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American National Standard

Safety Standard for Electrical and Electronic Test, Measuring, Controlling, and Related Equipment - General Requirements

Harmonized Standard to IEC Publication 1010-1

ANSI/ISA S82.01 — Safety Standard for Electrical and Electronic Test, Measuring, Controlling, and Related Equipment—General Requirements

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Preface

This preface is included for informational purposes and is not part of ISA S82.01.

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Contents

National Foreword

This American National Standard has been prepared under the direction of the ISA SP82 committee and is the United States version of IEC 1010-1, "Safety requirements for electrical equipment for measurement and control."

The following are United States national deviations to the requirements that appear in Clause 1 through Clause 14 and Annexes F, J, and K of this Standard. In addition, Annexes N, O, and P have been added to this Standard.

1.1 Remove "- laboratory use;" from the scope.

1.1 Add new clause referencing the National Electrical Code

This standard applies to equipment to be employed in accordance with ANSI/NFPA 70, National Electrical Code.

1.4 Add new clause addressing requirements for extended environments

Equipment used in extended environments, e.g., outdoors or sheltered locations, must comply with additional requirements not found in this standard, e.g., ANSI/ISA S82.03. Equipment in sheltered locations may have CREEPAGE DISTANCES and CLEARANCES designed in compliance with IEC 664 for POLLUTION DEGREE 3 in lieu of the ENCLOSURE or coating requirement specified in S82.03.

2.3 Add new clause to identify United States standards

ANSI/CGA V-1-1987	Compressed Gas Cylinder Valve Outlet and Inlet Connections
ANSI/NFPA 70: 1990	National Electrical Code
ANSI/UL 94: 1980	Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
ANSI/UL 498: 1986	Attachment Plugs and Receptacles
ANSI/UL 746C: 1989	Polymeric Materials — Use in Electrical Equipment Evaluations
ANSI/UL 817: 1986	Cord Sets and Power Supply Cords
ANSI/UL 1012: 1989	Power Supplies
ANSI/UL 1310: 1986	Direct Plug-in Transformer Units

3.2.6 Add new definition for field wiring TERMINAL

Field wiring TERMINAL: Any TERMINAL to which a mains circuit wire is intended to be connected by an installer in the field.

5.1.2 Add new factory identification marking

- Factory identification

If equipment bearing the same distinctive designation (model number) is manufactured at more than one location, equipment from each manufacturing location shall bear an identification of such location.

Such identification may be in code and need not be on the equipment exterior.

5.1.2 Add clarification for the term "manufacturer"

The term "manufacturer" may refer to the distributor or other supplier of the equipment.

5.2 Add letter height requirements for warnings

Warning markings shall have lettering in which:

a) the precautionary signal word shall be at least 2.75 mm high;

b) the text shall be at least 1.5 mm high and contrasting in color to the background; or

c) if molded or stamped in a material, the text shall be at least 2.0 mm high and, if not contrasting in color, a depth or raised height of at least 0.5 mm.

Table 1 Eliminate requirement for yellow background on some symbols

The yellow background is not required on Symbols 12 and 14 if the background is contrasting in color with the symbol and triangular outline.

6.7 Add spacing requirements for field wiring TERMINAL parts

The CREEPAGE DISTANCES and CLEARANCES between field wiring TERMINAL parts of opposite polarity and between field wiring TERMINAL parts and the ENCLOSURE in PERMANENTLY CONNECTED EQUIPMENT shall be at least those specified in Table NF-1.

Exception: If it can be demonstrated that the CREEPAGE DISTANCES and CLEARANCES of Annex D cannot be violated when evaluated per the compliance statement to 6.11.1 a).

Compliance is checked by first applying and removing a 2-newton force against any wire or uninsulated part followed by measuring the applicable CREEPAGE DISTANCE or CLEARANCE.

Table NF-1 — Spacings at field wiring TERMINAL parts

U_W V	CREEPAGE DISTANCE mm	CLEARANCE mm
51 - 250	6.3	6.3
251 - 440	9.5	9.5
441 - 600	12.5	12.5

6.7 Eliminate spacing requirements on inner layers of multi-layer printed circuit boards

The inner layers of a multi-layer printed circuit board are considered to be void-free molded parts. The CLEARANCES and CREEPAGE DISTANCES specified in Annex D do not apply to these inner layers (see Note 2 of Annex D, Subclause D.2.1).

6.7 Add requirements for circuit board coating

Coatings used to reduce spacings are subjected to additional requirements not found in this standard, e.g., ANSI/UL 746C.

6.10.1 Identify United States standards for mains cords

a) Requirements for mains cords or cord sets are contained in ANSI/UL 817.

b) Requirements for general use receptacles, attachment plugs, and similar wiring devices are contained in ANSI/UL 498.

6.10.3 Identify United States standards for mains connectors

Requirements for plugs of mains cords are contained in ANSI/UL 498.

6.10.4 Add provision for PERMANENTLY CONNECTED EQUIPMENT

Equipment intended for permanent connection to the mains shall have provision for connection of a wiring system in accordance with the ANSI/NFPA 70, National Electrical Code.

PERMANENTLY CONNECTED EQUIPMENT shall be provided with TERMINALS or leads for the connection of conductors having an ampacity that, in accordance with the National Electrical Code, is acceptable for the equipment.

Compliance is checked by inspection.

6.10.4.1 Wiring TERMINALS

a) A TERMINAL or splice compartment shall be complete — that is, the top, all sides, and a complete bottom are provided when the equipment is shipped from the factory — and shall enclose all field-wiring TERMINALS and splices intended to be made in the field.

Exception: Equipment with an ENCLOSURE that is complete need not be provided with a separate compartment.

The TERMINAL or splice compartment in which mains connections to PERMANENTLY CONNECTED EQUIPMENT are made shall be located so that:

1) internal wiring and electrical components are not exposed to mechanical damage or strain while connections are being made, and

2) these connections may be readily inspected after the equipment is installed as intended.

b) A wiring TERMINAL shall be provided in which connection is made by means of screws, nuts, or equally effective devices.

c) Wire binding screws are permitted as follows:

A No. 6 or M4 screw may be used to connect a 14 AWG (2.1 sq mm) or smaller wire.

A No. 8 or M4.5 screw may be used to connect a 12 AWG (3.3 sq mm) or smaller wire.

A No. 10 or M5 screw may be used to connect a 10 AWG (5.3 sq mm) or smaller wire.

Compliance is checked by inspection.

6.10.4.2 Leads

The free length of a lead inside a wiring compartment shall be at least 6 inches (150 mm).

Compliance is checked by inspection.

6.10.4.3 TERMINAL and lead identification

TERMINALS and leads shall be identified in a manner that will permit the equipment to be connected as intended by the manufacturer. Equipment containing either a mains-connected polarized convenience receptacle or a mains-connected polarized lamp socket must have an identified neutral (grounded) conductor.

a) Neutral (grounded) TERMINAL

A field wiring TERMINAL that is intended solely for connection of the neutral (grounded) mains conductor shall be readily distinguishable from all other TERMINALS. It shall be constructed of, or plated with, metal that is substantially white in color.

Exception: The neutral (grounded) TERMINAL need not be white in color if it can be clearly identified in some other manner — such as on a wiring diagram permanently attached to the equipment.

b) Neutral (grounded) lead

A lead intended solely for field wiring connection to the neutral (grounded) mains conductor shall be readily distinguishable from all other leads by being finished to show a white or natural gray color.

c) Protective grounding (earthing) TERMINAL

The TERMINAL shall be marked per 5.1.6 b).

Exception 1: Markings such as "G," "GR," "GND," "GROUND," or "GROUNDING" are also acceptable.

Exception 2: A TERMINAL provided with a green-colored screw head that is hexagonal, slotted, or both is also acceptable.

d) Protective grounding (earthing) lead

A lead intended for field connection to the protective grounding conductor shall be readily distinguishable from all other leads by being finished to show a green color with or without one or more yellow stripes.

Compliance is checked by inspection.

6.10.4.4 ENCLOSURE requirements for conduit entry

An ENCLOSURE shall not pull apart or sustain damage such as cracking and breaking, and knockouts shall remain in place when subjected to pulling, torque, and bending, which are likely to occur.

Exception: ENCLOSURES having sheet metal members with a thickness no less than 0.81 mm if of uncoated sheet steel, no less than 0.86 mm if of galvanized sheet steel, no less than 1.11 mm if of sheet aluminum, and no less than 1.09 mm if of sheet copper or sheet brass are presumed to pass these tests.

Compliance is checked by performing the tests of 6.10.4.5.

6.10.4.5 Conduit ENCLOSURE entry tests

After each of the tests in 6.10.4.5.1 - 6.10.4.5.4, the equipment must meet the criteria defined in 6.10.4.4.

6.10.4.5.1 Conduit pull-out test

The ENCLOSURE is to be suspended by a length of rigid conduit installed in one wall of the ENCLOSURE or mounted as intended in service, and a pulling force of 200 pounds (890 N) is to be applied for 5 minutes to a length of conduit installed in the opposite wall (or wall with conduit entry if ENCLOSURE is mounted rather than suspended).

6.10.4.5.2 Conduit torque test

The ENCLOSURE is to be securely mounted as intended in service. A torque in accordance with Table NF-2 is to be applied to a length of installed conduit in a direction tending to tighten the connection. The lever arm is to be measured from the center of the conduit.

Table NF-2 — Tightening torque for conduit

Trade size of conduit inches	Tightening torque, inch-pounds (N m)
3/4 and smaller	800 (90)
1, 1-1/4, 1-1/2	1000 (113)
2 and larger	1600 (181)

Exception: An end of line ENCLOSURE — an ENCLOSURE that is intended to be connected at the end of a run of conduit and has only one 3/4-inch maximum trade size opening for the connection of conduit — need only be subjected to a tightening torque of 200 inch pounds (22.6 N m)

6.10.4.5.3 Bending

A length of conduit at least 1 foot (300 mm) long of the intended size is to be installed (1) in the center of the largest unreinforced surface, or (2) in a hub or an opening if provided as part of the ENCLOSURE. The ENCLOSURE is to be securely mounted as intended in service, but positioned so that the installed conduit extends in a horizontal plane. A weight is to be suspended from the end of the conduit to produce the bending moment specified in Table NF-3. The magnitude of the weight is to be determined from the equation:

$$W = (M-0.5*C*L)/L$$

where:

W is the weight, in pounds, to be hung at the end of the conduit;

L is the length of the conduit, in inches, from the wall of the ENCLOSURE to the point at which the weight is suspended;

C is the weight of the conduit, in pounds; and

M is the bending moment required in inch-pounds.

For the SI system of units, the equation is

$$W = (0.1*M - 0.5*C* L)/L$$

where:

W and C are measured in kilograms;

M is measured in newton meters; and

L is measured in meters.

Table NF-3 — Bending moment for conduit openings

		Bending Moment (b),(c) inch-pounds (N m)	
Normal Mounting Plane of ENCLOSURE Surface (a)	**Conduit Size Inches**	**Metallic Conduit**	**Nonmetallic Conduit**
Horizontal	All	300 (34)	300 (34)
Vertical	1/2 - 3/4	300 (34)	300 (34)
	1 - up	600 (68)	300 (34)

a) If the ENCLOSURE surface may be installed in either a horizontal or a vertical plane, the vertical bending moment value is to be used.

b) The test procedure may be terminated prior to attaining the values specified if the deflection of the conduit exceeds 10 inches (250 mm) for a 10-foot (3.05 m) length of conduit.

c) For an end-of-line ENCLOSURE as defined in the exception to paragraph 6.10.4.5.2, the bending moment is to be 150 inch-pounds (17.0 N m).

6.10.4.5.4 Knockouts

A knockout is to be subjected to a force of 20 pounds (89 N) applied at right angles by means of a mandrel with a 1/4-inch (6.4 mm) diameter flat end. The mandrel is to be applied at the point most likely to cause movement of the knockout.

6.12 Add requirement for maintaining polarity

A line-connected single-pole switch, the center contact of a lampholder, and an automatic control with a marked off position shall be connected to a TERMINAL or lead intended for connection to the ungrounded conductor of the supply circuit.

8.2 Permit alternate impact hammer equipment

Any test apparatus that imparts the same energy levels using the same design at the impact surface is acceptable. Critical design parameters are the radius and material of the impact surface and the mass of the body imparting the impact.

8.3 Eliminate the vibration test requirement

Vibration testing to 8.3 is not required.

9.6 Add clauses for connections to overcurrent device

An overcurrent protective device shall be connected in the ungrounded supply conductor unless the overcurrent protective device or devices are so constructed as to interrupt both the neutral (grounded) and ungrounded conductors of the mains supply simultaneously. Where fuses are used as overcurrent protective devices in both the neutral (grounded) and ungrounded supply conductors, the fuseholders should be mounted adjacent to each other and the fuses shall be of the same RATING and characteristics.

The screw shell of a plug fuseholder and the ACCESSIBLE contact of an extractor fuseholder connected to the ungrounded supply conductor shall be connected toward the load. The

ACCESSIBLE contact or screw shell of fuseholders connected in the neutral (grounded) conductor shall be located toward the grounded supply line.

13.4 Fluid pressure and leakage

13.4.1 Hydraulic test pressure

If a pressure vessel has a pressure x volume content greater than 200 kPa-l and pressure greater than 50 kPa, it shall withstand the hydraulic test pressure.

Compliance is checked by the following tests:

The test pressure shall be the maximum permissible working pressure multiplied by a factor obtained from Figure NF-1. Any pressure relief device that is used to limit the maximum working pressure is inactive during the test.

The pressure is raised gradually to the specified test value and shall be held at that value for 1 minute. The sample shall not burst nor suffer from permanent (plastic) deformation, nor leak. Leakage at a gasket during this test is not considered to constitute failure unless it occurs at a pressure below 40% of the required test value or below the maximum permissible working pressure, whichever is greater.

No leakage is allowed for pressure vessels intended for toxic, flammable, or otherwise hazardous substances.

Where unmarked pressure vessels and pipes cannot be hydraulically tested, integrity shall be verified by other suitable tests, e.g., pneumatic using suitable media, at the same test pressure as for the hydraulic test.

13.4.2 Maximum permissible working pressure (P_{rated})

The maximum pressure to which a part can be subjected in NORMAL USE or SINGLE FAULT CONDITION shall not exceed the maximum permissible working pressure (P_{rated}) for the part.

The maximum pressure in use shall be considered to be whichever is the highest of the following:

a) the RATED maximum supply pressure specified for an external source;

b) the pressure setting of a pressure relief device provided as part of the assembly; or

c) the maximum pressure that can be developed by an air compressor that is part of the assembly, unless the pressure is limited by a pressure relief device.

Compliance is checked by inspection of the RATINGS of parts and where necessary by measuring pressures.

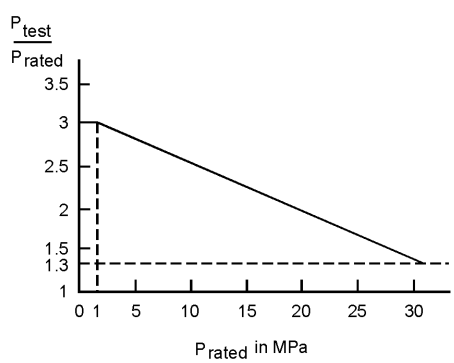


Figure NF-1 Ratio Between Hydraulic Test Pressure and Maximum Permissible Working Pressure (P_{rated})

13.4.3 Pressure relief device

Equipment shall incorporate pressure-relief device(s) where excessive pressure could otherwise occur.

A pressure-relief device shall not operate in NORMAL USE and shall comply with all of the following requirements:

a) It shall be connected as close as possible to the pressure vessel or parts of the system that it is intended to protect.

b) It shall be so installed that it can be easily accessed for inspection, maintenance, and repair.

c) It shall not be capable of being adjusted without the use of a TOOL.

d) It shall have its discharge opening so located and directed that the released material is not directed toward any person.

e) It shall have its discharge opening so located and directed that operation of the device will not deposit material on parts that may cause a safety hazard.

f) It shall be of adequate discharge capacity to ensure that the pressure will not exceed the maximum permissible working pressure of the system to which it is connected by more than 10% in the event of a failure in the control of the supply pressure.

g) There shall be no shut-off valve between a pressure-relief device and the parts that it is intended to protect.

Compliance is checked by inspection and functional test.

13.4.4 Leakage test

Leakage from fluid-containing parts at lower pressure than that specified in 13.4.1 shall not cause a hazard.

Compliance is checked by inspection of the RATINGS of parts and where necessary, by subjecting the parts to a fluid pressure of twice the maximum pressure of NORMAL USE. No leakage shall occur which could cause a hazard.

14.1 Identify that the United States standards may also be used for components

Where safety is involved, components shall comply with applicable safety requirements specified in relevant IEC standards or relevant ANSI standards as appropriate.

14.7 Add requirements for direct plug-in transformer units

Direct plug-in transformer units may be subjected to additional requirements not found in this standard, e.g., ANSI/UL 1310.

14.8 Add new section on EMC materials

14.8.1 Conductive coatings

The bond of a conductive (metallic) coating applied to a polymeric part shall be evaluated.

Exception: Evaluation of the bond is not required when it has been determined that flaking or peeling of the coating does not introduce the risk of fire or electric shock.

Compliance is checked by:

a) evaluating the bond in accordance with the requirements for "Adhesives" in the Standard for Polymeric Materials—Use in Electrical Equipment Evaluations, UL 746C, or

b) examination of the product to determine that peeling or flaking of the coating would not reduce spacings or bridge live parts so as to introduce a risk of fire or electric shock.

14.8.2 Conductive shield or tape

The bond between a conductive shield or tape and any other surface shall be investigated.

Exception: an evaluation of the bond is not required when it has been determined that peeling of the conductive shield or tape does not introduce a risk of fire or electric shock.

Compliance is checked by inspection.

F.4.2.2 Identify equivalent flame RATINGS

and

F.4.3.3

United States flame RATINGS of UL 94 V-0, V-1, and V-2 are equivalent to the designations of IEC 707 FV 0, FV 1, and FV 2, respectively.

ANNEX J Add explanatory note to Table J.1

The 120/240V system refers to a four wire, three phase delta system with center point grounding on one phase.

ANNEX K Add a required ROUTINE TEST

The ROUTINE TEST of Annex K is required between supply mains, connected together, and ACCESSIBLE conductive parts likely to become energized, including the protective grounding conductor.

The test shall be conducted when the equipment is complete (fully assembled) and with the supply mains switch in the on position. It is not intended that the equipment be unwired, modified, or disassembled for the test.

Exception 1: Parts such as snap covers or friction-fit knobs that would interfere with performing the test need not be in place.

Exception 2: The test may be performed before final assembly if the test represents that for the completed equipment.

Foreword

1) The formal decisions or agreements of the IEC on technical matters, prepared by Technical Committees on which all the National Committees having a special interest therein are represented, express, as nearly as possible, an international consensus of opinion on the subject dealt with.

2) They have the form of recommendations for international use and they are accepted by the National Committees in that sense.

3) In order to promote international unification, the IEC expresses the wish that all National Committees should adopt the text of the IEC recommendation for their national rules in so far as national conditions will permit. Any divergence between the IEC recommendation and the corresponding national rules should, as far as possible, be clearly indicated in the latter.

The standard has been prepared by Sub-Committee 66E: Safety of measuring, control and laboratory equipment of IEC Technical Committee No. 66: Electrical and electronic test measuring instruments, systems and accessories. It constitutes Part 1 of a series of publications dealing with safety requirements for electrical equipment for measurement, control, and laboratory use.

With this amendment, IEC 1010-1 supersedes IEC 348 which is withdrawn.

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

The text of this standard is based upon the following documents:

Six Month's Rule	Report on Voting	Two Month's Procedure	Report on Voting
66E(CO)4	66E(CO)6	66E(CO)7	66E(CO)8

Full information on the voting for the approval of this standard can be found in the Voting Reports indicated in the above table.

Annexes A, B, C, D, E, F, and G are normative and annexes H, J, K, L, and M are informative.

In this standard, the following print types are used:

- requirements and definitions in helvetica type
- NOTES in smaller helvetica type
- compliance in italic type
- terms used throughout this standard which have been defined in Clause 3 in small helvetica capitals

With this amendment, IEC 1010-1 supersedes IEC 348 which is withdrawn.

Superscripted ^{NF} identifies that a National Foreword clause exists.

Introduction

After many years of discussion and aware of the need for a General Standard for the safety of electrical equipment for measurement, control, and laboratory use, the majority of National Committees voted in 1988 in favor of the publication of IEC 1010-1.

This Part 1 specifies the safety requirements that are generally applicable to all equipment within its scope. For certain types of equipment, these requirements will be supplemented or modified by the special requirements of a Particular Standard that must be read in conjunction with Part 1 requirements.

Particular standards are under consideration for the following types of equipment or conditions of use:

- probes;
- laboratory centrifuges;
- laboratory equipment for the heating of materials;
- laboratory flame and arc photometers and ionizing equipment;
- laboratory sterilizers;
- laboratory mixing, crushing, and shaking equipment;
- equipment for use in outdoor and harsh indoor conditions.

1 Scope and object

1.1[NF] Scope

This International Standard specifies general safety requirements for electrical equipment intended for professional, industrial process, and educational use, including equipment and computing devices for:

- measurement and test;
- control;
- laboratory use;
- accessories intended for use with the above (e.g. sample handling equipment).

This Part 1 of the standard applies to the equipment defined in a) to c) below, when used under the environmental conditions of 1.4.

a) Electrical measurement and test equipment

This is equipment that by electrical means measures, indicates, or records one or more electrical or non-electrical quantities, also non-measuring equipment such as signal generators, measurement standards, power supplies, transducers, transmitters, etc.

NF See corresponding clause in National Foreword

b) Electrical control equipment

This is equipment that 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 that measures, indicates, monitors, or analyzes substances, or is used to prepare materials.

This equipment may also be used in areas other than laboratories.

1.1.1 Aspects excluded from scope

This Part 1 of the standard does not cover:

- reliable function, performance, or other properties of the equipment;
- servicing (repair);
- protection of servicing (repair) personnel.

NOTE – Servicing personnel are expected to be reasonably careful in dealing with obvious hazards, but the design should protect against mishap by the use of warning labels, shields for hazardous voltage TERMINALS, segregation of low-voltage circuits from hazardous voltages, etc. More important, servicing personnel should be trained against unexpected hazards.

1.1.2 Equipment excluded from scope

This Part 1 does not apply to:

- electric power equipment, for example power electronics;
- machine tools and their controls (see IEC 204);
- Class 0, 5,1 and 2 alternating current watt-hour meters (see IEC 521);
- medical electrical equipment within the scope of IEC 601:
- biological amplifiers that link humans to equipment in research or teaching contexts;
- type-tested and partially type-tested assemblies of low-voltage switchgear and controlgear (see IEC 439 1);
- circuits and equipment that are part of the building electrical installation (see IEC 364);
- computers, processors, and similar equipment, except as specified in 1.1.3 (see IEC 950);
- transformers separate from the equipment (see IEC 742);
- equipment intended for household use (see IEC 335);
- equipment intended for use in explosive gas atmospheres (see IEC 79).

1.1.3 Computing equipment

This Part 1 applies only to computers, processors, etc, that form part of equipment within the scope of this standard or are designed for use exclusively with the equipment.

NOTE – Computing devices and similar equipment within the scope of IEC 950 and complying with its requirements are considered to be suitable for use with equipment within the scope of this Part 1.

1.2 Object

The purpose of the requirements of this Part 1 is to ensure that the design and methods of construction used provide adequate protection for the OPERATOR and the surrounding area against:

- electric shock or burn (see Clause 6);

- mechanical hazards (see Clauses 7 and 8);
- excessive temperature (see Clause 9);
- spread of fire from the equipment (see Clause 9);
- effects of radiation, including lasers sources, sonic, and ultrasonic pressure (see Clause 12);
- liberated gases, explosion, and implosion (see Clause 13).

NOTE – Attention is drawn to the existence of additional requirements which may be specified by national authorities responsible for health and safety of labor forces.

1.3 Verification

This Part 1 also specifies methods of verifying, through inspection and TYPE TESTING, that the equipment meets the requirements of this standard.

NOTE – Recommendations for ROUTINE TESTS are given in Annex K.

1.4[NF] Environmental conditions

This Part 1 applies to equipment designed to be safe at least under the following conditions:

- indoor use;
- altitude up to 2000 m or above 2000 m if specified by the manufacturer (see Clause D.9 for further requirements);
- temperature 5°C to 40°C;
- maximum relative humidity 80% for temperatures up to 31°C decreasing linearly to 50% relative humidity at 40°C;
- mains supply voltage fluctuations not to exceed ±10% the nominal voltage;
- other supply voltage fluctuations as stated by the manufacturer;
- transient overvoltages according to installation categories (overvoltage categories) I, II and III (see Annex J). For mains supply the minimum and normal category is II;
- POLLUTION DEGREE 1 or 2 in accordance with IEC 664 (see 3.7.3).

2[NF] Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Part 1 of IEC 1010. At the time of publications, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this Part 1 of IEC 1010 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

2.1 IEC standards

50 (151): 1978,	International Electrotechnical Vocabulary - Chapter 151: Electrical and magnetic devices.
50 (351): 1975,	International Electrotechnical Vocabulary - Chapter 351: Automatic control.

