3,0	6,0	10,0

6.5.2.4 Impedance of PROTECTIVE BONDING of plug-connected equipment

The impedance between the PROTECTIVE CONDUCTOR TERMINAL and each ACCESSIBLE part for which PROTECTIVE BONDING is specified shall not exceed 0,1 Ω . If the equipment has a non-detachable power cord, the impedance between the protective conductor plug pin of the MAINS cord and each ACCESSIBLE part for which PROTECTIVE BONDING is specified shall not exceed 0,2 Ω .

Conformity is checked by applying a test current for 1 min and then calculating impedance. The test current is the greater of

- a) 25 A a.c. r.m.s. at RATED MAINS frequency or d.c.,
b) a current equal to twice the RATED current of the equipment.

If the equipment contains overcurrent protection devices for all poles of the MAINS supply, and if the wiring on the supply side of the overcurrent protection devices cannot become connected to ACCESSIBLE conductive parts in the case of a single fault, the test current need not be more than twice the RATED current of the internal overcurrent protection devices.

6.5.2.5 Impedance of PROTECTIVE BONDING of PERMANENTLY CONNECTED EQUIPMENT

PROTECTIVE BONDING of PERMANENTLY CONNECTED EQUIPMENT shall be of low impedance.

Conformity is checked by applying a test current of twice the value of the overcurrent protection means specified in the equipment installation instructions for the building supply MAINS CIRCUIT for 1 min between the PROTECTIVE CONDUCTOR TERMINAL and each ACCESSIBLE conductive part for which PROTECTIVE BONDING is required. The voltage between them shall not exceed 10 V a.c. r.m.s. or d.c.

1798 *If the equipment contains overcurrent protection devices for all poles of the MAINS supply, and*
1799 *if the wiring on the supply side of the overcurrent protection devices cannot become connected*
1800 *to ACCESSIBLE conductive parts in the case of a single fault, the test current need not be more*
1801 *than twice the RATED current of the internal overcurrent protection devices.*

1802 **6.5.2.6 Transformer PROTECTIVE BONDING screen**

1803 If the transformer is fitted with a screen for PROTECTIVE BONDING purposes that is separated only
1804 by BASIC INSULATION from a winding that is connected to a HAZARDOUS LIVE circuit, the screen
1805 shall satisfy the requirements of 6.5.2.2 a) and b), and be of low impedance.

1806 *Conformity is checked by inspection and by one of the following tests:*

1807 a) *a test current of twice the value of the overcurrent protection means of the winding is applied*
1808 *for 1 min between the screen and the PROTECTIVE CONDUCTOR TERMINAL. The voltage*
1809 *between them shall not exceed 10 V a.c. r.m.s. or d.c.;*

1810 b) *the test of 6.5.2.4 using test current twice the value of the overcurrent protection means of*
1811 *the winding. The impedance shall not exceed 0,1 Ω .*

1812 *NOTE If test a) or b) is carried out, a specially prepared sample transformer having an extra lead-out wire from*
1813 *the free end of the screen is used to ensure that the current during the test passes through the screen.*

1814 **6.5.3 SUPPLEMENTARY INSULATION and REINFORCED INSULATION**

1815 CLEARANCES, CREEPAGE DISTANCES and solid insulation forming SUPPLEMENTARY INSULATION or
1816 REINFORCED INSULATION shall meet the applicable requirements of 6.7.

1817 *Conformity is checked as specified in 6.7.*

1818 **6.5.4 PROTECTIVE IMPEDANCE**

1819 A PROTECTIVE IMPEDANCE shall limit the current or voltage to the levels of 6.3.1 in NORMAL
1820 CONDITION and 6.3.2 in SINGLE FAULT CONDITION.

1821 Insulation between the terminations of the PROTECTIVE IMPEDANCE shall meet the requirements
1822 of 6.7 for DOUBLE INSULATION or REINFORCED INSULATION.

1823 A PROTECTIVE IMPEDANCE shall be one or more of the following:

1824 a) an appropriate single component which shall be constructed, selected and tested so that
1825 safety and reliability for protection against electric shock is assured. In particular, the
1826 component shall be:

1827 c) RATED for twice the maximum WORKING VOLTAGE;

1828 d) if a resistor, RATED for twice the power dissipation for the maximum WORKING VOLTAGE.