[NF] See corresponding clause in National Foreword

51,	Direct acting indicating analogue electrical measuring instruments and their accessories.
60,	High-voltage test techniques.
60-2: 1973,	High-voltage test techniques - Part 2: Test procedures.
65: 1985,	Safety requirements for mains operated electronic and related apparatus for household and similar general use.
68-2 3: 1969,	Environmental testing, Part 2: Tests -Test Ca: Damp heat, steady state.
68-2 6: 1982,	Environmental testing - Part 2: Tests -Test Fc and guidance: Vibration (Sinusoidal).
68-2 31: 1969,	Environmental testing, Part 2: Tests -Test Ec: Drop and topple, primarily for equipment type specimens.
85: 1984,	Thermal evaluation and classification of electrical insulation.
227,	Polyvinyl chloride insulated cables of RATED voltages up to and including 450/750 V.
245,	Rubber insulated cables of RATED voltages up to and including 450/750 V.
309,	Plugs, socket-outlets and couplers for industrial purposes.
359: 1987,	Expression of the performance of electrical and electronic measuring equipment.
417: 1973,	Graphical symbols for use on equipment. Index, survey and compilation of the single sheets.
529: 1989,	Degrees of protection provided by enclosures (IP Code).
617-2: 1983,	Graphical symbols - Part 2: Symbol elements, qualifying symbols and other symbols having general applications.
664:,	Insulation coordination for equipment within low-voltage systems.
707: 1981,	Methods of tests for the determination of the flammability of solid electrical insulating materials when exposed to an igniting source.
799: 1984,	Cord sets.
817: 1984,	Spring-operated impact-test apparatus and its calibration.
825: 1984,	Radiation safety of laser products, equipment classification, requirements and user's guide.
947-1: 1988,	Low-voltage switchgear and controlgear - Part 1: General rules.
947-3: 1990,	Low-voltage switchgear and controlgear - Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units.
990: 1990,	Methods of measurement of touch-current and protective conductor current.

2.2 ISO standards

306: 1987,	Plastics - Thermoplastic materials. Determination of Vicat softening temperature.
3864: 1984,	Safety colors and safety signs.

3 Definitions

For the purpose of this International Standard the following definitions apply.

For the definitions of further terms used in this standard see IEC 50 (351), IEC 51, and IEC 359. Unless otherwise specified, the terms "voltage" and "current" mean the r.m.s. values of an alternating, direct, or composite voltage or current.

3.1 Equipment and states of equipment

3.1.1 FIXED EQUIPMENT: Equipment fastened to a support or otherwise secured in a specific location.

3.1.2 PERMANENTLY CONNECTED EQUIPMENT: Equipment that is electrically connected to a supply by means of a permanent connection that can be detached only by the use of a TOOL.

3.1.3 PORTABLE EQUIPMENT: Equipment intended to be carried by hand.

3.1.4 HAND-HELD EQUIPMENT: PORTABLE EQUIPMENT intended to be supported by one hand during NORMAL USE.

3.1.5 TOOL: An external device, including keys and coins, used to aid a person to perform a mechanical function.

3.2[NF] *Parts and accessories*

3.2.1 TERMINAL: A component provided for the connection of a device (equipment) to external conductors [IEV 151-01-03].

NOTE – It may contain one or several TERMINAL contacts.

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

NOTE – For measuring equipment, this TERMINAL is often termed "measuring earth TERMINAL."

3.2.3 PROTECTIVE CONDUCTOR TERMINAL: A TERMINAL that is bonded to conductive parts of an equipment for safety purposes and is intended to be connected to an external protective earthing system.

3.2.4 ENCLOSURE: A part providing protection of equipment against certain external influences and, in any direction, protection against direct contact.

3.2.5 BARRIER: A part providing protection against direct contact from any usual direction of access.

NOTE – ENCLOSURES and BARRIERS may provide protection against the spread of fire (see 9.1 and Annex F).

3.3 Electrical quantities

3.3.1 RATED (value): A quantity value assigned, generally by a manufacturer, for a specified operating condition of a component, device, or equipment [IEV 151-04-03].

3.3.2 RATING: The set of RATED values and operating conditions [IEV 151-04-04].

3.4 Tests

3.4.1 TYPE TEST: A test of one or more samples of equipment (or parts of equipment) made to

NF See corresponding clause in National Foreword

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 IEV 151-04-15 definition to cover both design and construction requirements.

3.4.2 ROUTINE TEST: A test to which each individual device (equipment) is subjected during or after manufacture to ascertain whether it complies with certain criteria (see Annex K) [IEV 151-04-16].

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 HAZARDOUS LIVE: Capable of rendering an electric shock or electric burn in NORMAL CONDITION or SINGLE FAULT CONDITION (see 6.3.1 for values applicable to NORMAL CONDITION and 6.3.2 for the higher values deemed to be appropriate in SINGLE FAULT CONDITION).

3.5.3 HIGH INTEGRITY: Not liable to become defective in such a manner as to cause a risk of hazard within the sense of this standard; a HIGH INTEGRITY part is considered as not subject to failure when tests under fault conditions are made.

3.5.4 PROTECTIVE IMPEDANCE: A component, assembly of components, or the combination of BASIC INSULATION and a current or voltage limiting device, the impedance, construction, and reliability of which are such that when connected between parts that are HAZARDOUS LIVE and ACCESSIBLE conductive parts, it provides protection to the extent required by this standard in NORMAL CONDITION and SINGLE FAULT CONDITION.

3.5.5 PROTECTIVE BONDING: Electrical connection of ACCESSIBLE conductive parts and/or of protective screening to provide electrical continuity to the means for connection of an external protective conductor.

3.5.6 NORMAL USE: Operation, including stand by, according to the instructions for use or for the obvious intended purpose.

NOTE – In most cases, NORMAL USE also implies NORMAL CONDITION, because the instructions for use will warn against using the equipment when it is not in NORMAL CONDITION.

3.5.7 NORMAL CONDITION: Condition in which all means for protection against hazards are intact.

3.5.8 SINGLE FAULT CONDITION: Condition in which one means for protection against hazard is defective or one fault is present that could cause a hazard (see 1.2).

NOTE – If a SINGLE FAULT CONDITION results unavoidably in another SINGLE FAULT CONDITION, the two failures are considered as one SINGLE FAULT CONDITION.

3.5.9 OPERATOR: Any person who uses equipment for its intended purpose.

3.6 Insulation

3.6.1 BASIC INSULATION: Insulation, the failure of which could cause a risk of electric shock.

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.

3.6.3 DOUBLE INSULATION: Insulation comprising both BASIC INSULATION and SUPPLEMENTARY INSULATION.

3.6.4 REINFORCED INSULATION: Insulation that provides protection against electric shock not less than that provided by DOUBLE INSULATION. It may comprise several layers that cannot be tested singly as SUPPLEMENTARY INSULATION or BASIC INSULATION.

3.7 Insulation co-ordination

3.7.1 INSTALLATION CATEGORY (OVERVOLTAGE CATEGORY): Classification of parts of installation systems or circuits with standardized limits for transient overvoltages, dependent on the nominal line voltage to earth (see Annex J and IEC 664).

3.7.2 POLLUTION: Any addition of foreign matter, solid, liquid, or gaseous (ionized gases) that may produce a reduction of dielectric strength or surface resistivity.

3.7.3 POLLUTION DEGREE: For the purpose of evaluating CLEARANCES the following two degrees of POLLUTION in the micro-environment are recognized for use with this Part 1.

3.7.3.1 POLLUTION DEGREE 1: No POLLUTION or only dry, non-conductive POLLUTION occurs. The POLLUTION has no influence.

3.7.3.2 POLLUTION DEGREE 2: Normally only non-conductive POLLUTION occurs. Occasionally, however, a temporary conductivity caused by condensation must be expected.

3.7.4 CLEARANCE: The shortest distance in air between two conductive parts.

3.7.5 CREEPAGE DISTANCE: The shortest distance along the surface of the insulating material between two conductive parts [IEV 151-03-37].

3.8 Mains

Where the term "mains" is used in this Part 1 it refers to the electricity supply (above the values of 6.3.2.1) that is available to the consumer from the distribution system or systems for which the equipment concerned is designed.

4 Tests

4.1 General

All tests in this Part 1 are TYPE TESTS to be carried out on samples of equipment or parts. Their only purpose is to check that the design and construction ensure compliance with this Part 1.

Tests on components or parts of the equipment meeting the requirements of the relevant standards specified in this Part 1 and used in accordance with them need not be repeated during TYPE TESTS of the whole equipment.

Compliance with the requirements of this Part 1 is checked by carrying out all applicable tests, except that a test may be omitted where examination of the equipment demonstrates conclusively that the equipment would pass the test. Tests are carried out under:

- *reference test conditions (see 4.3);*
- *specified fault conditions (see 4.4).*

NOTE 1 - If the RATED range of environmental conditions for equipment is wider than that stated in 1.4, the manufacturer should make sure (e.g., by suitable alteration of test requirements or additional tests) that the safety requirements of this Part 1 are still fulfilled.

NOTE 2 - If when carrying out a compliance test, there is any uncertainty about the exact value of the applied or measured quantity (e.g., voltage) due to the tolerance:

- the manufacturer should ensure that at least the specified test value is applied;
- the test house should ensure that no more than the specified test value is applied.

NOTE 3 - Equipment that has been TYPE TESTED may no longer be suitable for its intended function because of the residual effect of stresses resulting from some of the tests. For this reason TYPE TESTS should not be carried out (e.g., by the user) after the equipment has left the manufacturer.

4.2 Sequence of tests

The sequence of tests is optional unless otherwise specified in this Part 1. 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. Where tests under fault conditions may be destructive, these tests may follow those under reference test conditions.

4.3 Reference test conditions

4.3.1 Environmental conditions

Unless otherwise specified in this Part 1, the following environmental conditions, but not conflicting with those of 1.4, shall exist in the test location:

- a temperature of 15°C to 35°C;
- a relative humidity of not more than 75%;
- an air pressure of 75 kPa to 106 kPa;
- no hoarfrost, dew, percolating water, rain, solar irradiation, etc.

4.3.2 State of equipment

Unless otherwise specified, tests shall be carried out on the equipment assembled for NORMAL USE and under the least favorable combination of the conditions given in 4.3.3 to 4.3.16.

When dimensions or mass make it unsuitable to carry out particular tests on a complete equipment, tests on sub-assemblies are allowed, provided it is verified that the assembled equipment will be in accordance with this Part 1.

4.3.3 Position of equipment

The equipment shall be in any position of NORMAL USE and with any ventilation unimpeded.

4.3.4 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.

4.3.5 Covers and removable parts

Covers or parts that can be removed without using a TOOL shall be removed or not removed. Covers that do not require the use of a TOOL for removal need not be removed if they have interlock systems meeting the requirements of Clause 15.

4.3.6 Mains supply

The following requirements apply:

- 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, then any supply voltage within the fluctuation range;
- the frequency shall be any RATED frequency;
- equipment for both a.c. and d.c. shall be connected to an a.c. or d.c. supply;
- equipment for d.c. or single-phase supply shall be connected both with normal and reverse polarity;
- unless the equipment is specified for use only on a non-earthed mains supply, one pole of the reference test supply shall be at or near earth potential;
- where the means of connection permits reversal, battery-operated equipment shall be connected with both reverse and normal polarity.

4.3.7 Input and output voltages

Input and output voltages, including floating voltages but excluding the mains supply voltage, shall be set to any voltage within the RATED voltage range.

4.3.8 Earth TERMINALS

PROTECTIVE CONDUCTOR TERMINALS, if any, shall be connected to earth. FUNCTIONAL EARTH TERMINALS shall be connected or not connected to earth.

4.3.9 Controls

Controls that the OPERATOR can adjust by hand shall be set to any position except that:

- mains selection devices shall be set to the correct value;
- combinations of settings shall not be made if they are prohibited by the manufacturer by marking on the equipment.

4.3.10 Connections

The equipment shall be connected for its intended purpose or not connected for any use whatsoever.

4.3.11 Load on motors

Load conditions of motor-driven parts of equipment shall be in accordance with the intended purpose.

4.3.12 Output

For equipment giving an electrical output:

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

4.3.13 Duty cycle

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

4.3.14 Loading and filling

Equipment intended to be loaded with specified material shall be loaded (filled) with the maximum quantity of the specified material or not loaded (empty).

NOTE – If the specified material would 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.

4.3.15 Heating equipment

When measuring temperatures to evaluate the spread of fire, heating equipment shall be tested in a test corner as required by 9.2.1.

4.3.16 Built-in equipment

When measuring temperatures to evaluate the spread of fire, equipment intended for installation in a cabinet or a wall shall be built in as required by 9.2.2.

4.4 Testing in SINGLE FAULT CONDITION

4.4.1 General

The following requirements apply:

- examination of the equipment and its circuit diagram will generally show the fault conditions that are liable to result in hazards within the meaning of this Part 1 and therefore, shall be applied;
- fault tests shall be made except where it can be demonstrated that no hazard could arise from a particular fault condition;
- the equipment shall be operated under the least favorable combination of reference test conditions (see 4.3). These combinations may be different for different faults and they should be recorded for each test;
- Annex F provides an alternative to testing for protection against spread of fire under fault condition (see 9.1).

4.4.2 Application of fault conditions

Fault conditions shall include those specified in 4.4.2.1 to 4.4.2.12. They shall be applied only one at a time and shall be applied in turn in the most convenient order. Multiple simultaneous faults shall not be applied unless they are a consequence of an applied fault.

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

4.4.2.1 PROTECTIVE IMPEDANCE

The following requirements apply:

- If a PROTECTIVE IMPEDANCE is formed by a combination of components, each component shall be short-circuited or disconnected, whichever is the less favorable;

- If a PROTECTIVE IMPEDANCE is formed by the combination of BASIC INSULATION and a current or voltage limiting device, both the BASIC INSULATION and the current or voltage limiting device shall be subjected to single faults, applied one at a time. BASIC INSULATION shall be short-circuited and the current or voltage limiting device shall be short-circuited or disconnected, whichever is less favorable.

Parts of PROTECTIVE IMPEDANCE that are HIGH INTEGRITY components need not be short-circuited or disconnected (see 6.5.3 and 14.6).

4.4.2.2 Protective conductor

The protective conductor shall be interrupted, except for PERMANENTLY CONNECTED EQUIPMENT or equipment utilizing a connector in accordance with IEC 309.

4.4.2.3 Equipment or parts for short-term or intermittent operation

These shall be operated continuously if continuous operation could occur in a SINGLE FAULT CONDITIONS. It may include motors, relays, other electromagnetic devices, and heaters.

4.4.2.4 Motors

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

4.4.2.5 Capacitors

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

4.4.2.6 Mains transformers

The secondary windings of mains transformers tested as part of the equipment shall be short-circuited and also subjected to any overloads arising from any fault condition according to 4.4.

Windings and sections of tapped windings, which are loaded in NORMAL USE, shall be tested in turn, one at a time, to simulate short circuits in the load. All other windings are loaded or not loaded, whichever load condition of NORMAL USE is the least favorable.

Short-circuits shall be made on the load side of any current-limiting impedance of over-current protective device that is connected directly to the winding.

Requirements and tests for mains transformers tested as separate components are specified in 14.7.

4.4.2.7 Outputs

Outputs shall be short-circuited one at a time.

4.4.2.8 Equipment for more than one supply

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

4.4.2.9 Cooling

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

- air holes with filters shall be closed;
- forced cooling by motor-driven fans shall be stopped;
- cooling by circulation of water or other coolant shall be stopped.

4.4.2.10 Heating devices

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

- timers which limit the heating period shall be overridden to energize the heating circuit continuously;
- temperature controllers, except for over-temperature protection devices meeting the requirements of 14.3, shall be overridden to energize the heating circuit continuously;
- loss of cooling liquid shall be simulated.

4.4.2.11 Insulation between circuits and parts

The insulation between circuits and parts listed in Annex G shall be short-circuited unless it has been checked as specified in 9.1.

4.4.2.12 Interlocks

Each part of an interlock system for the protection of OPERATORS shall be short-circuited or open-circuited in turn if the system prevents access to hazards (see 1.2) when a cover, etc. is removed without the use of a TOOL.

HIGH INTEGRITY components of interlock systems (see 14.6 and 15.3) need not be short-circuited or open-circuited.

4.4.3 Duration of tests

4.4.3.1 The equipment shall be operated until further change as a result of the applied fault is unlikely. Each test is normally limited to 1 h since any secondary fault arising from a SINGLE FAULT CONDITION will usually manifest itself within that time. If at the end of 1 h there is an indication that a risk of electric shock, spread of fire, or injury to persons may eventually occur, the test shall be continued until one of these hazards does occur or for a maximum period of 4 h.

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

4.4.3.3 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. Evaluation with the pre-arcing time/current characteristics shall be made to find out whether the minimum operating current of the fuse is reached or exceeded 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 above.

4.4.4 Compliance

4.4.4.1 *Compliance with requirements for electric shock protection is checked:*

- *by making the measurements of 6.3.2*;
- *by a voltage test as specified in 6.8.4 for DOUBLE INSULATION or REINFORCED INSULATION, but with the test voltage for BASIC INSULATION only*.

NOTE – The test of BASIC INSULATION simulates the SINGLE FAULT CONDITION of failure of one level of DOUBLE INSULATION or partial failure of REINFORCED INSULATION.

4.4.4.2 *Compliance with requirements for temperature protection is checked by determining the temperature of the outer surface of the ENCLOSURE and of parts that can easily be touched.*

Except for heated surfaces of heating equipment, the temperature of these parts shall not exceed 105°C in an ambient temperature of 40°C (see 1.4).

This temperature is determined by measuring the temperature rise of the surface or part and adding it to 40°C.

4.4.4.3 *Compliance 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 that is not of importance according to the requirements of this Part 1 shall be ignored.*

4.4.4.4 *Compliance with the requirements for protection against the other hazards listed in 1.2 is checked as specified in Clauses 7 to 15.*

5 Marking and documentation

5.1 Marking

5.1.1 General

Equipment shall bear markings in accordance with 5.1.2 to 5.2. 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 that can be removed by an OPERATOR without the use of a TOOL.

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

Letter symbols for quantities and units shall be in accordance with IEC 27. Graphic symbols shall be in accordance with Table 1.

NOTE – Except on HAND-HELD EQUIPMENT or where space is limited, markings should not be on the bottom of the equipment.

Compliance is checked by inspection.

5.1.2[*NF*] Identification

The equipment shall, as a minimum, be identified by:

- manufacturer's name or registered trade mark;
- model number, name, or other means to identify the equipment.

5.1.3 Mains supply

The equipment shall be marked with the following information;

[*NF*] See corresponding clause in National Foreword

a) Nature of supply:

- a.c.: RATED mains frequency or range of frequencies;
- d.c.: with symbol 1 of Table 1.

NOTE – The documentation should give the INSTALLATION CATEGORY (OVERVOLTAGE CATEGORY) for which the equipment is intended (this is related to the ability to withstand transient overvoltages). For information purposes it may also be useful to mark:

- a.c. equipment 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 value(s) of the supply voltage(s) or the RATED range of the supply voltages.

NOTE – The permitted fluctuation from the RATED value(s) may also be marked.

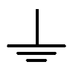
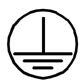
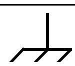
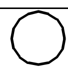
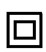
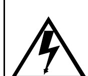
c) The maximum RATED power in watts (active power) or volt-amperes (apparent power), or the maximum RATED input current, with all accessories or plug-in modules connected.

d) Equipment that the OPERATOR can set for different RATED supply voltages shall be provided with means for the indication of the voltage for which the equipment is set. For PORTABLE EQUIPMENT, the indication shall be visible from the exterior. If the equipment is so constructed that the OPERATOR can alter the supply voltage setting without the use of a TOOL, the action of changing the setting shall also change the indication.

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

Compliance is checked by inspection and by measurement of power or input current to check the marking of 5.1.3 c). The measurement is made under reference test conditions (see 4.3), except that the equipment is connected to its RATED supply voltage. The measured value shall not exceed the marked value by more than 10%.

Table 1[NF]

Number	Symbol	Publication	Description
1		IEC 417, No. 5031	Direct current
2		IEC 417, No. 5032	Alternating current
3		IEC 417, No. 5033	Both direct and alternating current
4	3 	IEC 617-2, No. 02-02-06	Three-phase alternating current
5		IEC 417, No. 5017	Earth (ground) TERMINAL
6		IEC 417, No. 5019	PROTECTIVE CONDUCTOR TERMINAL
7		IEC 417, No. 5020	Frame or chassis TERMINAL
8		IEC 417, No. 5021	Equipotentiality
9		IEC 417, No. 5007	On (Supply)
10		IEC 417, No. 5008	Off (Supply)
11		IEC 417, No. 5172	Equipment protected throughout by DOUBLE INSULATION OR REIN-FORCED INSULATION (equivalent to Class II of IEC 536 — see annex H)
12	 Background color — yellow; symbol and outline — black	ISO 3864, No. B.3.6	Caution, risk of electric shock
13	Symbol under consideration		Easily-touched higher temperature parts
14	 Background color — yellow; symbol and outline — black	ISO 3864, No.B.3.1	Caution (refer to accompanying docu-ments)

NOTE – Color requirements for symbols 12 and 14 do not apply to markings on equipment, providing that the symbol is molded or engraved to a depth or raised height of 0.5 mm. The symbol should be sufficiently large to ensure that it will be noticed when necessary.

[NF] See corresponding clause in National Foreword

5.1.4 Fuses

For any fuses that may be replaced by an OPERATOR there shall be a marking beside the fuseholder specifying the current RATING and type, such as indication of rupturing speed, for example by the codes of IEC 127 (see note below). For fuses not replaceable by the OPERATOR the same information shall be provided in the documentation (see 5.4.5).

NOTE – The letter and color codes of IEC 127 are as follows:

- very quick acting:	FF, or black;
- quick acting:	F, or red;
- medium time-lag:	M, or yellow;
- time-lag:	T, or blue;
- long time-lag:	TT, or grey.

Compliance is checked by inspection.

5.1.5 Measuring circuit TERMINALS

Unless a clear indication is provided on a measuring instrument that it is not intended to be connected to voltages to earth above 50 V a.c. or 120 V d.c., the measuring input circuit TERMINALS for connection by an OPERATOR and used for voltage or current measurement shall be marked with the maximum RATED voltage to earth. An exception is permitted for circuit TERMINALS (connectors) that are dedicated only for connection to specific TERMINALS of other equipment if a means for identifying these TERMINALS is provided.

Examples of acceptable indications that the inputs in all cases are intended to be less than 50 V a.c. or 120 V d.c. to earth include:

- the full scale deflection marking of a single range indicating voltmeter or maximum marking of a multi-range voltmeter;
- the maximum range marking of a voltage selector switch;
- the marked intended function of the instrument (e.g., "millivoltmeter").

Marking shall be placed adjacent to the TERMINALS. However, if there is insufficient space (as in multi-input equipment), it is permissible for the marking to be on the RATING plate or scale plate or for the TERMINAL to be marked with symbol 14 of Table 1.

Compliance is checked by inspection.

5.1.6 TERMINALS and operating devices

Where necessary for safety, TERMINALS, connectors, controls, and indicators shall be identified by words or symbols indicating their purpose, including any sequence of operations. Where there is insufficient space for such marking, symbol 14 of Table 1 may be used.

NOTE – For additional information see IEC 445 and 447.

The following TERMINALS and operating devices 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 adjacent to or on the TERMINAL.

c) TERMINALS of measuring and control circuits that are permitted by 6.6.3 to be connected to ACCESSIBLE conductive parts with symbol 7 of Table 1 if this connection is not 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 where it is likely that the OPERATOR could make such a connection inadvertently.

d) TERMINALS supplied from the interior of the equipment and that are HAZARDOUS LIVE, with the voltage, current, charge or energy value or range, or with symbol 14 of Table 1. This requirement does not apply to mains supply outlets where a standard mains socket outlet is used.

e) ACCESSIBLE FUNCTIONAL EARTH TERMINALS connected to ACCESSIBLE conductive parts, with an indication that this is the case, unless it is self-evident, symbol 8 of Table 1 is acceptable for this marking.

f) The on-position or off-position or both of the power supply switch or circuit-breaker, if any, shall be clearly marked and may be suitable as the device identification, (see 6.12.3.1). An indicator lamp is not considered to be a satisfactory marking.

NOTE - Symbols 9 and 10 of Table 1 may be used for this purpose and should not be used to mark other switches.

Compliance is checked by inspection.

5.1.7 Equipment protected by DOUBLE INSULATION or REINFORCED INSULATION

Equipment protected throughout by DOUBLE INSULATION or REINFORCED INSULATION (see Annex H) shall be marked with symbol 11 of Table 1 unless it is provided with a PROTECTIVE CONDUCTOR TERMINAL.

Equipment that is only partially protected by DOUBLE INSULATION or REINFORCED INSULATION shall not bear symbol 11 of Table 1.

Compliance is checked by inspection.

5.1.8 Battery charging

Equipment that has means for charging rechargeable batteries and where non-rechargeable cells could be fitted and connected in the battery compartment shall be marked in or near the compartment to warn against the charging of non-rechargeable batteries and to indicate the type of rechargeable battery that can be used with the recharging circuit.

NOTE – An acceptable marking is symbol 14 of Table 1.

Compliance is checked by inspection.

5.2[NF] Warning markings

Warning markings shall be visible when the equipment is ready for NORMAL USE.

If it is necessary for the OPERATOR to refer to the instruction manual to preserve the protection afforded by the equipment, the equipment shall be marked with the symbol 14 of Table 1. If a warning applies to a particular part of the equipment, the marking shall be placed on or near to this part.

A warning shall advise the OPERATOR of precautions to be taken to avoid contact with HAZARDOUS LIVE parts that are ACCESSIBLE according to the exceptions of 6.1.1.

[NF] See corresponding clause in National Foreword

TERMINALS that are supplied from the interior of the equipment at a voltage exceeding 1 kV or allow connection to a voltage exceeding 1 kV (see 6.6.2) shall be marked with symbol 12 of Table 1.

Unless their heated state is self-evident or is obvious from the function of the equipment, parts that are easily touched and are also permitted by 9.1 to exceed the temperature limits of Table 3 shall be marked with symbol 13 of Table 1.

Warnings shall advise OPERATORS if a hazard (see 1.2) will continue for more than 2 s after the activation of an interlock system (see 15.1).

NOTE 1 - Warnings necessary for safety should contrast well with the background (see Table 1).

NOTE 2 - Warning markings relating to batteries are specified in 5.1.8 and 13.2.2.

Compliance is checked by inspection.

5.3 Durability of markings

Markings in accordance with 5.1.2 to 5.2 shall remain clear and legible under conditions of NORMAL USE and resist the effects of cleaning agents specified by the manufacturer.

Compliance is checked by inspection and by performing the following test for durability of markings on the outside of the equipment. The markings are rubbed by hand, without undue pressure, first for 15 s with a cloth soaked with the specified cleaning agent (or, if not specified, with water) and then for 15 s with a cloth soaked with isopropyl alcohol.

The markings shall be clearly legible after the above treatment, and adhesive labels shall not have worked loose or become curled at the edges.

5.4 Documentation

5.4.1 General

Equipment shall be accompanied by documentation for safety purposes as follows:

- technical specification;
- instructions for use;
- name and address of manufacturer or supplier from whom technical assistance may be obtained;
- the information specified in 5.4.2 to 5.4.5.

Where applicable, warning statements and a clear explanation of warning symbols marked on the equipment shall be provided in the documentation. Alternatively, such information shall be durably and legibly marked on the equipment.

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

Compliance is checked by inspection.

5.4.2 Equipment RATINGS

Documentation shall include the following:

- the supply voltage or voltage range, frequency or frequency range, and power or current RATING;
- a description of all input and output connections;

- the RATING of the insulation of external circuits, appropriate for SINGLE FAULT CONDITIONS, when such circuits are nowhere ACCESSIBLE (see 6.6);
- a statement of the range of environmental conditions for which the equipment is designed (see 1.4 and Note 1 of 4.1).

Compliance is checked by inspection.

5.4.3 Equipment installation

Documentation shall include the following installation and specific commissioning instructions as appropriate:

- assembly, location, and mounting requirements;
- instruction for protective earthing;
- connections to the supply;
- ventilation requirements;
- requirements for special services, for example air, cooling liquid.

For PERMANENTLY CONNECTED EQUIPMENT, additional information shall include:

- supply wiring requirements;
- requirements for any external switch or circuit-breaker (see 6.12.2.1) and external overcurrent protection devices (see 9.6) and a recommendation that the switch or circuit-breaker be near the equipment.

Compliance is checked by inspection.

5.4.4 Equipment operation

Instructions for use shall include:

- identification of operating controls and their use in all operating modes;
- instructions for interconnection to accessories and other equipment, including indication of suitable accessories, detachable parts, and any special materials;
- specification of limits for intermittent operation, where applicable;
- an explanation of symbols required by this Part 1 and used on the equipment;
- instructions for replacement of consumable materials;
- instructions for cleaning (see 11.2).

The user shall be made aware that, if the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

Compliance is checked by inspection.

5.4.5 Equipment maintenance

Instructions for the user concerning preventive maintenance and inspection necessary for safety shall be given in sufficient detail.

For equipment using batteries, the specific battery type shall be stated (see also 5.1.8).

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

The RATING and characteristics of fuses used shall be stated (see 5.1.4).

Compliance is checked by inspection.

6 Protection against electric shock

6.1 General

Protection against electric shock shall be maintained in NORMAL CONDITION (see 6.4) and SINGLE FAULT CONDITION (see 6.5). ACCESSIBLE parts of equipment shall not be HAZARDOUS LIVE (see 6.3).

NOTE – Annex H relates the safety requirements of this Part 1 to equipment safety classification used in other standards.

Compliance is checked by the determination of 6.2 and the measurements of 6.3, followed by the tests of 6.4 to 6.12.

6.1.1 Exceptions

The following HAZARDOUS LIVE parts are permitted to be ACCESSIBLE to the OPERATOR during NORMAL USE:

- parts of lamps and lamp sockets after lamp removal;
- parts intended to be replaced by the OPERATOR (e.g., batteries) and that 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 in accordance with 5.2;
- TERMINALS and sockets of operating and measuring circuits, if it is unavoidable for operating reasons that they are both ACCESSIBLE and HAZARDOUS LIVE. (This exception does not apply to the TERMINALS listed in 6.6.2.)

If any of these parts receive a charge from an internal capacitor, they shall not be HAZARDOUS LIVE 10 s after interruption of the supply.

NOTE 1 - Excepted TERMINALS should be protected as far as possible against unintentional contact, by covering or recessing, or by position or arrangement.

NOTE 2 - See 5.2 for warning markings for ACCESSIBLE parts that are HAZARDOUS LIVE and 5.4.1 for warning statements in the documentation.

Where a charge is received from an internal capacitor, compliance is checked by the measurements of 6.3 to establish that the levels of 6.3.1.3 are not exceeded.

6.2 Determination of ACCESSIBLE parts

Unless obvious, determination of whether a part is ACCESSIBLE shall be made as specified in 6.2.1 to 6.2.3. Test fingers (Annex B) and pins shall be applied without force unless a force is specified. Parts touched with a test finger or pin are considered to be ACCESSIBLE.

However, on equipment accepting plug-in modules, parts are not considered to be ACCESSIBLE if they cannot be touched with the jointed test finger (see 6.2.1) up to a depth of 180 mm from the opening in the equipment, nor if they are at a depth of more than 180 mm from the opening.

If the OPERATOR is intended to perform any actions in NORMAL USE (with or without a TOOL) that will increase the accessibility of parts, such actions shall be taken before performing the examinations of 6.2.1 to 6.2.3. Examples include:

- removing covers;
- opening doors;

- adjusting controls;
- replacing consumable material;
- removing parts.

For rack and panel mounted equipment the equipment shall be installed according to the manufacturer's instructions before making the examinations of 6.2.1 to 6.2.3. For such equipment, the OPERATOR is assumed to be in front of the panel.

6.2.1 General examination

The jointed test finger (see Annex B, Figure B.2) shall be applied in every possible position. Where a part could become ACCESSIBLE by applying a force, the rigid test finger (see Annex B, Figure B.1) shall be applied with a force of 10 N. The force shall be exerted by the tip of the test finger so as to avoid wedge and lever action. The test shall be applied to all outer surfaces, including the bottom.

6.2.2 Openings above parts which are HAZARDOUS LIVE

A metal test pin 100 mm long and 4 mm in diameter shall be inserted in any openings above parts which are HAZARDOUS LIVE. The test pin shall be suspended freely and allowed to penetrate up to 100 mm. The additional safety measures of 6.5 for protection in SINGLE FAULT CONDITION are not required solely because a part is ACCESSIBLE by this test only.

6.2.3 Openings for pre-set controls

A metal test pin 3 mm in diameter shall be inserted through holes intended to give access to pre-set controls that require the use of a screwdriver or other TOOL. The test pin shall be 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 Permissible limits for ACCESSIBLE parts

To ensure that ACCESSIBLE parts are not HAZARDOUS LIVE, the voltage, current, charge, or energy between an ACCESSIBLE part and reference test 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 values of 6.3.1 in NORMAL CONDITION nor of 6.3.2 in SINGLE FAULT CONDITION.

The ACCESSIBLE voltage shall be measured. If the voltage is below the limit of 6.3.1 or 6.3.2 as applicable, ACCESSIBLE current and capacitance need not be measured. If the voltage exceeds that value, the current and capacitance shall be measured.

6.3.1 Values in NORMAL CONDITION

Values above the levels of 6.3.1.1 to 6.3.1.3 in NORMAL CONDITION are deemed to be HAZARDOUS LIVE.

6.3.1.1 Voltage

The voltage levels are 30 V r.m.s. and 42.4 V peak or 60 V d.c.

6.3.1.2 Current

If the voltage exceeds one of the values of 6.3.1.1, the current levels are:

- 0.5 mA r.m.s. for sinusoidal waveforms, 0.7 mA peak for non-sinusoidal waveform or mixed frequencies, or 2 mA d.c., when measured with measuring circuit A.1 of Annex A. Alternatively measuring circuit A.2 can be used if the frequency does not exceed 100 Hz;

- 70 mA r.m.s. when measured with measuring circuit A.3. This relates to possible burns at higher frequencies.

6.3.1.3 Capacitance

If the voltage exceeds one of the values of 6.3.1.1, the capacitance levels are:

- 45 µC charge for voltages up to 15 kV peak or d.c.;
- 350 mJ stored energy for voltages above 15 kV peak or d.c.

6.3.2 Values in SINGLE FAULT CONDITION

Values above the following levels in SINGLE FAULT CONDITION are deemed to be HAZARDOUS LIVE.

6.3.2.1 Voltage

The voltage levels are 50 V r.m.s. and 70 V peak or 120 V d.c.

Where the voltage is transient, the levels are those of Figure 1, measured across a 50 kΩ resistor.

6.3.2.2 Current

If the voltage exceeds one of the values of 6.3.2.1, the current levels are:

- 3.5mA r.m.s. for sinusoidal waveforms, 5 mA peak for non-sinusoidal waveforms or mixed frequencies, or 15 mA d.c., when measured with measuring circuit A1. Alternatively measuring circuit A2 can be used if the frequency does not exceed 100 Hz;
- 500 mA r.m.s. when measured with measuring circuit A3. This relates to possible burns at higher frequencies.

6.3.2.3 Capacitance

If the voltage exceeds one of the values of 6.3.2.1, the capacitance level is that of Figure 2.

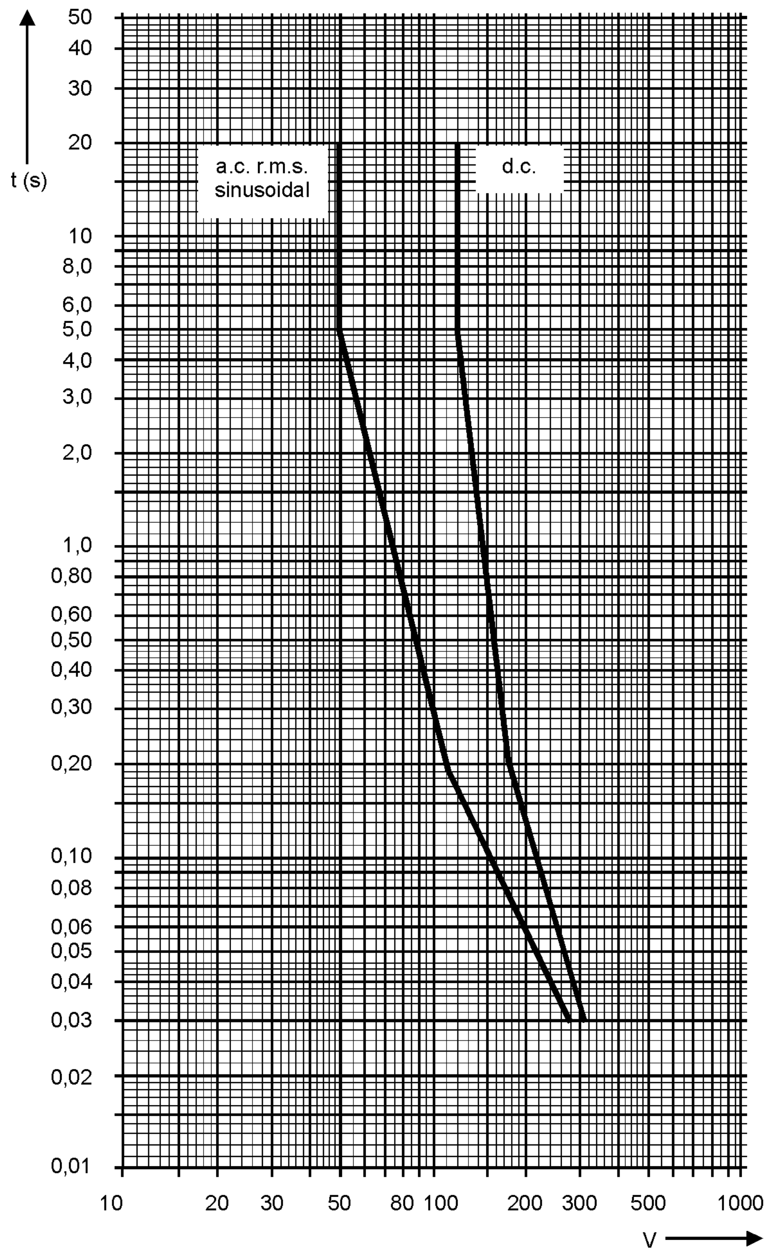


Figure 1 — Maximum duration of transient ACCESSIBLE voltages in SINGLE FAULT CONDITION (see 6.3.2.1)

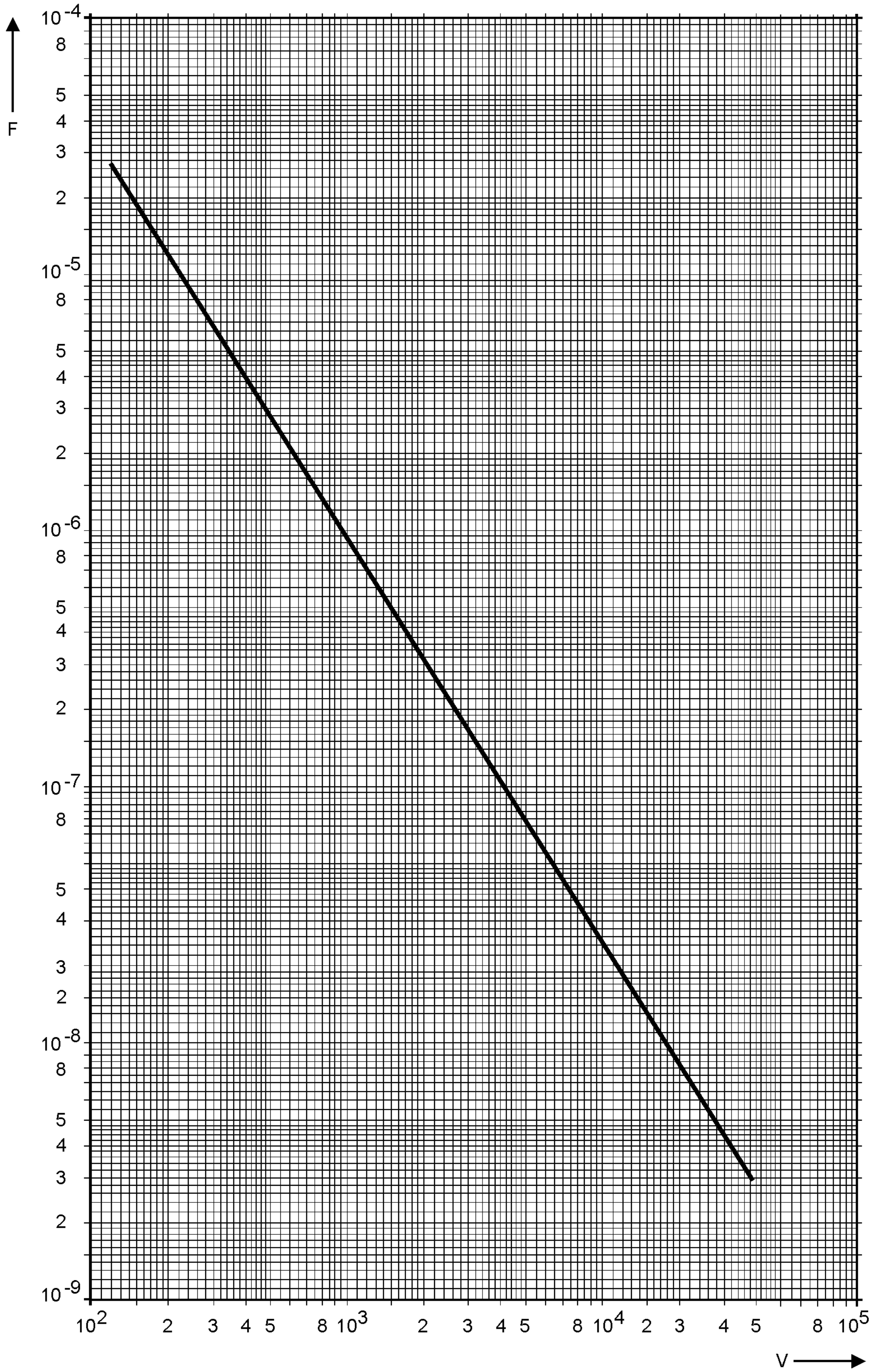


Figure 2 — Charged capacitance level in SINGLE FAULT CONDITION (see 6.3.2.3)

6.4 Protection in NORMAL CONDITION

Accessible parts shall be prevented from becoming HAZARDOUS LIVE by one or more of the following means:

- BASIC INSULATION (see Annex E);
- ENCLOSURES or BARRIERS;
- PROTECTIVE IMPEDANCE (see 6.5.3).

NOTE – Materials which can easily be damaged are not considered to provide suitable insulation. Examples include lacquer, enamel, oxides, anodic films, also non-impregnated materials such as paper, fibers, fibrous material, and wood.

ENCLOSURES and BARRIERS shall meet the rigidity requirements of 8.1. If ENCLOSURES or BARRIERS provide protection by insulation, it shall meet the requirements of BASIC INSULATION.

CLEARANCES, CREEPAGE DISTANCES, and insulation between ACCESSIBLE parts and HAZARDOUS LIVE parts shall meet the requirements of 6.7 and the values for BASIC INSULATION specified in Tables D.1 to D.6

NOTE 1 - CLEARANCES and CREEPAGE DISTANCES necessary for safety can be checked by measurement, except as specified in D.5 and D.7.

NOTE 2 - Solid insulation necessary for safety can be checked by applying the test voltage of Annex D appropriate to the working voltage. The thickness required for solid insulation can be determined from the test voltage it must withstand. Partial discharge testing may also be appropriate (See IEC 664).

NOTE 3 - Under mechanical or thermal stress conditions, insulation may have to be increased to meet the requirements of Clauses 7, 8 and 9.

Compliance is checked:

- by the determination of 6.2;
- by the tests of 6.8 for dielectric strength of BASIC INSULATION;
- by the test of 8.1 for rigidity of ENCLOSURES and BARRIERS.

6.5 Protection in SINGLE FAULT CONDITION

Additional protection shall be provided to ensure that ACCESSIBLE parts are prevented from becoming HAZARDOUS LIVE in SINGLE FAULT CONDITION. The protection shall consist of one or more of the protective means specified in 6.5.1 to 6.5.3, except as specified in 6.5.4, or by automatic disconnection of the supply in case of a fault.

NOTE 1 - Protective devices that automatically disconnect equipment from its supply source are normally part of the building installation but can form part of the equipment.

NOTE 2 - Protective earthing (see 6.5.1.) requires co-ordination of the type of system earthing, the characteristics of protective devices, and the impedance of the earth path. For means of system earthing and for automatic disconnection of the supply, see IEC 364-4-41, 413.1. However, if DOUBLE INSULATION or REINFORCED INSULATION (see 6.5.2) is used throughout, co-ordination with the system or the installation is not required.

Compliance is checked as specified in 6.5.1 to 6.5.3.

6.5.1 Protective earthing

ACCESSIBLE conductive parts shall be bonded to the PROTECTIVE CONDUCTOR TERMINAL if they could become HAZARDOUS LIVE in case of a single fault of the primary protective means specified in 6.4. Alternatively, such ACCESSIBLE parts shall be separated from parts that are HAZARDOUS LIVE by a conductive protective screen or BARRIER bonded to the PROTECTIVE

CONDUCTOR TERMINAL. For measuring and test equipment, indirect bonding is permitted as an alternative to direct bonding (see 6.5.1.4).

ACCESSIBLE conductive parts need not be bonded to the PROTECTIVE CONDUCTOR TERMINAL if they are separated from all HAZARDOUS LIVE parts by DOUBLE INSULATION or REINFORCED INSULATION.

Compliance is checked by inspection.

6.5.1.1 PROTECTIVE BONDING

PROTECTIVE BONDING shall consist of directly connected structural parts or discrete conductors, or both. It shall withstand all thermal and dynamic stresses to which it could be subjected before one of the overcurrent protection means (see 9.6) disconnects the equipment from the supply.

Compliance is checked by inspection and, when necessary, by measurement of the cross-sectional area of bonding conductors.

6.5.1.2 Bonding impedance 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. Mains cord impedance does not form part of the specified bonding impedance.

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

- 25 A d.c. or r.m.s. at RATED mains frequency;
- 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 between the supply and the overcurrent protection devices cannot become connected to ACCESSIBLE conductive parts in the case of a single fault, the current for the bonding impedance measurement shall not exceed twice the RATED current of the internal overcurrent protection devices.

6.5.1.3 Bonding impedance of PERMANENTLY CONNECTED EQUIPMENT

Bonding of PERMANENTLY CONNECTED EQUIPMENT shall be of low impedance.

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

If the equipment contains overcurrent protection devices for all poles of the mains supply, and if the wiring between the supply and the overcurrent protection devices cannot become connected to ACCESSIBLE conductive parts in the case of a single fault, the current for the bonding impedance measurement shall not exceed twice the RATED current of the internal overcurrent protection devices.

6.5.1.4 Indirect bonding for measuring and test equipment

Indirect bonding establishes a connection between the PROTECTIVE CONDUCTOR TERMINAL and ACCESSIBLE conductive parts when these become HAZARDOUS LIVE as a result of a fault. Devices to establish indirect bonding are:

a) Voltage limiting devices that become conductive when the voltage across them exceeds 50 V r.m.s., 70 V peak, or 120 V d.c., with overcurrent protection to prevent breakdown of the device.

Compliance is checked by connecting the ACCESSIBLE conductive parts to the mains supply TERMINALS while the equipment is connected to the mains supply as in NORMAL USE. The voltage between the ACCESSIBLE conductive parts and the PROTECTIVE CONDUCTOR TERMINAL shall not exceed 50 V r.m.s., 70 V peak, or 120 V d.c. for more than 0.2 s.

b) Voltage-sensitive tripping devices that interrupt all poles of the mains supply, and connect the ACCESSIBLE conductive parts to the PROTECTIVE CONDUCTOR TERMINAL whenever the voltage across them exceeds 50 V r.m.s., 70 V peak, or 120 V d.c.

Compliance is checked by applying a voltage of 50 V r.m.s., 70 V peak, or 120 V d.c. between the ACCESSIBLE conductive parts and the PROTECTIVE CONDUCTOR TERMINAL. The tripping action shall take place within 0.2 s.

6.5.2 DOUBLE INSULATION and REINFORCED INSULATION

CLEARANCES and CREEPAGE DISTANCES forming part of DOUBLE INSULATION or REINFORCED INSULATION shall meet the applicable requirements of Annex D and shall pass the dielectric strength test of 6.8 (see Annex E). ENCLOSURES shall meet the requirements of 6.9.2.

NOTE 3 - CLEARANCES and CREEPAGE DISTANCES necessary for safety can be checked by measurement, except as specified in D.5 and D.7.

NOTE 4 - Solid insulation necessary for safety can be checked by applying the test voltage of Annex D appropriate to the working voltage. The thickness required for solid insulation can be determined from the test voltage it must withstand. Partial discharge testing may also be appropriate (see IEC 664).

NOTE 5 - Under mechanical or thermal stress conditions, insulation may have to be increased to meet the requirements of Clauses 7, 8 and 9.

Compliance is checked as specified in 6.7, 6.8 and 6.9.2. The parts of DOUBLE INSULATION are tested separately if this is possible; the tests for REINFORCED INSULATION are otherwise used.

6.5.3 PROTECTIVE IMPEDANCE

A PROTECTIVE IMPEDANCE shall be one or more of the following, so that ACCESSIBLE conductive parts cannot become HAZARDOUS LIVE as a result of a SINGLE FAULT CONDITION:

- an appropriate HIGH INTEGRITY single component (see 14.6);
- a combination of components;
- a combination of BASIC INSULATION and a current or voltage limiting device.

Components, wires, and connections shall be RATED according to the requirements for both NORMAL CONDITION and SINGLE FAULT CONDITION.

Compliance is checked by inspection and by the measurements of 6.3 in SINGLE FAULT CONDITION (see 4.4.2.1).