1829 b) a combination of components.

1830 A PROTECTIVE IMPEDANCE shall not be a single electronic device that employs electron
1831 conduction in a vacuum, gas or semiconductor

1832 *Conformity is checked by inspection, by measuring the current or voltage to confirm that they*
1833 *do not exceed the applicable levels of 6.3 and by measuring CLEARANCES and CREEPAGE*
1834 *DISTANCES as specified in 6.7. Conformity of a single component is checked by inspection of its*
1835 *RATINGS.*

1836 **6.5.5 Automatic disconnection of the supply**

1837 An automatic disconnection device shall meet both the following requirements.

1838 a) It shall be RATED to disconnect the load within the time specified in [Figure 2](#).

1839 b) It shall be RATED for the maximum RATED load conditions of the equipment.

1840 *Conformity is checked by inspection of the device specification. In case of doubt, the device is*
1841 *tested to check that it disconnects the supply within the required time.*

1842 **6.5.6 Current- or voltage-limiting device**

1843 A current- or voltage-limiting device shall meet all the following requirements:

- a) it shall be **RATED** to limit the current or voltage to the levels not exceeding the values of 6.3.2;
- b) it shall be **RATED** for the maximum **WORKING VOLTAGE** and, if applicable, for the maximum operational current;
- c) **CLEARANCE** and **CREEPAGE DISTANCE** between the terminations of the current or voltage-limiting device shall meet the applicable requirements of 6.7 for **SUPPLEMENTARY INSULATION**.
- Conformity is checked by inspection, by measuring the voltage or current to confirm that they do not exceed the levels of 6.3.2, and by measuring CLEARANCES and CREEPAGE DISTANCES as specified in 6.7.*

6.6 Connections to external circuits

6.6.1 General

In **NORMAL CONDITION** and in **SINGLE FAULT CONDITION** of the equipment, no **ACCESSIBLE** parts of the equipment and no **ACCESSIBLE** parts of an external circuit shall become **HAZARDOUS LIVE** as a result of connecting the external circuit to the equipment.

NOTE 1 External circuits are all circuits connected to **TERMINALS** of the equipment.

NOTE 2 For connection to **MAINS** supply source, see 6.10.

Protection shall be achieved by separation of circuits, unless short-circuiting of the separation could not cause a **HAZARD**.

The manufacturer's instructions or equipment markings shall include the following information, if applicable, for each external **TERMINAL**:

- a) **RATED** conditions at which the **TERMINAL** has been designed to operate while maintaining safety (maximum **RATED** input/output voltage, specific type of connector, designated use, etc.);
- b) **RATING** of the insulation required for the external circuit to conform to the requirements for protection against electric shock, arising from the connection to the **TERMINAL**, in **NORMAL CONDITION** and **SINGLE FAULT CONDITION**.

Conformity is checked by:

- 1) *inspection;*
- 2) *the measurements of 6.3 and 6.7;*
- 3) *the voltage test of 6.8 (without humidity preconditioning) applicable to the type of insulation (see 6.7).*

6.6.2 TERMINALS for external circuits

ACCESSIBLE conductive parts of terminals that receive a charge from an internal capacitor shall not be **HAZARDOUS LIVE** 10 s after interruption of the supply. Unless it is self-evident, **TERMINALS which are connected to ACCESSIBLE conductive parts shall be marked accordingly (see 5.1.5.2 c)).**

Conformity is checked by inspection, and by the determination of ACCESSIBLE conductive parts as specified in 6.2 and in case of doubt by measurement of the remaining voltage or charge.

6.6.3 Circuits with TERMINALS which are HAZARDOUS LIVE

These circuits shall not be connected to **ACCESSIBLE** conductive parts, except for circuits which are not **MAINS CIRCUITS**, and which are designed to be operated with one **TERMINAL** contact at earth potential. In such cases, the **ACCESSIBLE** conductive parts shall not be **HAZARDOUS LIVE**.