6.5.4 Built-in equipment

Equipment intended exclusively to be fixed and built-in is not required to meet the requirements of 6.5.1 to 6.5.3 provided that:

- the equipment has no ACCESSIBLE conductive parts;

- ACCESSIBLE surfaces are separated from HAZARDOUS LIVE parts at least by BASIC INSULATION;
- ACCESSIBLE surfaces of parts intended to be grasped are separated from HAZARDOUS LIVE parts by DOUBLE INSULATION or REINFORCED INSULATION.

6.6 External circuits

6.6.1 Separation of internal circuits

If an internal circuit that is not HAZARDOUS LIVE in NORMAL USE is intended for connection to an external circuit, separation shall be provided between this externally connected internal circuit and other internal circuits to prevent the external circuit from becoming HAZARDOUS LIVE in NORMAL CONDITION or SINGLE FAULT CONDITION.

Circuits that do not exceed the values of 6.3.2 in NORMAL CONDITION and SINGLE FAULT CONDITION and that are ACCESSIBLE at external TERMINALS shall be separated from other internal circuits having values above those of 6.3.1 in NORMAL CONDITION. BASIC INSULATION is sufficient if the other internal circuit does not exceed the values of 6.3.2 in NORMAL CONDITION. If the values of 6.3.2 are exceeded in NORMAL CONDITION, one of the following means shall be applied:

- DOUBLE INSULATION or REINFORCED INSULATION (see Annex E);
- PROTECTIVE IMPEDANCE;
- BASIC INSULATION and protective screening (see Annex E);
- BASIC INSULATION and PROTECTIVE BONDING, provided the protected circuit is of such low impedance that it will not become HAZARDOUS LIVE in a SINGLE FAULT CONDITION of the other internal circuit (see Annex E).

Even if the other internal circuit exceeds the values of 6.3.2 in NORMAL CONDITION, BASIC INSULATION is sufficient if the TERMINAL (socket, connector, etc.) for the external circuit has no live parts that are ACCESSIBLE and if the manufacturer's instructions (see 5.4.3 and 5.4.4) include the following:

- a statement that the TERMINAL is for use only with equipment that has no live parts that are ACCESSIBLE;
- the RATING of the insulation required for external circuits, making it clear that the insulation must be suitable for SINGLE FAULT CONDITION;
- the connection to be used at the remote end of external circuits;
- the type of equipment that may be connected to the TERMINAL, unless the specified connection complies with or is specified by an IEC standard.

These requirements do not apply if short-circuiting between the two circuits could not cause the external circuit to become HAZARDOUS LIVE.

NOTE – Annex E gives the examples of circuits and the separation required between them; 9.1 and Annex G gives additional requirements for the separation or circuits to prevent fire.

Compliance is checked by inspection and by the dielectric strength tests of 6.8.

6.6.2 TERMINALS for external circuits

ACCESSIBLE TERMINALS shall not be HAZARDOUS LIVE, except as permitted by 6.1.1.

NOTE – TERMINALS can contain one or several contacts (see 3.2.1) and the term therefore includes sockets, connectors, etc.

The following TERMINALS shall not be HAZARDOUS LIVE and the exceptions of 6.1.1 do not apply:

- PROTECTIVE CONDUCTOR TERMINALS
- FUNCTIONAL EARTH TERMINALS (measuring earth TERMINALS);
- TERMINALS for headphones.

TERMINALS which receive a charge from an internal capacitor shall not be HAZARDOUS LIVE 10 s after interruption of the supply (see 6.10.3).

The following TERMINALS energized from the interior shall not be ACCESSIBLE, and the exceptions of 6.1.1 do not apply:

- TERMINALS with HAZARDOUS LIVE voltage exceeding 1 kV;
- TERMINALS with floating voltage exceeding 1 kV.

Compliance is checked by inspection, and by the determination of 6.2 and the measurements of 6.3.

6.6.3 Circuits with TERMINALS that are HAZARDOUS LIVE

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

If such a circuit is also designed to be operated with one ACCESSIBLE TERMINAL contact (signal low) floating at a voltage that 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.

Compliance is checked by inspection.

6.7^{NF} CLEARANCES and CREEPAGE DISTANCES

CLEARANCES and CREEPAGE DISTANCES between circuits and parts shall be at least those specified in Annex D.

Compliance is checked by inspection and measurement. When determining a CLEARANCE or CREEPAGE DISTANCE to ACCESSIBLE parts, the ACCESSIBLE surface of an insulating ENCLOSURE is considered to be conductive as if it was covered by metal foil wherever it can be touched with a standard test finger (see Annex B).

To simulate a possible reduction in CLEARANCE or CREEPAGE DISTANCE, the rigid test finger is used during measurement to apply a force of 10 N to any point on bare conductors connected to TERMINALS and a force of 30 N to the outside of ENCLOSURES.

6.8 Dielectric strength tests

Compliance with the requirements of 6.4 to 6.6 is checked by dielectric strength tests between all parts where BASIC INSULATION, DOUBLE INSULATION, or REINFORCED INSULATION are specified for protection against electric shock (see Annex E).

Where protection against spread of fire is assured by separation of circuits, compliance with the requirements of 9.1 is checked by dielectric strength tests between the circuits and parts listed in Annex G.

6.8.1 Reference test earth

The reference test earth is the reference point for voltage tests. It is one or more of the following, bonded together if more than one:

- any PROTECTIVE CONDUCTOR TERMINAL of FUNCTIONAL EARTH TERMINAL;

- any ACCESSIBLE conductive part, except for any live parts permitted to be ACCESSIBLE because they do not exceed the values of 6.3.1. Such live parts are bonded together but do not form part of the reference test earth;
- any ACCESSIBLE insulating part of the ENCLOSURE, covered with metal foil everywhere except around TERMINALS. For test voltages up to 10 kV a.c. peak or d.c., the distance from foil to TERMINAL is not more than 20 mm. For higher voltages the distance is the minimum to prevent flashover;
- ACCESSIBLE parts of controls with parts made of insulating material being wrapped in metal foil or having soft conductive material pressed against them.

6.8.2 Humidity preconditioning

To ensure that equipment will not become hazardous in the humidity conditions of 1.4, it is subjected to humidity preconditioning before the voltage tests of 6.8.4. The equipment is not operated during preconditioning.

If wrapping in foil is required by 6.8.1, the foil is not applied until after humidity preconditioning and recovery.

Electrical components, covers, and other parts that can be removed by hand are removed and subjected to the humidity preconditioning together with the main part.

Preconditioning is carried out in a humidity chamber containing air with a humidity of 92.5% r.h. ± 2.5% r.h. The temperature of the air in the chamber is maintained at 40°C ± 2°C.

Before applying humidity, the equipment is brought to a temperature of 42°C ± 2°C, normally by keeping it at this temperature for at least 4 h before the humidity preconditioning.

The air in the chamber is stirred and the chamber is designed so that condensation will not precipitate on the equipment.

The equipment remains in the chamber for 48 h, after which it is removed and allowed a recovery period of 2 h under the environmental conditions of 4.3.1, with the covers of non-ventilated equipment removed.

6.8.3 Conduct of tests

The tests specified in 6.8.4 are performed and completed within 1 h of the end of the recovery period after humidity preconditioning. The equipment is not operated during the tests.

Voltage tests are not made between two circuits or between a circuit and an ACCESSIBLE conductive part, if they are connected to each other or not separated from each other.

PROTECTIVE IMPEDANCE in parallel with the insulation to be tested is disconnected.

Where two or more protective means are used in combination (see 6.5 and 6.6.1), the voltages specified for DOUBLE INSULATION and REINFORCED INSULATION could be applied to parts of circuits that are not required to withstand these voltages. To avoid this, such parts may be disconnected during the tests, or the parts of circuits where DOUBLE INSULATION or REINFORCED INSULATION is required may be tested separately.

6.8.4 Voltage tests

Voltage tests are applied, using the values specified in Annex D. No breakdown or repeated flashover shall occur. Corona effects and similar phenomena are disregarded.

The a.c., d.c., and peak impulse tests are alternative test methods. It is sufficient that the equipment passes any one of the three. For example, a.c. may be chosen for simplicity, d.c. to avoid capacitive currents, or the impulse test to reduce power dissipation in components.

Impulse tests are the 1.2/50 µs test specified in IEC 60, conducted for a minimum of 3 pulses of each polarity at 1 s minimum intervals.

The a.c. and d.c. tests are conducted with the voltage raised gradually over a period of 10 s or less to the specified value so that no appreciable transients occur, then maintained for 1 min.

NOTE 1 - When testing circuits, it may not be possible to separate tests of CLEARANCE from tests of solid insulation.

NOTE 2 - The maximum test current of test equipment is usually limited to avoid hazards arising from the test and damage to equipment that fails the test.

NOTE 3 - It may be useful to make partial discharges within the insulation material perceptible (see IEC 270).

NOTE 4 - Care should be taken to discharge stored energy after test.

6.9 Constructional requirements for protection against electric shock

6.9.1 General

In circuits exceeding the values of 6.3.2 in NORMAL CONDITION or SINGLE FAULT CONDITION:

- the security of wiring connections subject to mechanical stresses shall not depend only on soldering.
- screws securing removable covers shall be captive if their length determines a CLEARANCE or CREEPAGE DISTANCE between ACCESSIBLE conductive parts and HAZARDOUS LIVE parts.
- accidental loosening or freeing of the wiring, screws, etc., shall not cause ACCESSIBLE parts to become HAZARDOUS LIVE.

Compliance is checked by inspection.

6.9.2 ENCLOSURES of equipment with DOUBLE INSULATION or REINFORCED INSULATION

Equipment that relies on DOUBLE INSULATION or REINFORCED INSULATION for protection against electric shock shall have an ENCLOSURE that surrounds all metal parts. This requirement does not apply to small metal parts such as nameplates, screws, or rivets, if they are separated from parts which are HAZARDOUS LIVE by REINFORCED INSULATION or its equivalent.

ENCLOSURES or parts of ENCLOSURES made of insulating material shall meet the requirements for DOUBLE INSULATION and REINFORCED INSULATION.

Protection for ENCLOSURES or parts of ENCLOSURES made of metal shall be provided by one of the following means, except for parts where PROTECTIVE IMPEDANCE is used:

- provision of an insulating coating or BARRIER on the inside of the ENCLOSURE. This shall surround all metal parts and all places where loosening of a part which is HAZARDOUS LIVE might cause it to touch a metal part of the ENCLOSURE;
- ensuring that CLEARANCES and CREEPAGE DISTANCES between the ENCLOSURE and parts that are HAZARDOUS LIVE cannot be reduced below the values of Tables D.1 to D.6 by loosening of parts or wires.

NOTE – Screws or nuts with lock washers are not regarded as liable to become loose nor are wires that are mechanically secured by more than soldering alone.

Compliance is checked by inspection and measurement, and by the tests of 6.8.

6.9.3 Equipment using PROTECTIVE BONDING

a) Where a part of the equipment is removable by the OPERATOR, the PROTECTIVE BONDING (see 6.5.1) for the remainder of the equipment shall not be interrupted (except when that part also carries the mains input connection to the whole equipment).

b) Movable conductive connections, for example, hinges, slides, etc., shall not be in the sole PROTECTIVE BONDING path unless they are specifically designed for electrical interconnection and meet the requirements of 6.5.1.

c) The exterior metal braid of cables, even if connected to the PROTECTIVE CONDUCTOR TERMINAL, shall not be regarded as PROTECTIVE BONDING.

d) When 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 6.5.1.2.

e) Protective earthing conductors may be bare or insulated. Insulation shall be green/yellow, except in the following cases:

- for earthing braids, either green/yellow or transparent;
- for internal protective conductors in assemblies such as ribbon cables, busbars, flexible printed wiring, etc., any color may be used provided that no hazard is likely to arise from non-identification of the protective conductor.

f) Equipment using PROTECTIVE BONDING shall be provided with a TERMINAL meeting the requirements of 6.11.2 and suitable for connection to a protective conductor.

NOTE – Metal structural parts of the equipment may be used to provide continuity of PROTECTIVE BONDING.

Compliance is checked by inspection.

6.10 Connection to mains supply source

6.10.1[NF] Mains supply cords

The following requirements apply both to non-detachable mains supply cords and to mains supply cords supplied with the equipment:

- mains supply cords shall be RATED for the maximum current for the equipment and the cable used shall meet the requirements of IEC 227 or IEC 245. Mains supply cords certified or approved by any recognized national test house are regarded as meeting this requirement;
- green/yellow covered conductors shall be used only for connection to PROTECTIVE CONDUCTOR TERMINALS;
- if a mains supply cord contains a combination of HAZARDOUS LIVE conductors and other conductors connected to ACCESSIBLE conductive parts, all conductors shall have the same degree of insulation except where a short-circuit between any two conductors could not cause conductive parts to become HAZARDOUS LIVE.

Detachable mains supply cords with mains connectors according to IEC 320 shall either comply with the requirements of IEC 799 or shall be RATED at least for the current RATING of the mains connector that is fitted to the cord.

[NF] See corresponding clause in National Foreword

The terminology for mains supply cords is given in Figure 3.

Compliance is checked by inspection and, where necessary, by measurement.

6.10.2 Fitting of non-detachable mains supply cords

6.10.2.1 Cord entry

Non-detachable mains supply cords shall be protected against abrasion and sharp bends at the point where the cord enters the equipment, by one of the following means:

- an inlet or bushing with a smoothly rounded bell-mouthed opening with a radius of curvature at least one and a half times the overall diameter of a cord with the largest cross-sectional area that can be fitted;
- a reliably-fixed cord guard made of insulating material protruding beyond the inlet opening by at least five times the overall diameter of a cord with the largest cross-sectional area that can be fitted. For flat cords the major overall cross-sectional dimension is taken as the overall diameter.

Compliance is checked by inspection and measurement and by the dielectric strength test of 6.8.4 (where applicable). In case of doubt, cord guards are checked by the following test, which is performed in an ambient temperature of 23°C ± 2°C, using the cord fitted by the manufacturer:

A mass of 10 D^2 *g is attached to the free end of the cord, where D is the overall diameter of a round cord or the minor overall dimension of a flat cord. Flat cords are bent in the place of least resistance. Immediately after the mass has been attached, the radius of curvature of the center-line of the cord shall nowhere be less than 1.5 D.*

Equipment shall be in the position of NORMAL USE, except that for HAND-HELD EQUIPMENT and equipment intended to be moved while in operation, the test is carried out with axis of the cord guard, where the cord leaves it, at an angle of 45° above the horizontal.

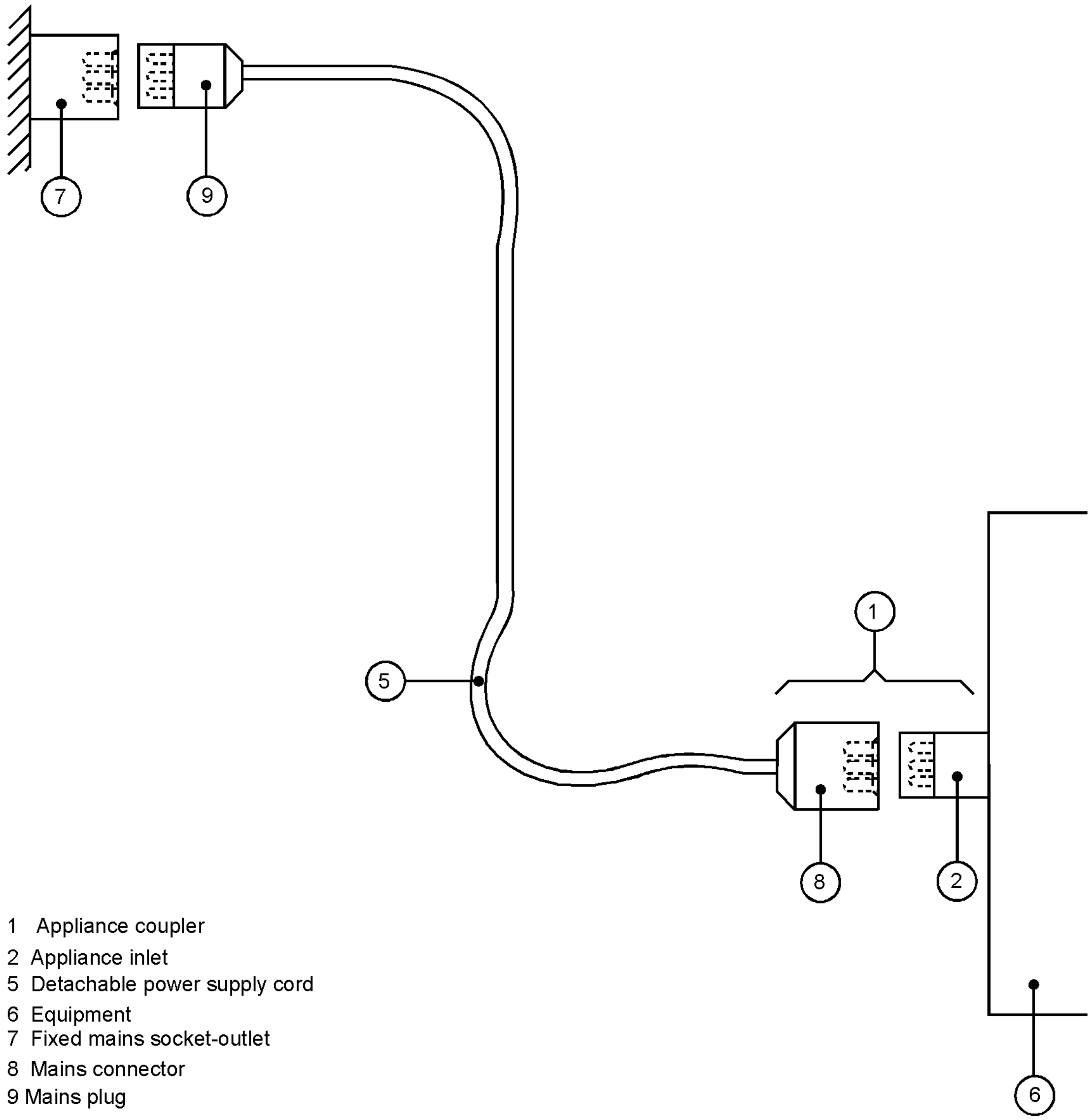


Figure 3 — Detachable mains supply cords and connections

6.10.2.2 Cord anchorage

The cord anchorage shall relieve the conductors of the cord from strain, including twisting, where they are connected within the equipment, and shall protect the insulation of the conductors from abrasion. The protective earth conductor, if any, shall be the last to take the strain if the cord slips in its anchorage.

Cord anchorages shall meet the following requirements:

- the cord shall not be clamped by a screw which bears directly on the cord;
- knots in the cord shall not be used;
- it shall not be possible to push the cord into the equipment to an extent that could cause a hazard;

- failure of the cord insulation in a cord anchorage that has metal parts shall not cause ACCESSIBLE conductive parts to become HAZARDOUS LIVE;
- a compression bushing shall not be used as a cord anchorage unless it has provision for clamping all types and sizes of mains supply cords that meet the requirements of 6.10.1 and are suitable for connection to the TERMINALS provided, or the bushing has been designed to terminate a screened mains supply cord;
- the cord anchorage shall be designed so that cord replacement does not cause a hazard and it shall be clear how the relief from strain is provided.

Compliance is checked by inspection and the following push-pull test: the cord is pushed into the equipment manually, as far as possible. It is then subjected 25 times to a steady pull of the value shown in Table 2, applied for 1 s each time in the least favorable direction. Immediately afterwards it is subjected for 1 min to a torque of the value shown in Table 2.

Table 2 — Physical tests on power supply cords

Mass (M) of equipment kg	Pull N	Torque N m
M ≤ 1	30	0.10
1 < M ≤ 4	60	0.25
4 < M	100	0.35

After the tests:

- the cord shall not have been damaged;
- the cord shall not have been displayed longitudinally by more than 2 mm;
- there shall be no signs of strain at the point where the anchorage clamps the cable;
- CLEARANCES and CREEPAGE DISTANCES shall not have been reduced below the applicable values of Annex D.

6.10.3[NF] Plugs and connectors

a) Plugs and connectors for connecting equipment to the mains supply, including appliance couplers used to connect detachable mains supply cords to the equipment, shall comply with the relevant specifications for plugs, socket outlets, and connectors.

b) If the equipment is designed to be supplied only at voltages below the level of 6.3.2.1 in NORMAL CONDITION or SINGLE FAULT CONDITION, or from a source used solely to supply that equipment, the plugs of the mains supply cord shall not fit into the socket outlets of mains supply systems at voltages above the RATED supply voltage of the equipment. Mains type plugs and sockets shall not be used for purposes other than connection of a mains supply.

c) If plug pins of cord-connected equipment receive a charge from an internal capacitor, the pins shall not be HAZARDOUS LIVE 5 s after disconnection of the supply.

d) On equipment with accessory mains socket outlets:

[NF] See corresponding clause in National Foreword

- if the outlet can accept a standard mains supply plug, there shall be a marking according to 5.1.3 e);
- if the outlet has a TERMINAL contact for a protective earth conductor, the input mains supply connection to the equipment shall include a protective earth conductor connected to a PROTECTIVE CONDUCTOR TERMINAL.

Compliance is checked by inspection. For plugs receiving a charge from an internal capacitor, the measurements of 6.3 are made to establish that the levels of 6.3.1.3 are not exceeded.

6.11 TERMINALS

6.11.1 ACCESSIBLE TERMINALS

a) ACCESSIBLE TERMINALS for flexible cords shall be located or shielded so that there is no risk of accidental contact between HAZARDOUS LIVE parts of different polarity or between such parts and other conductive parts, even if a strand of a conductor escapes from a TERMINAL. Unless it is self-evident (which is preferable) ACCESSIBLE TERMINALS shall be marked to show whether or not they are connected to ACCESSIBLE conductive parts (see 5.1.6 c).

Compliance is checked by inspection after fully inserting a stranded conductor with an 8 mm length of insulation removed, with one of the strands free. The strand shall not touch parts of different polarity or ACCESSIBLE conductive parts, when bent in every possible direction, without tearing back the insulation or making sharp bends around BARRIERS.

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

Compliance is checked by manual test and inspection.

6.11.2 PROTECTIVE CONDUCTOR TERMINAL

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

b) For equipment provided with a rewireable flexible cord and for PERMANENTLY CONNECTED EQUIPMENT, the PROTECTIVE CONDUCTOR TERMINAL shall be located close to the mains supply TERMINALS.

c) If the equipment does not require connection to a mains supply, but nevertheless has a circuit or part that is required to be protectively earthed, the PROTECTIVE CONDUCTOR TERMINAL shall be located near to 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.

d) PROTECTIVE CONDUCTOR TERMINALS for mains circuits shall be at least equivalent in current-carrying capacity to the mains supply TERMINALS.

e) Soldered connections subject to mechanical stress shall be mechanically secured independently from the soldering. Such connections shall not be used for other purposes such as fixing constructional parts. Screw connections shall be secured against loosening.

f) The contact surfaces of PROTECTIVE CONDUCTOR TERMINALS shall be metal.

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

g) Plug-in type PROTECTIVE CONDUCTOR TERMINALS combined with other TERMINALS and intended to be connected and disconnected by hand, for example plugs and appliance couplers for mains cords or connector assemblies of plug-in units, shall be designed so that the protective conductor connection makes first and breaks last with respect to the other connections.

Compliance is checked by inspection.

6.11.3 FUNCTIONAL EARTH TERMINALS

FUNCTIONAL EARTH TERMINALS (measuring earth TERMINALS), if any, shall allow a connection that is independent of the protective conductor.

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

Compliance is checked by inspection

6.12[NF] Disconnection from supply source

6.12.1 General

Except as specified in 6.12.1.1, equipment shall be provided with a means for disconnecting it from each operating energy supply source, whether external or internal to the equipment. The disconnecting means shall disconnect all current carrying conductors.

NOTE – Equipment may also be provided with a switch or other disconnecting device for functional purposes.

Compliance is checked as specified in 6.12.1.1 to 6.12.3.

6.12.1.1 Exceptions

A disconnecting device is not required if a short circuit or overload cannot cause a hazard in the sense of this Part 1. Examples include:

- equipment intended for supply only from a low-energy source such as a small battery;
- equipment intended only for connection to an impedance-protected supply. Such a supply is one having an impedance of such value that, when the equipment is subjected to an overload or short circuit, the RATED supply conditions are not exceeded and no hazard can arise in the sense of this Part 1;
- equipment that constitutes an impedance-protected load. Such a load is a component without discrete overcurrent or thermal protection, and of such impedance that the RATING is not exceeded when the circuit of which the component is a part is subjected to an overload or short circuit.

Compliance is checked by inspection. In case of doubt a short circuit or overload is applied to check that no hazard can arise.

6.12.2 Requirements according to type of equipment

6.12.2.1 PERMANENTLY CONNECTED EQUIPMENT

PERMANENTLY CONNECTED EQUIPMENT and multi-phase equipment shall employ a switch or circuit breaker as the means for disconnection.

[NF] See corresponding clause in National Foreword

Where a switch is not part of the equipment, documentation for equipment installation (see 5.4.3) shall specify that:

- a switch or circuit-breaker shall be included in the building installation;
- it shall be in close proximity to the equipment and within easy reach of the OPERATOR;
- it shall be marked as the disconnecting device for the equipment.

Compliance is checked by inspection.

6.12.2.2 Single-phase cord-connected equipment shall have one of the following as a disconnecting device:

- a switch or circuit breaker;
- an appliance coupler that can be disconnected without the use of a TOOL;
- a separable plug, without a locking device, to mate with a socket-outlet in the building.

Compliance is checked by inspection.

6.12.2.3 Hazards arising from function

Equipment whose function may give rise to a hazard shall have an emergency switch, which need not disconnect auxiliary circuits (such as cooling) that are necessary for safety.

Equipment having ACCESSIBLE moving parts that could cause a hazard shall have an emergency switch for disconnection that shall not be more than 1 m from the moving part.

Compliance is checked by inspection.

6.12.3 Disconnecting devices

If a disconnecting device is part of the equipment, it shall be located electrically as close as practicable to the supply. Power-consuming components shall not be electrically located between the supply source and the disconnecting device.

Electromagnetic interference suppression circuits are permitted to be located on the supply side of the disconnecting device.

Compliance is checked by inspection.

6.12.3.1 Switches and circuit breakers

An equipment switch or circuit-breaker employed as a disconnecting device shall meet the relevant requirements of IEC 947-1 and IEC 947-3.

The relevant parts of IEC 947-3 include those requirements that relate to contact separation and to ensuring that it is always evident whether the contacts are open or closed when the indicator is in the "off" position.

If a switch or circuit-breaker is used as a disconnecting device, it shall be marked to indicate this function. If there is only one device - one switch or one circuit breaker - symbols 9 and 10 of Table 1 are sufficient.

A switch shall not be incorporated in a mains supply cord.

A switch or circuit-breaker shall not interrupt any protective earth conductor.

A switch or circuit- breaker with contacts for disconnecting and other contacts for other purposes shall comply with the requirements of 6.6 and 6.7 for separation between circuits.

Compliance is checked by inspection.

6.12.3.2 Appliance couplers and plugs

If an appliance coupler or separable plug is used as the disconnecting device (see 6.12.2.2), it shall be readily identifiable and easily reached by the OPERATOR. For single-phase PORTABLE EQUIPMENT, a plug on a cord of length not greater than 3 m is considered to be easily reached.

The protective earth conductor of an appliance coupler shall be connected before the supply conductors and disconnected after them.

Compliance is checked by inspection.

7 Protection against mechanical hazards

7.1 General

Handling during NORMAL USE shall not lead to a hazard.

Protection against expelled parts shall be provided in SINGLE FAULT CONDITION.

NOTE – All easily touched edges, projections, corners, openings, guards, handles, and the like of the equipment ENCLOSURE, should be smooth and rounded so as not to cause injury during NORMAL USE of the equipment.

Compliance is checked as specified in 7.2 to 7.5.

7.2 Moving parts

Moving parts shall not be able to crush, cut, or pierce parts of the body of an OPERATOR likely to contact them nor severely pinch the OPERATOR's skin.

This requirement does not apply to easily touched moving parts that are obviously intended to operate on parts or materials external to the equipment, for example drilling and mixing equipment. Such equipment should be designed to minimize inadvertent touching of such moving parts (e.g., by fitting of guards, handles, etc.)

Compliance is checked by inspection.

7.3 Stability

Equipment and assemblies of equipment not secured to the building structure before operation shall be physically stable in NORMAL USE.

If means are provided to ensure that stability is maintained after the opening of drawers, etc. by an OPERATOR, either these means shall be automatic or there shall be warning marking complying with 5.2.

Compliance is checked by carrying out each of the following tests independently (where relevant), during which the equipment shall not overbalance. Containers contain the RATED amount of substance to provide the least favorable conditions of NORMAL USE. Castors are in their least favorable position of NORMAL USE. Doors, drawers, etc. are closed unless otherwise specified.

- equipment other than HAND-HELD EQUIPMENT is tilted in each direction to an angle of 10° its normal position.
- equipment that has both a height of 1 m or more and a mass of 25 kg or more and all floor standing equipment has a force applied at its top, or at a height of 2 m if the equipment

has a height more than 2 m. The force is 250 N or 20% of the mass of the equipment, whichever is less, and is applied in all directions except upwards. Jacks used in NORMAL USE and doors, drawers, etc., intended to be opened by an OPERATOR, are in their least favorable positions.

- floor standing equipment has a force of 800 N applied downwards at the point of maximum moment to:
  - all horizontal working surfaces;
  - other surfaces providing an obvious ledge and that are not more than 1 m above floor level.

7.4 Provisions for lifting and carrying

Where carrying handles or grips are supplied with the equipment, they shall be capable of withstanding a force of four times the mass of the equipment.

Equipment or parts having a weight of 18 kg or more shall be provided with a means for lifting and carrying or directions shall be given in the manufacturer's documentation.

Compliance is checked by inspection and the following test:

> *A single handle or grip is subjected to a force corresponding to four times the mass of the equipment. The force is applied uniformly over a 7 cm width at the center of the handle or grip, without clamping. The force is steadily increased so that the test value is attained after 10 s and maintained for a period of 1 min.*
>
> *If more than one handle or grip is fitted, the force is distributed between the handles or grips in the same proportion as in NORMAL USE. If the equipment is fitted with more than one handle or grip but so designed that it may readily be carried by only one handle or grip, each handle or grip shall be capable of sustaining the total force.*
>
> *The handles or grips shall not break loose from the equipment and there shall not be any permanent distortion, cracking, or other evidence of failure.*

7.5 Expelled parts

Equipment shall contain or limit the energy of parts that might cause a hazard if expelled in the event of a fault.

The means of protection against expelled parts shall not be removable without the aid of a TOOL.

Compliance is checked by inspection after fault testing as specified in 4.4.4.4.

8 Mechanical resistance to shock, vibration, and impact

Equipment shall not cause a hazard when subjected to shock, vibration, and impact likely to occur in NORMAL USE. To achieve this requirement, equipment shall have adequate mechanical strength, components shall be reliably secured, and electrical connections shall be secure.

Compliance is checked by performing the tests of 8.1 to 8.3 and, except for FIXED EQUIPMENT, the appropriate test of 8.4. The equipment is not operated during the tests.

After the completion of the tests, the equipment shall pass the voltage tests of 6.8.4 and is inspected to check that:

- *parts that are HAZARDOUS LIVE have not become ACCESSIBLE;*
- *ENCLOSURES show no cracks that could cause a hazard;*
- *CLEARANCES are not less than their permitted values and the insulation of internal wiring remains undamaged;*
- *BARRIERS have not been damaged or loosened;*
- *no moving parts are exposed, except as permitted by 7.2;*
- *there has been no damage that could cause spread of fire.*

Damage to the finish, small dents that do not reduce CREEPAGE DISTANCES or CLEARANCES below the values specified in this Part 1, and small chips that do not adversely affect the protection against electric shock or moisture are to be ignored.

8.1 Rigidity test

The equipment is held firmly against a rigid support and subjected to a force of 30 N applied by the hemispherical end of a hard rod of 12 mm diameter. The rod is applied to any part of the ENCLOSURE that is ACCESSIBLE when the equipment is ready for use and that could cause a hazard if distorted, including any part of the bottom of PORTABLE EQUIPMENT.

For equipment with non-metallic ENCLOSURES, this test is performed at an ambient temperature of 40°C (see 10.1).

8.2[NF] Impact hammer test

Bases, covers, etc., intended to be removed and replaced by the OPERATOR have their fixing screws tightened with the torque applied in NORMAL USE. The equipment is then held firmly against a rigid support and tested with the impact hammer specified in IEC 817 (see Annex C). The hammer nose is pressed perpendicularly against the surface of all external parts that are ACCESSIBLE in NORMAL USE and that would be likely to cause a hazard if broken.

Three blows with an energy of 0.5 J are applied to each part, except that windows of panel-mounted indicating and recording instruments are subjected to an energy of only 0.2 J.

8.3[NF] Vibration test

The equipment is subjected to vibration over a range of frequencies as specified in IEC 68-2-6.

Parts that are intended to be loose in NORMAL USE are removed for this test. The equipment is fastened in its position of NORMAL USE to the vibration generator, using any specified shock absorbers. Straps around the ENCLOSURE may be used in the absence of other fastening means.

The vibration conditions are:

- *direction*:	*vertical*;
- *amplitude*:	*0.15 mm*;
- *sweep frequency range*:	*10 Hz - 55 Hz - 10 Hz* ;
- *sweep rate*:	*1 octave/min*;
- *duration*:	*30 min*.

[NF] See corresponding clause in National Foreword

If the normal transport position of the equipment differs from that of NORMAL USE, the test shall be carried out for 15 min in each position.

8.4 Drop test

8.4.1 Equipment other than HAND-HELD EQUIPMENT

The equipment is placed in its position of NORMAL USE on a smooth, hard, rigid surface of concrete or steel, then tilted about one bottom edge so that the distance between the opposite bottom edge and the test surface is 25 mm ± 2.5 mm or to the highest point at which it will fall back freely, if this is lower.

The equipment shall not be allowed to topple onto its side when it is tilted. The test is carried out once about each of a maximum of four edges (see IEC 68-2-31).

8.4.2 HAND-HELD EQUIPMENT

HAND-HELD EQUIPMENT is dropped once through a distance of 1 m on to a 50 mm thick hardwood board having a density of more than 700 kg/m^3 lying flat on a rigid base such as concrete block. The equipment is dropped so that it lands in the position expected to present the most severe condition.

9 Equipment temperature limits and protection against the spread of fire

9.1 General

Any heating shall not cause a hazard in NORMAL CONDITION or in SINGLE FAULT CONDITION nor shall it cause spread of fire outside the equipment.

If easily touched heated surfaces are necessary for functional reasons, they are permitted to exceed the values in Table 3, but shall be recognizable as such by appearance, function, or shall be marked (see 5.2).

Where protection against fire depends on separation of circuits, they shall be separated at least by BASIC INSULATION.

NOTE – See also 13.2.2 concerning protection against fire caused by batteries.

Table 3 — Maximum temperatures in NORMAL USE and maximum ambient temperature (see Note 1)

Outer surface of ENCLOSURE (see Note 2)	
metal	70°C
non-metallic	80°C
Small areas of the ENCLOSURE (e.g., easily discernible heat sinks) not likely to be touched in NORMAL USE	100°C
knobs and handles	
metal	55°C
non-metallic	70°C
Non- metallic parts held during NORMAL USE for short periods only	85°C
Parts in contact with liquids having a fire point t and exposed to the atmosphere (see Note 3)	t -25°C
Wood (inside surface closest to the source of heat)	95°C
Insulating material. Windings and core laminations in contact with winding insulation material (see Notes 2 and 4) of:	
Class A	105°C
Class B	130°C
Class E	120°C
Class F	155°C
Class H	180°C

NOTES -

1) The maximum temperatures of a part is in most cases determined by measuring the temperature rise of the part under the conditions of 9.2 and adding it to the maximum ambient temperature (40 °C see 1.4).

2) The temperature of given insulating material is limited to that specified in IEC 85.

3) Fire point is the temperature to which a liquid must be heated (under specified conditions) so that the vapor/air mixture at the surface will support a flame for at least 5 s when an external flame is applied and withdrawn.

4) The temperature of windings shall be determined by the resistance method or by the use of temperature sensors chosen and positioned so that they have a negligible effect on the temperature of the part under test. The latter method shall be used if the windings are non-uniform or if it is difficult to measure the resistance.

Compliance is checked by inspection, by the tests of 9.2, and by tests in the SINGLE FAULT CONDITIONS of 4.4. Alternatively, if protection is assured by separation of circuits, compliance is checked by measurement of CLEARANCES and CREEPAGE DISTANCES and by making the voltage tests of 6.8.4 between the circuits and parts listed in Annex G.

Annex F describes an alternative method for satisfying the requirements of 9.1 for protection against the spread of fire and for checking compliance.

9.2 Temperature tests

Equipment is tested under reference test conditions and in the position of NORMAL USE (see 4.3.2). Temperatures are measured when steady has been attained. The values of Table 3 shall not be exceeded.

NORMAL USE includes compliance with requirements for ventilation and with any specified limits for intermittent operation given in the documentation. If cooling liquid is used during the test, it is at the maximum temperature specified by the manufacturer.

9.2.1 Heating equipment

Equipment intended to produce heat for functional purposes is tested in a test corner.

The test corner consists of two walls at right angles, a floor and, if necessary, a ceiling, all of plywood approximately 20 mm thick and painted matt black. The linear dimensions of the test corner should be at least 15% greater than those of the equipment under test. Equipment is positioned at the distances from the walls, ceiling, or floor specified by the manufacturer. If no distances are specified then:

- equipment normally used on a floor or a table is placed as near to the walls as possible;
- equipment normally fixed to a wall is mounted on one of the walls, as near to the other wall and to the floor or ceiling as is likely to occur in NORMAL USE;
- equipment normally fixed to a ceiling is fixed to the ceiling as near to the walls as is likely to occur in NORMAL USE.

9.2.2 Equipment intended for installation in a cabinet or a wall

Such equipment is built-in as specified in the installation instructions, using walls of plywood painted matt black and approximately 10 mm thick when representing the walls of a cabinet or approximately 20 mm thick when representing the walls of a building.

9.3 Guards

Surfaces whose temperature is liable to exceed 100°C in an ambient temperature of 40°C shall be protected by guards unless they are clearly marked as being excessively hot or are intended to be hot as permitted by 9.1. Where guards are required, they shall be removable only with the use of a TOOL.

Compliance is checked by temperature measurement and by inspection of the fixing of guards (where required).

9.4 Field wiring terminal boxes

A field wiring TERMINAL box or compartment operating at a temperature exceeding 60°C in an ambient temperature of 40°C shall bear a marking specifying the RATED temperature of the cables to be used in the box or compartment that shall be not less than the maximum temperature of the box or compartment. The marking shall be adjacent to the field wiring TERMINALS or be visible during and after installation.

Compliance is checked by measuring the temperatures attained during the tests of 9.2 and by inspection of the markings.

9.5 Overtemperature protection devices

Loss of cooling liquid or other failure of a cooling means shall not cause electric shock or the spread of fire. Equipment having a heating control system shall not cause electric shock or the spread of fire if the control system fails.

If required, protection shall be by an overtemperature protection device that operates in SINGLE FAULT CONDITION. Devices, whether actuated by temperature, liquid level, airflow, or other means, shall meet the requirements of 14.3

An overtemperature protection device shall not operate in NORMAL USE. It shall not be possible to set a self-resetting overtemperature device to operate except in SINGLE FAULT CONDITION or as part of a test procedure of the device itself.

NOTE – Test procedures to check the performance of protective devices may be appropriate. Such procedures should be described in the documentation (see 5.4.5).

Compliance is checked by inspection and during fault tests according to 4.4.2.9 and 4.4.2.10.

9.6[NF] Overcurrent protection

Equipment intended to operate from a mains supply shall be protected by fuses, circuit breakers, thermal cut-outs, impedance limiting circuits, or similar means, to provide protection against excessive energy being drawn from the mains in case of a fault in the equipment. This limits the development of a fault and the probability of the start and spread of fire. Overcurrent protection devices may also provide protection against electric shock in case of fault (see 6.5).

NOTE 1 - Overcurrent protection devices (e.g., fuses) should preferably be fitted in all supply conductors. Where fuses are used as overcurrent protection devices, the fuse holders should be mounted adjacent to each other. The fuses should be of the same RATING and characteristic. Overcurrent protection devices should preferably be located on the supply side of the mains circuits in the equipment, including any mains switch. It is recognized that, in equipment generating high frequencies, it is essential for the interference suppression components to be located between the mains supply and the overcurrent protection devices.

NOTE 2 - In some equipment the operation of the overcurrent protection device(s) may need to be detected and indicated.

9.6.1 PERMANENTLY CONNECTED EQUIPMENT

Overcurrent protection devices in the equipment are optional. If none is fitted, the manufacturer's instructions shall specify the overcurrent protection devices required in the building installation.

Compliance is checked by inspection.

9.6.2 Other equipment

Protection shall be within the equipment by fuses, circuit breakers, thermal cutouts, impedance limiting devices, etc.

Overcurrent protection devices shall not be used in the protective conductor. Fuses or single pole circuit breakers shall not be fitted in the neutral conductor of multi-phase equipment.

Compliance is checked by inspection.

[NF] See corresponding clause in National Foreword.

10 Resistance to heat

10.1 Integrity of CLEARANCES and CREEPAGE DISTANCES

CLEARANCES and CREEPAGE DISTANCES shall meet the requirements of 6.7 and Annex D when the equipment is operated at an ambient temperature of 40°C (the maximum ambient temperature specified in 1.4).

Compliance in cases of doubt, where the equipment produces an appreciable amount of heat, is checked by operating the equipment under the reference test conditions of 4.3, except that the ambient temperature shall be 40°C. After this test, CLEARANCES and CREEPAGE DISTANCES shall not have been reduced below the requirements of 6.7 and Annex D.

If the equipment has an ENCLOSURE that is non-metallic, the temperature of parts of the ENCLOSURE is measured for the purpose of 10.2.

NOTE – This test also provides the conditions required for the test of 8.1 for non-metallic ENCLOSURES.

10.2 Resistance to heat of non-metallic ENCLOSURES

ENCLOSURES of non-metallic material shall be resistant to elevated temperatures.

Compliance is checked by one of the following treatments:

- *a non-operative treatment, in which the equipment, not energized, is stored for 7 h at a temperature of 70°C. However, if during the test of 10.1 a higher temperature is measured, the storage temperature is to be 10°C above that measured temperature. If the equipment contains components that might be damaged by this treatment, an empty ENCLOSURE may be treated, followed by assembly of the equipment at the end of the treatment.*
- *an operative treatment, in which the equipment is operated under the reference test conditions of 4.3 and in an ambient temperature of 60°C.*

After the treatment, the equipment shall cause no hazard in the sense of this Part 1 and shall pass the tests of 6.8.

10.3 Resistance to heat of insulating material

Non-metallic ENCLOSURES and covers, and parts made of insulating material that are used to support parts that are connected to the mains supply shall be made of insulating materials that will not cause a safety hazard if short circuits occur inside the equipment.

Insulation that supports TERMINALS shall be made of material resistant to heat if, under reference test conditions, these TERMINALS carry a current exceeding 0.5 A and substantial heat could be dissipated in case of poor contact. The selected materials shall not soften to such an extent as to cause a hazard or further short-circuits.

Compliance is checked by subjecting the insulating material to the Vicat softening test according to ISO 306 method A or by the inspection of appropriate documentary evidence that the material complies with this test. The Vicat softening temperature shall be at least 130°C.

11 Resistance to moisture and liquids

11.1 General

Equipment containing liquids or to be used in measurements of processes on liquids shall be designed to give protection to the OPERATOR and surrounding area against hazards from moisture and liquids encountered in NORMAL USE.

NOTE – Liquids likely to be encountered fall into three categories:

- having continuous contact, for example in vessels intended to contain them;
- having occasional contact, for example cleaning fluids;
- having accidental (unexpected) contact. The manufacturer cannot safeguard against such cases.

Liquids such as cleaning fluids (except those specified by the manufacturer) and beverages are not considered.

Compliance is checked by the treatment and tests of 11.2 to 11.5.

11.2 Cleaning

Where a cleaning or decontamination process is specified by the manufacturer, this shall not cause a direct safety hazard, nor an electrical hazard, nor a hazard resulting from corrosion or other weakening of structural parts associated with safety.

The cleaning method shall be described in the documentation (see 5.4.4).

Compliance is checked by cleaning the equipment three times. If, immediately after this treatment, there are any signs of wetting of parts likely to cause a hazard, the equipment shall pass the voltage test of 6.8.4 and ACCESSIBLE parts shall not exceed the limits of 6.3.1.

11.3 Spillage

If in NORMAL USE liquid is likely to be spilt into the equipment, the equipment shall be designed so that no hazard will occur, for example as a result of the wetting of insulation or of internal uninsulated parts that are HAZARDOUS LIVE.

Compliance shall be checked by inspection. In case of doubt, 0.2 l of water is poured steadily from a height of 0.1 m over a period of 15 s onto each point in turn where liquid might gain access to electrical parts. Immediately after this treatment, the equipment shall pass the voltage test of 6.8.4 and ACCESSIBLE parts shall not exceed the limits of 6.3.1.

11.4 Overflow

Liquid overflowing from containers in the equipment that can be overfilled shall not cause a hazard during NORMAL USE, for example as a result of the wetting of insulation or uninsulated live parts.

Equipment likely to be moved while a container is full of liquid shall be protected against liquid surging out from the container.

Compliance is checked by the following treatment and tests. The liquid is completely filled. A further quantity of liquid equal to 15% of the capacity of the container or 0.25 l, whichever is the greater, is then poured in steadily over a period of 60 s. The equipment that is likely to be moved while a container is full of liquid is then tilted 0.26 rad (15°) in the most unfavorable direction(s) from the position of NORMAL USE, containers being refilled if it is necessary to do this in more *than one direction. Immediately after this treatment, the equipment shall pass the voltage test of 6.8.4 and ACCESSIBLE parts shall not exceed the limits of 6.3.1.*

11.5 Liquid leakage

11.5.1 Equipment containing liquid

Equipment shall be designed so that liquids leaking from containers, hoses, couplings, seals, etc., shall not cause a hazard, for example as a result of the wetting of insulation or of uninsulated live parts.

NOTE – Additional requirements are under consideration for equipment containing liquids at pressures exceeding 2 kPa above atmospheric pressure.

Compliance is checked by the following treatment and tests. Drops of water are applied to parts from which leakage might occur, moving parts being in operation or at rest, whichever is least favorable. Immediately after this treatment, the equipment shall pass the voltage test 6.8.4 and ACCESSIBLE parts shall not exceed the limits of 6.3.1.

11.5.2 Battery electrolyte

Batteries shall be so mounted that safety cannot be impaired by leakage of their electrolyte.

Compliance is checked by inspection.

11.6 Specially protected equipment

Where the equipment is RATED by the manufacturer as complying with one of the stated degrees of protection of IEC 529, it shall resist the entry of liquid to the extent specified.

Compliance is checked by subjecting the equipment to the appropriate treatment of IEC 529, after which the equipment shall pass the voltage test of 6.8.4 and ACCESSIBLE parts shall not exceed the limits of 6.3.1.

12 Protection against radiation, including laser sources, and against sonic and ultrasonic pressure

12.1 General

The equipment shall provide protection against the effects of internally generated ultraviolet, ionizing and microwave radiation including laser sources, and against sonic and ultrasonic pressure.

Compliance tests are carried out if the equipment is likely to cause such hazards.

12.2 Equipment producing ionizing radiation

12.2.1 Ionizing radiation

The equivalent dose rate of unintended and stray radiation at any easily reached point 50 mm from the outer surface of the equipment shall not exceed 5 uSv/h. This includes radiation from equipment in which electrons are accelerated by voltages exceeding 5 kV.

NOTE – Protection against intended radiation may be dealt with in other parts of this standard. For further information on the requirements for equipment which utilizes ionizing radiation, see IEC 405.

Compliance is checked by measuring the amount of radiation under reference test conditions in such a way as to produce maximum radiation. The method of determining the amount of radiation shall be effective over the range of possible radiation energies.

Cathode-ray equipment shall display a pattern from each beam not exceeding 30 mm x 30 mm or the smallest possible display, whichever is smaller. The display(s) shall be positioned so as to produce maximum radiation.

12.2.2 Accelerated electrons

The equipment shall be so constructed that compartments in which electrons are accelerated by voltages exceeding 5 kV cannot be opened without the use of a TOOL

Compliance is checked by inspection.

12.3 Ultra-violet radiation

The equipment containing a UV light source not designed to provide external UV illumination shall not permit unintentional escape of UV radiation that would be harmful to the OPERATOR.

Compliance is under consideration.

12.4 Microwave radiation

The power density of microwave radiation at all points in the vicinity of the apparatus shall not exceed 10 W/m^2 under reference test conditions. This requirement applies to spurious radiation at frequencies between 1 GHz and 100 GHz. It does not apply to parts of the apparatus where microwave radiation is propagated intentionally, for example at waveguide output ports.

The compliance test and limit of 10 W/m^2 are under consideration.

12.5 Sonic and ultrasonic pressure

12.5.1 Sound pressure level

The equipment shall not produce a sound pressure level above 85 dBA, when measured both at the OPERATOR's normal position and at 1 m from the position on the equipment with the highest sound pressure level.

Compliance, in case of doubt, is checked by measuring the sound pressure level while the equipment is operated under reference test conditions in such a way as to produce the maximum sound pressure.

12.5.2 Ultrasonic pressure

The ultrasonic pressure shall not exceed specified limits when measured both at the OPERATORS normal position and at 1 m from the position on the equipment with the highest pressure level.

NOTE – A limit of 110 dB above the reference pressure value of 20 uPa, applicable to frequencies between 20 kHz and 100 kHz, is under consideration.

Compliance is checked by measuring the pressure under reference test conditions.

12.6 Laser sources

Requirements for equipment employing laser sources are specified in IEC 825.

13 Protection against liberated gases, explosion, and implosion

13.1 Poisonous and injurious gases

Equipment shall not liberate dangerous amounts of poisonous or injurious gases in NORMAL CONDITION or SINGLE FAULT CONDITION.