HAZARDOUS LIVE terminals shall be anchored, fitted or designed so that internal conductors and terminal mechanical mountings will not work loose when the terminals are tightened or loosened, or when connections are made.

If such a circuit is also designed to be operated with one **ACCESSIBLE TERMINAL** contact floating at a voltage which is not **HAZARDOUS LIVE**, this **TERMINAL** contact is permitted to be connected to a common **FUNCTIONAL EARTH TERMINAL** or system (for example, a coaxial screening system). This common **FUNCTIONAL EARTH TERMINAL** or system is also permitted to be connected to other **ACCESSIBLE** conductive parts.

1893 *Conformity is checked by inspection.*

1894 **6.6.4 TERMINALS for stranded conductors**

1895 TERMINALS for stranded conductors that are intended to be connected during installation,
1896 maintenance, or operation of the equipment shall be located or shielded so that there is no
1897 possibility of accidental contact between HAZARDOUS LIVE parts of different polarity or between
1898 such parts and other ACCESSIBLE parts, even if a strand of a conductor escapes from a TERMINAL.
1899 This requirement does not apply to connections that are only to be made at the manufacturing
1900 facility.

1901 *Conformity is checked by inspection after fully inserting a stranded conductor:*

1902 1) with the maximum length of insulation removed as specified by the equipment manufacturer,
1903 or

1904 2) with an 8 mm length of insulation removed if no specification is given by the equipment
1905 manufacturer,

1906 With one of the strands free, the free strand shall not touch parts of different polarity or other
1907 ACCESSIBLE parts, when bent in every possible direction, without tearing back the insulation or
1908 making sharp bends.

1909 TERMINALS of circuits carrying HAZARDOUS LIVE voltage or current shall be anchored, fitted or
1910 designed so that conductors will not work loose when they are tightened, loosened or when
1911 connections are made.

1912 *Conformity is checked by manual test and inspection.*

1913 **6.7 Insulation requirements**

1914 **6.7.1 The nature of insulation**

1915 **6.7.1.1 General**

1916 Insulation between circuits and ACCESSIBLE parts (see 6.2) or between separate circuits consists
1917 of a combination of CLEARANCES, CREEPAGE DISTANCES and solid insulation. When used to
1918 provide protection against a HAZARD, the insulation needs to withstand the electric stresses that
1919 are caused by the voltages that may appear on the MAINS supply or in the equipment.

1920 Electric stresses originating from MAINS include:

- 1921 a) WORKING VOLTAGE across the insulation. This WORKING VOLTAGE is normally the line-to-
1922 neutral voltage of the MAINS supply (also see Annex I);
- 1923 b) TRANSIENT OVERVOLTAGES that may occasionally appear on the line conductors. The
1924 magnitude of the overvoltages depends on the OVERVOLTAGE CATEGORY and the line-to-
1925 neutral voltage of the MAINS supply;
- 1926 c) short-term TEMPORARY OVERVOLTAGES that may occur between the line conductor and
1927 earth in electrical installations. These TEMPORARY OVERVOLTAGES may have a value of
1928 the line-to-neutral voltage of the MAINS supply plus 1 200 V, and may last up to 5 s;
- 1929 d) long-term TEMPORARY OVERVOLTAGES that may occur between the line conductor and
1930 earth in electrical installations. These TEMPORARY OVERVOLTAGES may have a value of
1931 the line-to neutral voltage of the MAINS supply plus 250 V and may last longer than 5 s.

1932 NOTE See IEC 60364-4-44, Clause 442 for additional information on these TEMPORARY OVERVOLTAGES.

1933 The requirements for insulation depend on:

- 1934 1) the required level of insulation (BASIC INSULATION, SUPPLEMENTARY INSULATION, or
1935 REINFORCED INSULATION);
- 1936 2) the maximum TRANSIENT OVERVOLTAGE that may appear on the circuit, either as a result of
1937 an external event (such as a lightning strike or a switching transient), or as the result of the
1938 operation of the equipment;
- 1939 3) the maximum WORKING VOLTAGE (including steady-state and recurring peak voltages);
- 1940 4) the POLLUTION DEGREE of the micro-environment;