Compliance: the wide variety of gases makes it impossible to specify compliance tests based on limit values, so reference should be made to tables of occupational threshold limit values.

13.2 Explosion and implosion

13.2.1 Components

When components liable to explode if overheated or overcharged are not provided with a pressure release device, protection for the OPERATOR shall be incorporated in the apparatus (see 7.5).

Pressure release devices shall be located so that a discharge will not cause danger to the OPERATOR. The construction shall be such that any pressure release device shall not be obstructed.

Compliance is checked by inspection.

13.2.2 Batteries

Batteries shall not cause explosion or produce a fire hazard as a result of excessive charge or discharge, or if a battery is installed with incorrect polarity. Where necessary, protection shall be incorporated in the equipment, unless the manufacturer's instructions specify that it is for use only with batteries that have built in protection.

If an explosion or fire hazard could occur through fitting a battery of the wrong type (e.g., where a battery with built-in protection is specified) there shall be a warning marking on or near the battery compartment or mounting and a warning in the manufacturer's instructions. An acceptable marking is symbol No. 14 of Table 1.

The battery compartment shall be designed so that there is no possibility of explosion or fire caused by build-up of flammable gases. (See 5.1.8 concerning warning against attempting to charge non-rechargeable batteries.)

Compliance is checked by inspection, including inspection of battery data, to establish that failure of any single component cannot lead to an explosion or fire hazard. Where necessary, a short circuit and open circuit are made on any single component (except the battery itself) whose failure could lead to such a hazard.

For batteries intended to be replaced by the OPERATOR, an attempt is made to install a battery with its polarity reversed. No hazard (see 1.2) shall arise.

13.3 Implosion of high-vacuum devices

High-vacuum devices, including a cathode-ray tube with a maximum face dimension exceeding 160 mm, either shall be intrinsically protected with respect to the effects of implosion and to mechanical impact, or the ENCLOSURE of the equipment shall provide adequate protection against the effects of implosion.

A non-intrinsically protected tube or high-vacuum device shall be provided with an effective protective screen that cannot be removed without the use of a TOOL. If a separate screen of glass is used, it shall not be in contact with the surface of the tube or of the high-vacuum device.

A cathode-ray tube or other high-vacuum device is considered to be intrinsically protected with respect to the effects of implosion if no additional protection is necessary when it is correctly mounted.

Compliance for cathode-ray tubes is checked as specified in IEC 65. Compliance tests for other high-vacuum devices are not yet under consideration.

14 Components

14.1[NF] General

Where safety is involved, components shall comply with applicable safety requirements specified in relevant IEC standards.

If components are marked with their operating characteristics, the conditions under which they are used in the equipment shall be in accordance with these markings, unless a specific exception is made.

Compliance is checked by inspection. Where no IEC standards exist for the relevant components, or where the component is not marked or is used not in accordance with its marking, the component shall be tested under the conditions occurring in the equipment.

14.2 Motors

14.2.1 Motor temperatures

Motors that, when stopped or prevented from starting (see 4.4.2.4), would present an electric shock hazard, a temperature hazard, or a fire hazard shall be protected by an overtemperature or thermal protection device (see 14.3).

Compliance is checked in the fault condition of 4.4.2.4 by measurement of the temperature, which shall not exceed the values specified in Table 4.

[NF] See corresponding clause in National Foreword

Table 4 — Motor temperatures

Material Classification	Maximum temperature of windings and core laminations in contact therewith at the maximum ambient temperature of 40°C specified in 1.4
A	150°C
B	175°C
E	165°C
F	190°C
H	210°C

NOTE 1 - The values in this table are derived from Table C1 of IEC 950.

NOTE 2 - This temperature is determined by measuring the temperature rise (K) of the winding and adding it to 40°C.

14.2.2 Series excitation motors

Series excitation motors shall be directly connected to the devices driven by them if an overspeeding motor could cause a safety hazard.

Compliance is checked by inspection.

14.3 Overtemperature protection devices

Overtemperature protection devices are devices operating in SINGLE FAULT CONDITION and shall:

- be constructed and tested so that reliable function is ensured;
- be RATED to interrupt the maximum voltage and current of the circuit in which they are employed;
- be RATED so that the maximum surface temperature ensures compliance with 4.4.4.2;
- meet the requirements of 9.5 for prevention of operation in NORMAL USE

Compliance is checked by studying the operating principle of the device and by performing adequate reliability tests with the equipment operated in SINGLE FAULT CONDITION (see 4.4). The number of operations is as follows:

- self-resetting overtemperature protection devices are caused to operate 200 times;
- non-self-resetting overtemperature protection devices, except thermal fuses, are reset after each operation and thus caused to operate 10 times;
- non-resetting overtemperature protective devices are caused to operate once.

NOTE – Forced cooling and resting periods may be introduced to prevent damage to the equipment.

During the test, resetting devices shall operate each time the SINGLE FAULT CONDITION is applied and non-resetting devices shall operate once. After the test, resetting devices shall show no sign of damage that could prevent their operation in a further SINGLE FAULT CONDITION.

14.4 Fuse holders

Fuse holders with fuses intended to be replaceable by an OPERATOR shall not permit access during fuse replacement to parts that are HAZARDOUS LIVE.

Compliance is checked by testing with the jointed test finger (see Annex B, Figure B.2) applied without force.

14.5 Mains voltage selecting devices

Devices shall be constructed so that a change from one voltage or one type of supply to another cannot occur accidentally. The marking of voltage selecting devices is specified in 5.1.3 d).

Compliance is checked by inspection and manual test.

14.6[NF] HIGH INTEGRITY components

HIGH INTEGRITY components shall be used in positions (e.g., 6.5.3, PROTECTIVE IMPEDANCE) where, if short-circuiting or disconnection occurred, an infringement of the requirements in SINGLE FAULT CONDITION would be caused. HIGH INTEGRITY components shall be constructed, dimensioned, and tested to IEC publications (where applicable) so that safety and reliability for the expected application is assured. They may be regarded as fault-free in relation to the safety requirements of this Part 1.

NOTE – Examples for such requirements and tests are:

- dielectric strength tests appropriate for DOUBLE INSULATION or REINFORCED INSULATION;
- dimensioning for at least twice the dissipation (resistor);
- climatic tests and endurance tests to ensure reliability for the expected life of the equipment;
- surge tests for resistors (see IEC 65).

A single electronic device that employs electron conduction in a vacuum, gas, or semi-conductor is not regarded as a HIGH INTEGRITY component.

Compliance is checked by performing the relevant tests.

NOTE – Requirements and test methods are under consideration for evaluating whether a single component can be considered to be a HIGH INTEGRITY component.

14.7 Mains transformers

Mains transformers not tested as part of the equipment according to 4.4.2.6 shall comply with the following requirements and tests:

- tests shall be conducted with the transformer either installed in the equipment or outside the equipment;
- tests outside the equipment shall be carried out in the same conditions as exist inside the equipment where these could affect the test results;
- a transformer damaged during one test may be repaired or replaced before the next test;
- devices protecting the transformer shall be included during the short circuit and overload tests. For example, short-circuit and overload tests of an output winding are performed on the load side of any current limiting impedance or overcurrent protection device for the output winding.

Compliance is checked by the short-circuit and overload tests specified in 14.7.1 and 14.7.2 and the tests specified in 4.4.4.1 to 4.4.4.3.

NF See corresponding clause in National Foreword

14.7.1 Short-circuit tests

Windings and sections of tapped windings that are loaded in NORMAL USE are tested in turn, one at a time, to simulate short-circuits in the load. All other windings are loaded or not loaded, whichever load condition of NORMAL USE is the least favorable.

14.7.2 Overload tests

Each output winding or section of a tapped winding is overloaded in turn, one at a time, for the duration specified in 4.4.3.1, with the other windings loaded or not loaded, whichever load condition of NORMAL USE is the least favorable.

Overloading is carried out by connecting a variable resistor across the winding. The resistor is adjusted as quickly as possible and readjusted, if necessary, after 1 min to maintain the applicable overload. No further readjustments are then permitted.

If overcurrent protection is provided by a current-breaking device, the overload test current is the maximum current that the overcurrent protection device is just capable of passing for 1 h. If this value cannot be derived from the specification, it is to be established by test.

In the case of equipment in which the output voltage is designed to collapse when a specified overload current is reached, the overload is slowly increased to the point which causes the output voltage to collapse. The overload is then established at the point where the output voltage recovers and is held for the required duration of the test.

In all other cases, the loading is the maximum power output obtainable from the transformer.

Transformers with overtemperature protection that meets the requirements of 14.3 during the short-circuit test of 14.7.1 need not be subjected to overload tests.

15 Protection by interlocks

If interlocks are used to protect OPERATORS from any of the hazards specified in 1.2, they shall meet the requirements of 15.1 to 15.3.

15.1 General

Interlocks shall be designed to remove a hazard (see 1.2) before the OPERATOR is exposed to it. The following exceptions are, however, permitted for a maximum of 2 s after access is possible, or a longer period if there is a warning marking (see 5.2) that tells the OPERATOR to wait for a longer period:

- temperatures of easily touched parts may exceed the values of Table 3;
- for moving parts, the requirements of 7.2 need not be met during this period.

Warning markings shall be placed on covers or other parts that have to be removed to obtain access and also on or beside the hazardous part.

Compliance is checked by inspection and by performing all relevant tests of this standard after removing the covers or other parts.

15.2 Prevention of reactivation

Any interlock for the protection of an OPERATOR shall be designed so that the hazard (see 1.2) cannot be re-established by reactivation by hand until the action which caused the interlock to operate has been reversed or canceled.

Compliance is checked by inspection and where necessary by operation by hand of the interlock parts that can be touched by the jointed test finger (see Figure B2).

15.3 Reliability

Any interlock system for the protection of OPERATORS shall be designed so that a single fault is either unlikely to occur during the expected life of the equipment or cannot cause a hazard (see 1.2).

Compliance is checked by assessment of the system. In case of doubt, the interlock system or relevant parts of the system, are cycled to switch the least favorable load in NORMAL USE. The number of cycles is twice the maximum number likely to occur during the expected life of the equipment. Switches are tested for not less than 10,000 cycles of operation. Parts passing this test are considered to be HIGH INTEGRITY components (see 4.4.2.12).

Annex A (normative)

Measuring circuits for ACCESSIBLE current (see 6.3)

For procedures for measuring of ACCESSIBLE current, see IEC 990, which also specifies the characteristics of test voltmeters.

A.1 Measuring circuits for d.c. and for a.c. with frequencies up to 1 MHz

The current shall be measured with the circuit of Figure A.1. The current shall be calculated from:

$$I = \frac{U}{500}$$

where:

I is the current, in amperes; and

U is the voltage indicated by the voltmeter.

This circuit represents the impedance of the body and compensates for the change of physiological response of the body with frequency.

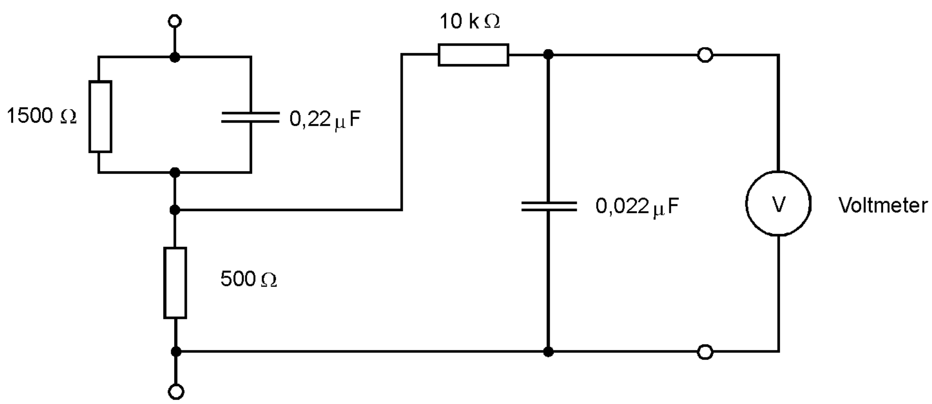


Figure A.1 — Measuring circuit for d.c. and for a.c. with frequencies up to 1 MHz

A.2 Measuring circuits for d.c. and for a.c. with sinusoidal frequencies up to 100 Hz

Where the frequency does not exceed 100 Hz, the current may be measured with the alternative circuit of Figure A.2. When using the voltmeter, the current shall be calculated from:

$$I = \frac{U}{2000}$$

where:

I is the current in amperes; and

U is the voltage indicated by the voltmeter.

The circuit represents the impedance of the body for frequencies not exceeding 100 Hz.

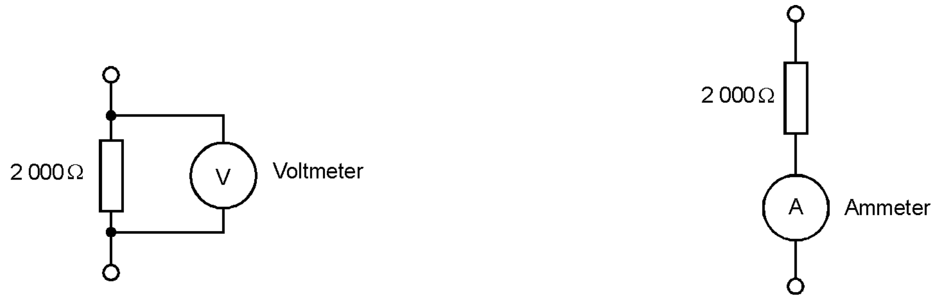


Figure A.2 — Measuring circuits for d.c. and for a.c. with sinusoidal frequencies up to 100 Hz

NOTE – The value of 2000 Ω includes the impedance of the measuring instrument.

A.3 Current measuring circuit for electrical burns at high frequencies

The current shall be measured with the circuit of Figure A.3. The current shall be calculated from:

$$I = \frac{U}{500}$$

where:

I is the current amperes; and

U is the voltage indicated by the voltmeter.

This circuit compensates for the change of physiological response to the body with frequency.

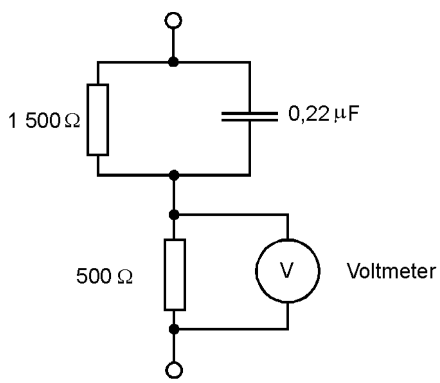
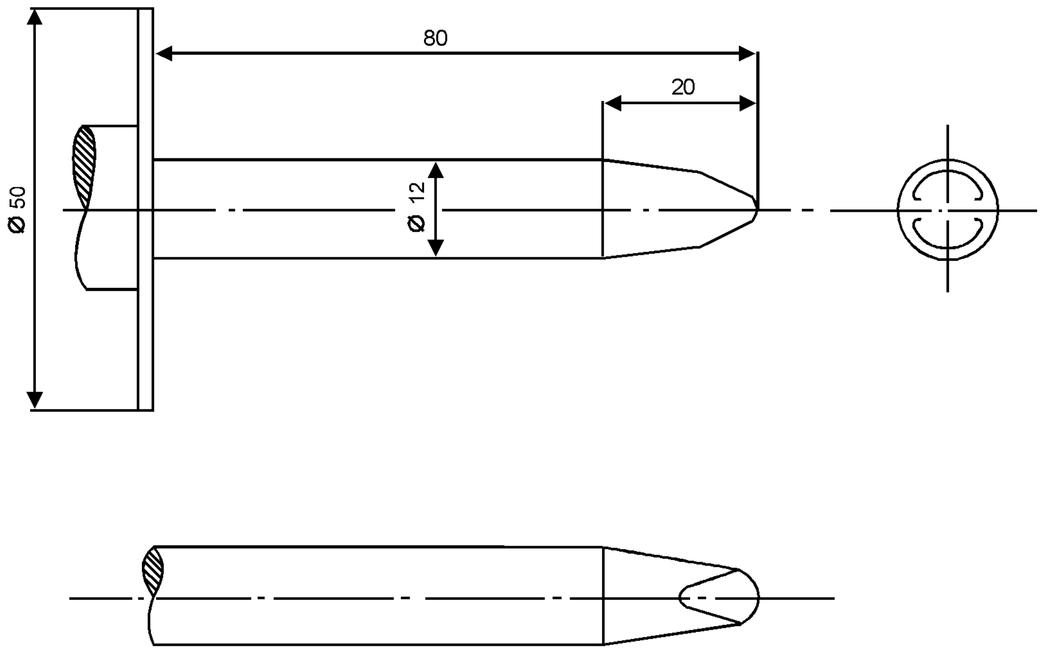


Figure A.3 — Current measuring circuit for electrical burns

Annex B (normative)

Standard test fingers (See 6.2)



Dimensions in millimeters

Figure B.1 — Rigid test finger

For tolerances and dimensions of the fingertip: see Figure B.2.

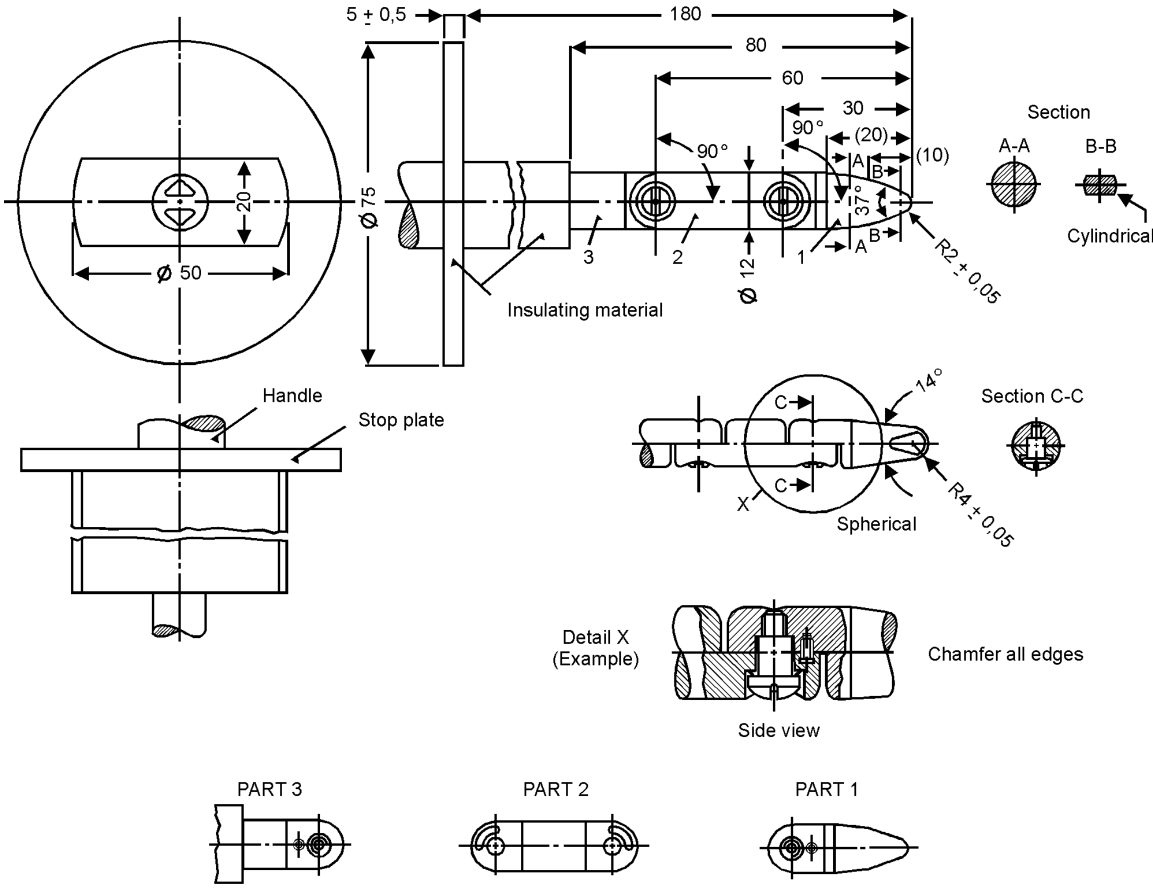


Figure B.2 — Jointed test finger

Dimensions in millimeters

Tolerances on dimensions without specific tolerance:

- on angles: 0,

  -10’
- on linear dimensions:

  up to 25 mm: 0,

  -0.05 mm

  over 25 mm: ± 0.2 mm

Material of finger: heat-treated steel, etc.

Both joints of this finger may be bent through an angle of $(90\ ^{+10}_{0})°$ but in one and the same direction only.

Using the pin and groove solution is only one of the possible approaches in order to limit the bending angle to 90°. For this reason dimensions and tolerances of these details are not given in the drawing. The actual design must ensure a $(90\ ^{+10}_{0})°$ bending angle.

Annex C (normative)

Impact hammer (see 8.2)

IEC 817 describes the construction, the application, and the calibration of the impact test apparatus. The following brief description is not intended to give full details of how to make or calibrate the apparatus.

The test apparatus (see Figure C.1 below) consists of three main parts: the body, the striking element, and the spring-loaded release cone.

The body comprises the housing, the striking element guide, the release mechanism, and all parts rigidly fixed thereto.

The striking element comprises the hammer head, the hammer shaft, and the cocking knob. The hammer head has a hemispherical face of polyamide having a Rockwell hardness of HR 100, with a radius of 10 mm; it is so fixed to the hammer shaft that the distance from its tip to the plane of the front of the cone when the striking element is on the point of release is 20 mm.

The cone has a mass of 60 g and the cone spring is such that it exerts a force of 20 N when the release jaws are on the point of releasing the striking element.

The apparatus is cocked by pulling the cocking knob until the release jaws engage in the hammer shaft.

For an impact energy of 0.5 J ± 0.05 J, the hammer spring is adjusted so that the product of the compression, in millimeters, and the force exerted, in newtons, equals 1 000, the compression being approximately 20 mm.

For other energy levels, adjust as described in IEC 817 or according to the instructions supplied with the apparatus.

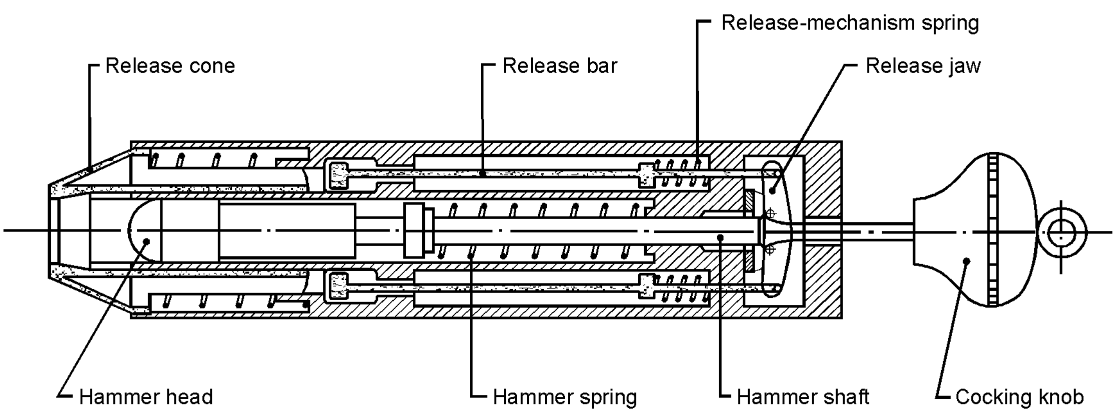


Figure C.1 — Test apparatus

Annex D (normative)

Tables for CLEARANCES and CREEPAGE DISTANCES in equipment and on printed wiring boards, and test voltages

D.1 General

This annex specifies CLEARANCES, CREEPAGE DISTANCES, and overvoltages for dielectric strength tests, derived from IEC 664.

CLEARANCE and CREEPAGE DISTANCES shall be measured according to IEC 664.

Circuits, other than mains circuits, that fail to comply with the requirements of this annex for CLEARANCE and CREEPAGE DISTANCE may be accepted, if compliance is achieved under the fault conditions described in 4.4., and if HAZARDOUS LIVE parts are not ACCESSIBLE after a fault.

D.1.1 Working voltage

The tables specify values in relation to working voltage, which is defined in IEC 664 as "the highest r.m.s. value of the a.c. or d.c. voltage which may occur (locally) across any insulation at RATED supply voltage, transients being disregarded," in open circuit conditions or in NORMAL USE. The tables for test voltages and CLEARANCES take into account the effect of transients (transient over-voltages) as determined for insulation coordination in IEC 664.

D.1.2 Notes on tables

In IEC 664 insulating materials are separated into four groups by the Comparative Tracking Index (CTI) values as specified in IEC 112. For more information see IEC 664.

- Material Group I — $600 \leq CTI$
- Material Group II — $400 \leq CTI < 600$
- Material Group IIIa — $175 \leq CTI < 400$
- Material Group IIIb — $100 \leq CTI < 175$

The peak impulse voltage test prescribed in Tables D.1 to D.12 is the "standard lightning impulse" test as specified in IEC 60-2. This is defined as a full lightning impulse having a virtual front time of 1.2 µs and a virtual time to half-value of 50 µs.

Information on the details of measurement, assessment of errors, etc. is given in IEC 60.

Values of CREEPAGE DISTANCE for coated printed wiring boards apply to boards whose coatings meet the requirements for type A coatings given in IEC 664-3.

D.2 Determination of CLEARANCE and CREEPAGE DISTANCE if the working voltage is up to 1,000 V and if installation categories (overvoltage categories) are applicable

D.2.1 Applicable table

The applicable table depends on:

- type of insulation. Tables D.1 to D.6 apply to BASIC INSULATION or SUPPLEMENTARY INSULATION, Tables D.7 to D.12 to DOUBLE INSULATION or REINFORCED INSULATION (see 6.4 to 6.6);
- INSTALLATION CATEGORY (OVERVOLTAGE CATEGORY) (see Annex J);
- POLLUTION DEGREE (see 3.7.2 and 3.7.3). This is the POLLUTION DEGREE of the micro-environment of the CLEARANCE or CREEPAGE DISTANCE under consideration.

NOTE 1 - It is the micro-environment of the CLEARANCE or CREEPAGE DISTANCE that determines the effect on insulation, not the environment of the equipment as a whole. Micro-environment includes all factors affecting insulation, including climatic, electromagnetic, generation of POLLUTION, etc.

NOTE 2 - No CLEARANCES nor CREEPAGE DISTANCES can exist inside void-free molded parts (see definitions 3.7.4 and 3.7.5). The environment within sealed components is deemed to be POLLUTION DEGREE 1.

NOTE 3 - Values in Tables D.1 to D.12 are valid up to an altitude of 2000 m above sea level. CLEARANCE for higher altitudes must be corrected to Paschen's Law (see D.9).

NOTE 4 - The values given in Annex D are minimum values. The manufacturer should make sure that the values will be maintained, taking account of production tolerances and other foreseeable influences.

NOTE 5 - Relative phasing between circuits or parts of circuits (e.g., transformers) may affect the actual working voltage between them.

D.2.2 Application of Tables D.1 to D.12

Interpolation of CREEPAGE DISTANCE is permissible. Interpolation of CLEARANCE is only permissible for a circuit or part which has no direct connection to the mains supply, but is powered from a transformer, converter, or equivalent isolation device within the equipment (see also the notes to Tables D.13, D.15 and D.16). For CLEARANCES in the primaries of switching power supplies, see Clause D.4.

CREEPAGE DISTANCE shall always be at least as large as the value specified for CLEARANCE.

For CREEPAGE DISTANCE between two circuits, the actual working voltage that stresses the insulation between the circuits shall be used.

For test voltage and CLEARANCE between two circuits, the values for each circuit are obtained separately from the appropriate table, using the working voltage of each circuit. The higher values of test voltage and CLEARANCE shall then be used.

Table D.1 — BASIC INSULATION or SUPPLEMENTARY INSULATION

Working voltage (r.m.s. or d.c.) up to	POLLUTION DEGREE 1 INSTALLATION CATEGORY (OVERVOLTAGE CATEGORY) I					
	CLEARANCE	CREEPAGE DISTANCE mm		Test voltage V		
		In equipment	On printed wiring board	Peak impulse	r.m.s. 50/60 Hz	d.c. or 50/60 Hz peak
V	mm	CTI>100	CTI>100	1.2/50 µs	1 min	1 min
50	0.1	0.18	0.10	330	230	330
100	0.1	0.25	0.10	500	350	500
150	0.1	0.30	0.22	800	490	700
300	0.5	0.70	0.70	1500	820	1150
600	1.5	1.70	1.70	2500	1350	1900
1000	3.0	3.20	3.20	4000	2200	3100

Table D.2 — BASIC INSULATION or SUPPLEMENTARY INSULATION

Working voltage (r.m.s. or d.c.) up to	POLLUTION DEGREE 2 INSTALLATION CATEGORY (OVERVOLTAGE CATEGORY) I								
	CLEAR-ANCE	CREEPAGE DISTANCE mm					Test voltage V		
		In equipment			On printed wiring board		Peak impulse	r.m.s. 50/60 Hz	d.c. or 50/60 Hz peak
		Material group			Not coated	Coated			
		I	II	III					
V	mm	CTI>600	CTI>400	CTI>100	CTI>175	CTI>100	1.2/50 µs	1 min	1 min
50	0.2	0.6	0.85	1.2	0.20	0.10	330	230	330
100	0.2	0.7	1.00	1.4	0.20	0.10	500	350	500
150	0.2	0.8	1.10	1.6	0.35	0.22	800	490	700
300	0.5	1.5	2.10	3.0	1.40	0.70	1500	820	1150
600	1.5	3.0	4.30	6.0	3.00	1.70	2500	1350	1900
1000	3.0	5.0	7.00	10.0	5.00	3.20	4000	2200	3100

Table D.3 — BASIC INSULATION or SUPPLEMENTARY INSULATION

Working voltage (r.m.s. or d.c.) up to	POLLUTION DEGREE 1 INSTALLATION CATEGORY (OVERVOLTAGE CATEGORY) II					
	CLEARANCE	CREEPAGE DISTANCE mm		Test voltage V		
		In equipment	On printed wiring board	Peak impulse	r.m.s. 50/60 Hz	d.c. or 50/60 Hz peak
V	mm	CTI>100	CTI>100	1.2/50 µs	1 min	1 min
50	0.1	0.18	0.1	500	350	500
100	0.1	0.25	0.1	800	490	700
150	0.5	0.50	0.5	1500	820	1150
300	1.5	1.50	1.5	2500	1350	1900
600	3.0	3.00	3.0	4000	2200	3100
1000	5.5	5.50	5.5	6000	3250	4600

Table D.4 — BASIC INSULATION or SUPPLEMENTARY INSULATION

Working voltage (r.m.s. or d.c.) up to	POLLUTION DEGREE 2 INSTALLATION CATEGORY (OVERVOLTAGE CATEGORY) II								
	CLEAR-ANCE	CREEPAGE DISTANCE mm					Test voltage V		
		In equipment			On printed wiring board		Peak impulse	r.m.s. 50/60 Hz	d.c. or 50/60 Hz peak
		Material group			Not coated	Coated			
		I	II	III					
V	mm	CTI>600	CTI>400	CTI>100	CTI>175	CTI>100	1.2/50 µs	1 min	1 min
50	0.2	0.6	0.85	1.2	0.2	0.1	500	350	530
100	0.2	0.7	1.00	1.4	0.2	0.1	800	490	700
150	0.5	0.8	1.10	1.6	0.5	0.5	1500	820	1150
300	1.5	1.5	2.10	3.0	1.5	1.5	2500	1350	1900
600	3.0	3.0	4.30	6.0	3.0	3.0	4000	2200	3100
1000	5.5	5.5	7.00	10.0	5.5	5.5	6000	3250	4600

Table D.5 — BASIC INSULATION or SUPPLEMENTARY INSULATION

Working voltage (r.m.s. or d.c.) up to	POLLUTION DEGREE 1 INSTALLATION CATEGORY (OVERVOLTAGE CATEGORY) III					
	CLEARANCE	CREEPAGE DISTANCE mm		Test voltage V		
		In equipment	On printed wiring board	Peak impulse	r.m.s. 50/60 Hz	d.c. or 50/60 Hz peak
V	mm	CTI>100	CTI>100	1.2/50 µs	1 min	1 min
50	0.1	0.18	0.1	800	490	700
100	0.5	0.50	0.5	1500	820	1150
150	1.5	1.50	1.5	2500	1350	1900
300	3.0	3.00	3.0	4000	2200	3100
600	5.5	5.50	5.5	6000	3250	4600
1000	8.0	8.00	8.0	8000	4350	6150

Table D.6 — BASIC INSULATION or SUPPLEMENTARY INSULATION

Working voltage (r.m.s. or d.c.) up to	POLLUTION DEGREE 2 INSTALLATION CATEGORY (OVERVOLTAGE CATEGORY) III								
	CLEAR-ANCE	CREEPAGE DISTANCE mm					Test voltage V		
		In equipment			On printed wiring board		Peak impulse	r.m.s. 50/60 Hz	d.c. or 50/60 Hz peak
		Material group			Not coated	Coated			
		I	II	III					
V	mm	CTI>600	CTI>400	CTI>100	CTI>175	CTI>100	1.2/50 µs	1 min	1 min
50	0.2	0.6	0.85	1.2	0.2	0.1	800	490	700
100	0.5	0.7	1.00	1.4	0.5	0.5	1500	820	1150
150	1.5	1.5	1.50	1.6	1.5	1.5	2500	1350	1900
300	3.0	3.0	3.00	3.0	3.0	3.0	4000	2200	3100
600	5.5	5.5	5.50	6.0	5.5	5.5	6000	3250	4600
1000	8.0	8.0	8.00	10.0	8.0	8.0	8000	4350	6150

Table D.7 — DOUBLE INSULATION or REINFORCED INSULATION

Working voltage (r.m.s. or d.c.) up to V	POLLUTION DEGREE 1 INSTALLATION CATEGORY (OVERVOLTAGE CATEGORY) I					
	CLEARANCE mm	CREEPAGE DISTANCE mm		Test voltage V		
		In equipment CTI>100	On printed wiring board CTI>100	Peak impulse 1.2/50 µs	r.m.s. 50/60 Hz 1 min	d.c. or 50/60 Hz peak 1 min
50	0.10	0.35	0.10	560	400	560
100	0.12	0.50	0.20	850	510	720
150	0.40	0.60	0.45	1360	740	1050
300	1.60	1.60	1.60	2550	1400	1950
600	3.30	3.40	3.40	4250	2300	3250
1000	6.50	6.50	6.50	6800	3700	5250

Table D.8 — DOUBLE INSULATION or REINFORCED INSULATION

Working voltage (r.m.s. or d.c.) up to V	POLLUTION DEGREE 2 INSTALLATION CATEGORY (OVERVOLTAGE CATEGORY) I								
	CLEAR-ANCE mm	CREEPAGE DISTANCE mm					Test voltage V		
		In equipment			On printed wiring board		Peak impulse	r.m.s. 50/60 Hz	d.c. or 50/60 Hz peak
		Material group			Not coated	Coated			
		I CTI>600	II CTI>400	III CTI>100	CTI>175	CTI>100	1.2/50 µs	1 min	1 min
50	0.2	1.2	1.7	2.4	0.4	0.10	560	400	560
100	0.2	1.4	2.0	2.8	0.4	0.20	850	510	720
150	0.4	1.6	2.2	3.2	0.7	0.45	1360	740	1050
300	1.6	3.0	4.2	6.0	2.8	1.60	2550	1400	1950
600	3.3	6.0	8.5	12.0	6.0	3.40	4250	2300	3250
1000	6.5	10.0	14.0	20.0	10.0	6.50	6800	3700	5250

Table D.9 — DOUBLE INSULATION or REINFORCED INSULATION

Working voltage (r.m.s. or d.c.) up to V	POLLUTION DEGREE 1 INSTALLATION CATEGORY (OVERVOLTAGE CATEGORY) II					
	CLEARANCE	CREEPAGE DISTANCE mm		Test voltage V		
		In equipment	On printed wiring board	Peak impulse	r.m.s. 50/60 Hz	d.c. or 50/60 Hz peak
	mm	CTI>100	CTI>100	1.2/50 µs	1 min	1 min
50	0.12	0.35	0.12	850	510	720
100	0.40	0.50	0.40	1360	740	1050
150	1.60	1.60	1.60	2550	1400	1950
300	3.30	3.30	3.30	4250	2300	3250
600	6.50	6.50	6.50	6800	3700	5250
1000	11.50	11.50	11.50	10200	5500	7850

Table D.10 — DOUBLE INSULATION or REINFORCED INSULATION

Working voltage (r.m.s. or d.c.) up to V	POLLUTION DEGREE 2 INSTALLATION CATEGORY (OVERVOLTAGE CATEGORY) II								
	CLEAR-ANCE	CREEPAGE DISTANCE mm					Test voltage V		
		In equipment			On printed wiring board		Peak impulse	r.m.s. 50/60 Hz	d.c. or 50/60 Hz peak
		Material group			Not coated	Coated			
	mm	I CTI>600	II CTI>400	III CTI>100	CTI>175	CTI>100	1.2/50 µs	1 min	1 min
50	0.2	1.2	1.7	2.4	0.4	0.12	850	510	720
100	0.4	1.4	2.0	2.8	0.4	0.40	1360	740	1050
150	1.6	1.6	2.2	3.2	1.6	1.60	2550	1400	1950
300	3.3	3.3	4.2	6.0	3.3	3.30	4250	2300	3250
600	6.5	6.5	8.5	12.0	6.5	6.50	6800	3700	5250
1000	11.5	11.5	14.0	20.0	11.5	11.50	10200	5550	7850

Table D.11 — DOUBLE INSULATION or REINFORCED INSULATION

Working voltage (r.m.s. or d.c.) up to	POLLUTION DEGREE 1 INSTALLATION CATEGORY (OVERLOAD CATEGORY) III					
	CLEARANCE	CREEPAGE DISTANCE mm		Test voltage V		
		In equipment	On printed wiring board	Peak impulse	r.m.s. 50/60 Hz	d.c. or 50/60 Hz peak
V	mm	CTI>100	CTI>100	1.2/50 µs	1 min	1 min
50	0.4	0.6	0.4	1360	740	1050
100	1.6	1.6	1.6	2550	1400	1950
150	3.3	3.3	3.3	4250	2300	3250
300	6.5	6.5	6.5	6800	3700	5250
600	11.5	11.50	11.5	10200	5550	7850
1000	16.0	16.00	16.0	13600	7400	10450

Table D.12 — DOUBLE INSULATION or REINFORCED INSULATION

Working voltage (r.m.s. or d.c.) up to	POLLUTION DEGREE 2 INSTALLATION CATEGORY (OVERVOLTAGE CATEGORY) III								
	CLEAR-ANCE	CREEPAGE DISTANCE mm					Test voltage V		
		In equipment			On printed wiring board		Peak impulse	r.m.s. 50/60 Hz	d.c. or 50/60 Hz peak
		Material group			Not coated	Coated			
		I	II	III					
V	mm	CTI>600	CTI>400	CTI>100	CTI>175	CTI>100	1.2/50 µs	1 min	1 min
50	0.4	1.2	1.7	2.4	0.4	0.4	1360	740	1050
100	1.6	1.6	2.0	2.8	1.6	1.6	2550	1400	1950
150	3.3	3.3	3.3	3.3	3.3	3.3	4250	2300	3250
300	6.5	6.5	6.5	6.5	6.5	6.5	6800	3700	5250
600	11.5	11.5	11.5	12.0	11.5	11.5	10200	5550	7850
1000	16.0	16.0	16.0	20.0	16.0	16.0	13600	7400	10450

D.3 Determination of CLEARANCE for working voltage above 1000 V r.m.s. or d.c.

D.3.1 CLEARANCE for BASIC INSULATION or SUPPLEMENTARY INSULATION

a) For working voltages above 1000 V r.m.s. or d.c., where neither overvoltage control nor homogeneous construction is employed within the equipment, the CLEARANCE of the Table D.13 applies.

CLEARANCE values in Table D.13 are for high-voltage secondary circuits where the primary circuits are low-voltage systems as described in IEC 664. The values for type 1 circuits apply when the primary is INSTALLATION CATEGORY (OVERVOLTAGE CATEGORY) II and the values for type 2 circuits apply when the primary is INSTALLATION CATEGORY (OVERVOLTAGE CATEGORY) III.

NOTE – See also D.11.1 for rationale.

b) Acceptable CLEARANCES alternative to those of Table D.13 may be calculated according to Clause D.5, if applicable.

D.3.2 CLEARANCE for REINFORCED INSULATION

CLEARANCE for REINFORCED INSULATION shall be twice the CLEARANCE value determined for BASIC INSULATION or SUPPLEMENTARY INSULATION.

D.4 CLEARANCE in the primary of switching power supplies

The CLEARANCE between circuits connected to the mains and other circuits or ACCESSIBLE parts shall be not less than the CLEARANCE given in the appropriate Table of D.1 to D.12. However, if a repetitive working voltage exists, whose peak value exceeds the appropriate phase-to-earth voltage of Table D.14 (caused for example by voltage doubling), the CLEARANCE shall be calculated according to Clause D.5.

CLEARANCES for circuits in which controlled overvoltage is employed (see D.5.1 and Clause D.10) and that are between poles of the mains can be calculated according to Clause D.5.

D.5 Determination of CLEARANCE when neither Clause D.2 nor Table D.13 applies

D.5.1 General

Clause D.5 enables CLEARANCES to be calculated if the maximum voltage U_m (peak value of working voltage plus transient overvoltage) meets one of the following criteria:

a) It is controlled within the equipment to levels below the impulse withstand voltages of Table D.14;

In circuits other than mains circuits, lower values than those of Clause D.2 can be used. For a mains circuit, lower values are only permitted within parts of the circuit where controlled overvoltage is employed.

b) It is above the impulse withstand voltages of Table D.14;

c) It includes a working voltage as described in Clause D.4;

d) It includes a working voltage that is the sum of voltages from more than one circuit or a mixed voltage.

Table D.13 — CLEARANCE for BASIC INSULATION or SUPPLEMENTARY INSULATION for circuits with working voltages above 1000 V r.m.s. or d.c.

Working voltage (Uw) V		CLEARANCE mm	
a.c.r.m.s. sinusoidal	d.c. or peak if mixed or a.c. non-sinusoidal	Type 1 circuit	Type 2 circuit
1060	1000 to 1500	3.71	5.82
1250	1770	4.25	6.42
1600	2250	5.31	7.55
2000	2830	6.60	8.86
2500	3540	8.17	10.5
3200	4530	10.4	12.9
4000	5660	13.0	15.4
5000	7070	16.2	18.6
6300	8910	20.4	22.9
8000	11300	26.1	28.7
10000	14100	33.0	35.7
12500	17700	42.0	44.7
16000	22600	55.0	57.9
20000	28300	70.5	73.5
25000	35400	90.6	93.6
32000	45200	120	123
40000	56600	154	158
50000	70700	199	203
63000	89100	260	264
NOTE – Linear interpolation is permitted.			

NOTE – The term "controlled overvoltage" refers to the condition in which means have been taken within the equipment to limit the peak level of transient overvoltage (see Clause D.10).

The transient overvoltage that is caused by phenomenon such as lightning or load switching adds to the peak value of working voltage raising the level to the maximum voltage.

Table D.14 — Impulse withstand voltage (derived from Table J.1 of Annex J)

Voltage phase-to-earth V r.m.s.	Preferred series of impulse withstand voltages for INSTALLATION CATEGORY (OVERVOLTAGE CATEGORY) I to III V		
	I	II	III
50	330	500	800
100	500	800	1500
150	800	1500	2500
300	1500	2500	4000
600	2500	4000	6000
1000	4000	6000	8000

D.5.2 Calculation of CLEARANCE for inhomogeneous construction for BASIC INSULATION or SUPPLEMENTARY INSULATION

For calculation of CLEARANCE, Table D.15 applies (see D.11.2). Two values of CLEARANCE are given in Table D.15. CLEARANCE D1 is the CLEARANCE for a 1.2 x 50 µs impulse of the maximum voltage U_m.

CLEARANCE D2 is for a working voltage (d.c., a.c., or mixed) without transient overvoltages. In this case, U_m and the peak value of the working voltage are the same.

The calculation is made in the following order:

a) Determine peak value of the working voltage at the highest level, according to the reference test conditions of 4.3

U_w = __________ V peak

b) Determine maximum voltage

U_m = __________ V peak

NOTE – The term "maximum voltage" (U_m) is the peak level resulting from the addition of a transient overvoltage (U_i) to the peak value of the working voltage (U_w):

$$U_m = U_w + U_i$$

c) Determine CLEARANCES D1 and D2 from Table D.15, both relating to maximum voltage

D1 = _________mm

D2 = _________mm

d) Interpolation between CLEARANCES D1 and D2 is based on the ratio of peak value of working voltage divided by maximum voltage

Calculate ratio U_w / U_m Ratio = _________

The interpolation factor F is taken from Figure D.1

F = ________

Calculate: CLEARANCE = D1 + F (D2 – D1) = ________

After the calculation of CLEARANCE, correction for altitude above 2000 m (see clause D.9) is considered if appropriate. If the final CLEARANCE is below the minimum, the CLEARANCE is raised to the minimum. (Minimum CLEARANCE is 0.01 mm for POLLUTION DEGREE 1 and 0.2 mm for POLLUTION DEGREE 2.) (See Table II of IEC 664.)

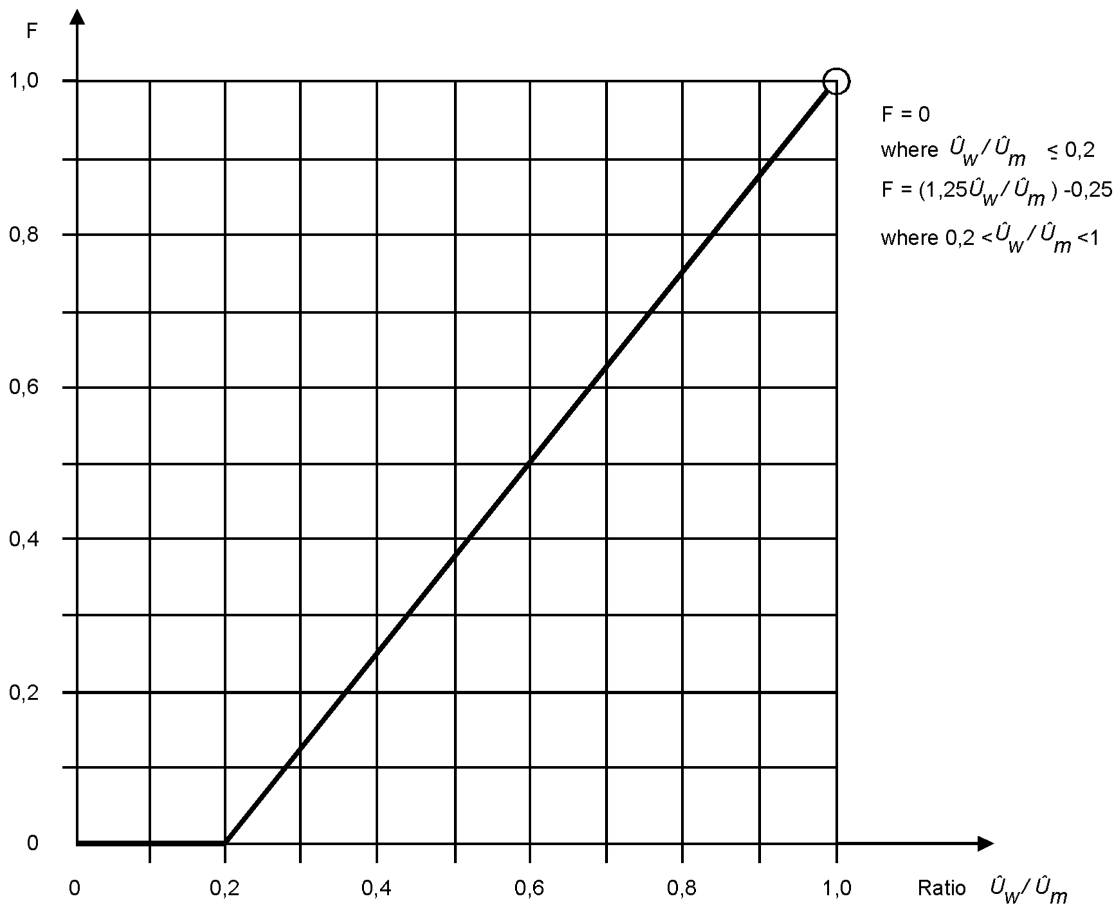


Figure D.1 — Interpolation factor (F) for CLEARANCE

Table D.15 — Range of CLEARANCE related to maximum voltage for BASIC INSULATION or SUPPLEMENTARY INSULATION

$\hat{U}_m$ in V	CLEARANCE mm	
	When $\hat{U}_m$ is mainly impulse D1 (see Note 2)	When $\hat{U}_m$ is working voltage with no impulse D2 (see Note 2)
14.1 to 266	0.010	0.010
283	0.010	0.013
330	0.010	0.020
354	0.013	0.025
453	0.027	0.052
500	0.036	0.071
566	0.052	0.10
707	0.081	0.20
800	0.099	0.29
891	0.12	0.41
1130	0.19	0.83
1410	0.38	1.27
1500	0.45	1.40
1770	0.75	1.79
2260	1.25	2.58
2500	1.45	3.00
2830	1.74	3.61
3540	2.44	5.04
4000	2.93	6.05
4530	3.53	7.29
5660	4.92	10.1
6000	5.37	10.8
7070	6.86	13.1
8000	8.25	15.2
8910	9.69	17.2
11300	12.9	22.8
14100	16.7	29.5
17700	21.8	38.5
22600	29.0	51.2
28300	37.8	66.7
35400	49.1	86.7
45300	65.5	116
56600	85.0	150
70700	110	195
89100	145	255

NOTES -
1 - Linear interpolation is permitted.
2 - CLEARANCE values are to two significant figures for CLEARANCES below 1 mm and three significant figures for CLEARANCES ≥ 1 mm.

D.5.3 CLEARANCE for REINFORCED INSULATION

CLEARANCE for REINFORCED INSULATION shall be twice the CLEARANCE values determined for BASIC INSULATION or SUPPLEMENTARY INSULATION.

D.6 Test voltages for insulations where the CLEARANCES are determined according to Clause D.3 or D.5

Test voltages are based on CLEARANCE and are given in Table D.16 (minimum CLEARANCE is 0.01 mm for POLLUTION DEGREE 1 and 0.2 mm for POLLUTION DEGREE 2).

Table D.16 — Test voltage related to CLEARANCE

CLEARANCE	Test voltage V			CLEARANCE	Test voltage V		
mm	r.m.s. 50Hz-60Hz	d.c. or a.c. peak	Peak impulse 1.2x50 µs	mm	r.m.s. 50Hz-60Hz	d.c. or a.c. peak	Peak impulse 1.2x50 µs
0.010	231	327	327	8.3	4370	6180	8040
0.015	265	374	374	10	4950	7000	9100
0.022	300	425	425	12	5790	8180	10600
0.032	340	481	481	15	7000	9900	12900
0.046	383	542	542	18	8180	11600	15000
0.0625	424	600	600	22	9710	13700	17800
0.068	436	617	633	26	11200	15800	20600
0.10	495	700	806	32	13400	18900	24600
0.15	566	801	1040	38	15500	21900	28500
0.22	643	909	1180	46	18200	25800	33500
0.32	727	1030	1340	56	21600	30500	39600
0.46	820	1160	1510	68	25400	36000	46800
0.68	933	1320	1720	83	30200	42700	55500
1.0	1060	1500	1950	100	35400	50000	65000
1.2	1200	1700	2200	120	41300	58500	76000
1.5	1390	1970	2560	150	50000	70700	92000
1.8	1570	2220	2890	180	58400	82600	107000
2.2	1800	2540	3310	220	69400	98100	128000
2.6	2010	2840	3700	260	80000	113000	147000
3.2	2310	3270	4250	264	81100	115000	149000
3.8	2590	3670	4770				
4.6	2950	4170	5410				
5.6	3360	4750	6180				
6.8	3830	5410	7030				

NOTES -
1- Linear Interpolation Is Permitted.
2 - See D.11.3 for rationale.

D.7 CLEARANCE when homogenous construction is employed

D.7.1 General

In circuits other than mains circuits, reduced CLEARANCES can be accepted if the construction is homogeneous or nearly homogeneous and if they pass the appropriate test specified in D.7.2 or D. 7.3 (see D.11.4 for rationale). For mains circuits, lower values are permitted only for those parts of a high voltage circuit exceeding 1000 V.

NOTE – The term "homogeneous construction" refers to construction in which the shape and arrangement of conductive parts, between which a CLEARANCE exists, are such that homogeneous or near homogeneous electric field conditions exist in the CLEARANCE.

The test voltages specified in D.7.2 and D.7.3 are based on an altitude of 2000 m. If the test site is at another altitude, the voltage shall be corrected according to Table D.17 when verifying CLEARANCE with homogeneous construction.

D.7.2 Testing of BASIC INSULATION or SUPPLEMENTARY INSULATION

The test voltage is d.c. or a.c. 50 Hz/60 Hz.

For CLEARANCES below the value of the appropriate Table of D.1 to D.6, the test voltage shall have the same peak value as the appropriate impulse withstand voltage from Table D.14.

For CLEARANCES below the values of Table D.13 or below the calculated values of D.5.1 or D.5.2, the test voltage is based on the CLEARANCE value specified in Table D.13 or on the calculated value according to D.5.2. The test voltage shall have the same peak value as the impulse test voltage given in Table D.16.

NOTE – Minimum CLEARANCE is 0.01 mm for POLLUTION DEGREE 1 and 0.2 mm for POLLUTION DEGREE 2.

D.7.3 Testing of REINFORCED INSULATION

The test voltage is d.c. or a.c. 50 Hz/60 Hz.

For CLEARANCES below the value of the appropriate table of Clauses D.7 to D.12, the test voltage shall have the same peak value as the appropriate impulse withstand voltage from Table D.14 multiplied by the factor 1.6.

For CLEARANCES below the calculated values of D.3.2 and D.5.3, the test voltage is based on the calculated CLEARANCE. The test voltage shall have the same peak value as the impulse test voltage given in Table D.16.

NOTE – Minimum CLEARANCE is 0.01 mm for POLLUTION DEGREE 1 and 0.2 mm for POLLUTION DEGREE 2.

D.7.4 Altitude correction of test voltages for testing homogeneous construction

Factors for correction of test voltage, when the test site is at an altitude different from 2000 m, are given in Table D.17. The factors are to be used only when using a voltage test to qualify a CLEARANCE of homogeneous construction. When applicable, the test voltage for 2000 m is to be multiplied by the appropriate factor. The new test voltage will provide the same voltage stress relative to breakdown of a CLEARANCE at the test site altitude as would the original test voltage at 2000 m.

Table D.17 — Correction factors for test voltage according to test site altitude

Test site altitude m	Altitude correction factors for ranges of test voltage			
	327 $V_{peak} < Û_{test} <$ 600 V_{peak} 231 $V_{r.m.s.} < Û_{test}$ < 424 $V_{r.m.s.}$	600 $V_{peak} < Û_{test} <$ 3500 V_{peak} 424 $V_{r.m.s.} < Û_{test}$ < 2475 $V_{r.m.s.}$	3500 $V_{peak} < Û_{test} <$ 25 kV_{peak} 2475 $V_{r.m.s.} < Û_{test}$ 17.7 $kV_{r.m.s.}$	25 $kV_{peak} < Û_{test}$ 17.7 $kV_{r.m.s.} <$ $Û_{test}$
Sea level	1.08	1.16	1.22	1.24
500	1.06	1.12	1.16	1.17
1000	1.04	1.08	1.11	1.12
2000	1.00	1.00	1.00	1.00
3000	0.96	0.92	0.89	0.88
4000	0.92	0.85	0.80	0.79
5000	0.88	0.78	0.71	0.70

D.8 Determination of CREEPAGE DISTANCES if Clause D.2 does not apply

D.8.1 General

CREEPAGE DISTANCES are determined according to D.8.2 or D.8.3, if Clause D.2 does not apply or when alternatives to Tables D.1 to D.12 are needed in those cases where the CLEARANCES are determined according to Clauses D.3, D.4, D.5, and D.7.

D.8.2 CREEPAGE DISTANCE for BASIC INSULATION or SUPPLEMENTARY INSULATION

CREEPAGE DISTANCE is obtained from Table D.18 for the working voltage.

If this CREEPAGE DISTANCE is below the calculated CLEARANCE, the CREEPAGE DISTANCE shall be equal to the calculated value of CLEARANCE.

D.8.3 CREEPAGE DISTANCE for REINFORCED INSULATION

The CREEPAGE DISTANCE for REINFORCED INSULATION shall be twice the value of that for BASIC INSULATION.

Table D.18 — CREEPAGE DISTANCE

Working voltage r.m.s. or d.c. up to V	CREEPAGE DISTANCE mm					
	POLLUTION DEGREE			POLLUTION DEGREE 2		
	1	2	1	Material group		
	On printed wiring board		Other material	I CTI > 600	II CTI > 400	IIIa/IIIb CTI > 100
10	0.025	0.040	0.080	0.40	0.40	0.40
12.5	0.025	0.040	0.090	0.42	0.42	0.42
16	0.025	0.040	0.10	0.45	0.45	0.45
20	0.025	0.040	0.11	0.48	0.48	0.48
25	0.025	0.040	0.125	0.50	0.50	0.50
32	0.025	0.040	0.14	0.53	0.53	0.53
40	0.025	0.040	0.16	0.56	0.80	1.1
50	0.025	0.040	0.18	0.60	0.85	1.2
63	0.040	0.063	0.20	0.63	0.90	1.25
80	0.063	0.10	0.22	0.67	0.95	1.3
100	0.10	0.16	0.25	0.71	1.0	1.4
125	0.16	0.25	0.28	0.75	1.05	1.5
160	0.25	0.40	0.32	0.80	1.1	1.6
200	0.40	0.63	0.42	1.0	1.4	2.0
250	0.56	1.0	0.56	1.25	1.8	2.5
320	0.75	1.6	0.75	1.6	2.2	3.2
400	1.0	2.0	1.0	2.0	2.8	4.0
500	1.3	2.5	1.3	2.5	3.6	5.0
630	1.8	3.2	1.8	3.2	4.5	6.3
800	2.4	4.0	2.4	4.0	5.6	8.0
1000	3.2	5.0	3.2	5.0	7.1	10
1250			4.2	6.3	9.0	12.5
1600			5.6	8.0	11	16
2000			7.5	10	14	20
2500			10	12.5	18	25
3200			12.5	16	22	32
4000			16	20	28	40
5000			20	25	36	50
6300			25	32	45	63
8000			32	40	56	80
10000			40	50	71	100
12500			50	63	90	125
16000			63	80	110	160
20000			80	100	140	200
25000			100	125	180	250
32000			125	160	220	320
40000			160	200	280	400
50000			200	250	360	500
63000			250	320	450	630

D.9 CLEARANCE and CREEPAGE DISTANCE for equipment for use above an altitude of 2000 m

CLEARANCE and CREEPAGE DISTANCE and test voltages given in Annex D are calculated for an altitude of 2000 m.

Table D.19, derived from IEC 664, gives factors for CLEARANCE for altitudes above 2000 m. The factors are not applied to CREEPAGE DISTANCE. CREEPAGE DISTANCE shall always be at least as large as the value specified for CLEARANCE.

Table D.19 — Multiplication factors for CLEARANCE for altitudes up to 5000 m

Altitude m	Multiplication factor
2000	1.00
3000	1.14
4000	1.29
5000	1.48

D.10 Testing of circuits or components used to control overvoltage (see Clause D.4 and D.5.1)

Where controlled overvoltage is employed in the equipment, any overvoltage limiting component or circuit shall withstand 10 positive and 10 negative impulses with the appropriate voltage of Table D.14, spaced up to 1 min apart, from a 1.2 x 50 s impulse generator. The maximum generator impedance shall be that given for the INSTALLATION CATEGORY (OVERVOLTAGE CATEGORY) of the circuit in which the limiting component is applied.

The generator shall produce an open circuit voltage waveform of 1.2 x 50 µs and a short circuit current waveform of 8 x 20 µs The output impedance is defined as the peak open circuit voltage divided by the peak short-circuit current and values are given in Table D.20.

Table D.20 — Output impedance for impulse generators

INSTALLATION CATEGORY (OVERVOLTAGE CATEGORY)	Output impedance Ω
III	2
II	12 (see note)
I	30 (see note)
NOTE – Resistance can be added in series with a lower impedance generator to raise the impedance to the appropriate value.	

Compliance is checked by the above test. After the test there shall be no sign of overload nor degradation of performance of a component.

D.11 Rationale

D.11.1 Derivation of Table D.13

CLEARANCE values for Table D.13 were calculated by the method of Clause D.5. The peak value of the working voltage for the calculation was the peak voltage shown in Table D.13. The maximum level of impulse overvoltage was the sum of the peak value of the working voltage and the maximum expected impulses of 2600 V for type 1 or 4600 V for type 2 high-voltage circuits.

These maximum expected levels were derived, according to the intent of IEC 664, by first reducing the withstand voltages by one INSTALLATION CATEGORY (OVERVOLTAGE CATEGORY) to account for the impulse loss in the primary-to-secondary transfer. The 1000 V phase-to-earth condition (see Table D.14) was chosen to include the worst case impulse level that is expected. This leads to withstand voltages of 4,000 V if derived from a primary circuit of INSTALLATION CATEGORY (OVERVOLTAGE CATEGORY) II or 6,000 V if derived from INSTALLATION CATEGORY (OVERVOLTAGE CATEGORY) III. Secondly, the rounded peak phase-to-earth voltage of 1,400 V was subtracted from the 4,000 V or 6,000 V withstand voltage to extract the maximum expected impulse level of 2,600 V or 4,600 V.

D.11.2 Method for determination of CLEARANCE according to Clause D.5

The method for determination of CLEARANCE involves calculation based on the peak working voltage (U_w) and the maximum voltage (U_m) which is the sum of peak working voltage and impulse overvoltage. The method is illustrated in Figure D.2, which is Figure A1 of IEC 664. The figure shows three possibilities for CLEARANCE at a specified value of U_m. The CLEARANCES for 2,500 V peak are illustrated.

- Line (1) shows that a CLEARANCE of 0.6 mm is the minimum to withstand 2,500 V peak when homogeneous construction is employed (point k).
- Line (2) shows that a CLEARANCE of 1.5 mm will withstand 2,500 V peak if the voltage is a pure impulse and the construction is inhomogeneous. This relates to impulse overvoltage (point l).
- Line (3) indicates that a CLEARANCE of 2.15 mm is required to withstand 2,500 V peak if the voltage is 50 Hz/60 Hz and the construction is inhomogeneous. This relates to working voltage without impulse overvoltage (point m).

In practice, the CLEARANCE, for inhomogeneous construction, which is normal, will be a minimum of line (2) up to line (3) depending on the ratio of U_w / U_m. The method for CLEARANCE in controlled overvoltage conditions provided in Table D.15 gives the two CLEARANCES and a method of interpolation based on the ratio of U_w / U_m (see Figure D.1).

When determining the CLEARANCE values when U_m is working voltage with no impulse (column D2 of Table D.15), a margin has been provided to ensure that the test voltage and the breakdown voltage will always be above the working voltage. The CLEARANCE values in column D2 of Table D.15 are those for voltage values that are multiplied by a factor of 1.25, using line (3) of Figures D.2. For example, the CLEARANCE value for 2,500 V peak shown in Table D.15 is 3.0 mm that is the CLEARANCE for 1.25 x 2,500 V = 3,125 V peak on line 3 (point n).

Example for calculation of CLEARANCE (see D.5.2):

a) Determine peak value of the working voltage at the highest level, according to the reference test conditions of 4.3

U_w = 5,000 V peak

b) Determine maximum voltage

U_m = 7,500 V peak

c) Determine CLEARANCES D1 and D2 from Table D.15, both relating to maximum voltage

D1 = 7.55 mm

D2 = 14.07

d) Interpolation between CLEARANCE D1 and D2 is based on the ratio of peak value of working voltage divided by maximum voltage

Calculate ratio use of U_w / U_m Ratio = 0.666

The interpolation factor F is taken from figure D.1

$$F = 0.58$$

Calculate: CLEARANCE = D1 + F (D2 – D1)

$$= 7.55 + 0.58 \times 6.52$$

$$= 11.3 \text{ mm}$$

D.11.3 CLEARANCE for homogeneous construction (see Clause D.7)

A method is also provided for CLEARANCES when the construction is homogeneous. While all tables for CLEARANCES in this standard are valid for inhomogeneous construction and need no verification by a voltage test, the validity of CLEARANCES with homogeneous construction requires testing for voltage withstand and, if the altitude is other than 2000 m, adjustment of the test voltage for the test site altitude.

For further information on this context see IEC 664.

D.11.4 Altitude correction factors (see D.7.4)

Table D.17 provides test voltage correction factors for test site altitudes different from 2000 m. These factors were calculated from equations which define the withstand voltage under homogeneous field condition shown in curve (1) of Figure D.2. The equations are given in four segments as follows:

$U_1 = 1{,}500\ D^{0.3305}$ 0.01 mm < D < 0.0625 mm
327 V < U < 600 V

$U_2 = 3{,}500\ D^{0.6361}$ 0.0625 mm < D < 1 mm
600 V < U < 3,500 V

$U_3 = 3{,}500\ D^{0.8539}$ 1 mm < D < 10 mm
3,500 V < U < 25 kV

$U_4 = 2{,}976\ D^{0.9243}$ 10 mm < D
25 kV < U < 210 kV

A test voltage is corrected to test site altitude by a factor that is the ratio of withstand voltage at the test site pressure to the withstand voltage at a pressure for 2000 m. For example, sea level correction factor for voltages between 600 V and 3,500 V is calculated using equation U_2 as follows:

$$\text{Factor} = \frac{\hat{U}_{sealevel}}{\hat{U}_{2000}} = \left[\frac{101.3}{80}\right]^{0.6361} = 1.16$$

See Appendix A of IEC 664:

Pressure at sea level = 101.3 kPa

Pressure at 2000 m = 80 kPa

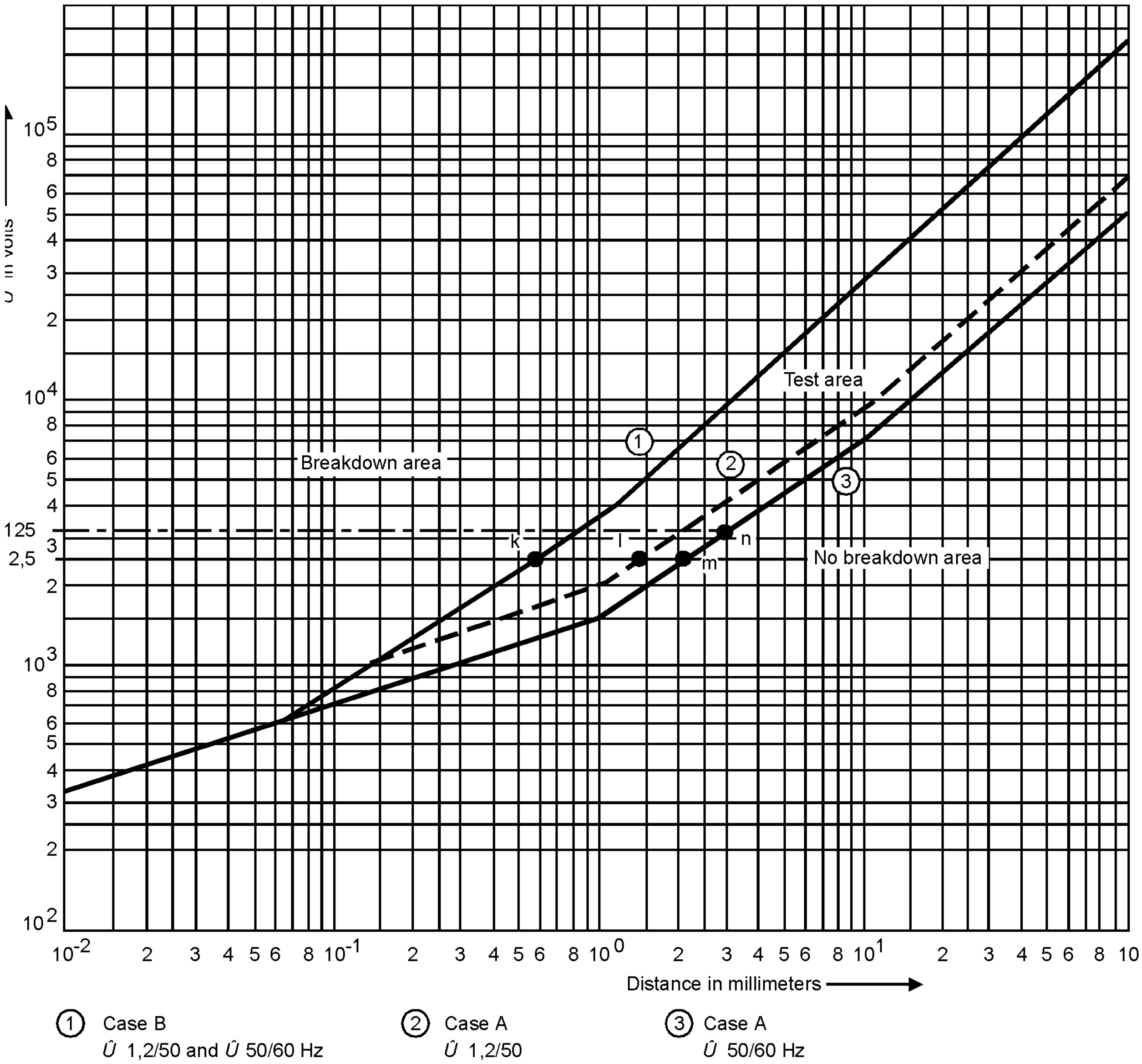


Figure D.2 — Withstand voltage for an altitude of 2000 m above sea level

Annex E (normative)

Guidance on parts between which insulation requirements are specified

The following symbols are used for the diagrams in E.1 and E.2 to indicate:

B A test for BASIC INSULATION is required.

D A test for DOUBLE INSULATION or REINFORCED INSULATION is required.

The secondary circuits shown may also be regarded merely as a part.

In the diagrams of this annex, HAZARDOUS LIVE means HAZARDOUS LIVE in NORMAL CONDITION.

E.1 Protection between HAZARDOUS LIVE circuits and circuits not exceeding the values of 6.3.2 in NORMAL CONDITION and having external TERMINALS of ACCESSIBLE parts (see Figures E.1.1. to E.1.8)

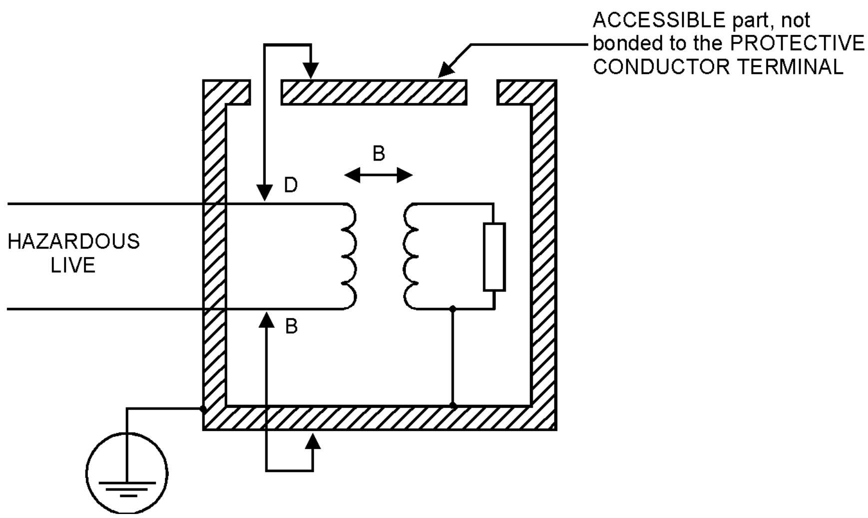


Figure E.1.1

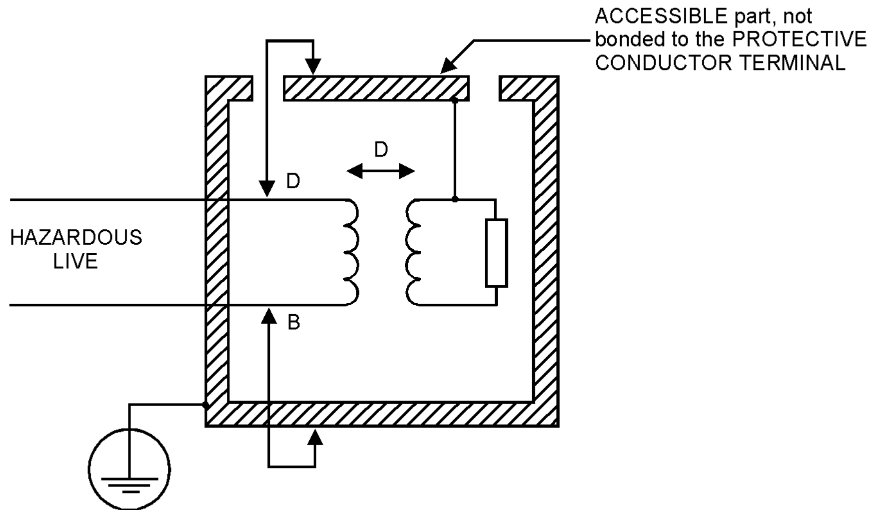


Figure E.1.2

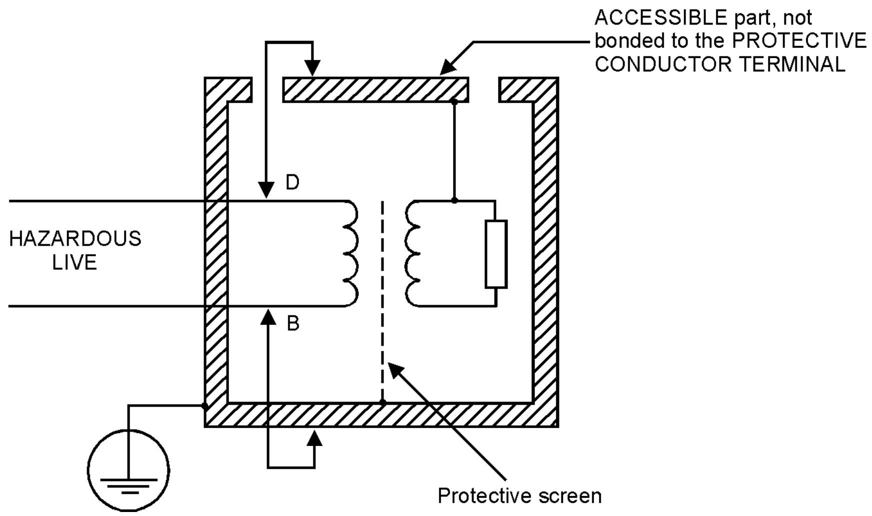


Figure E.1.3

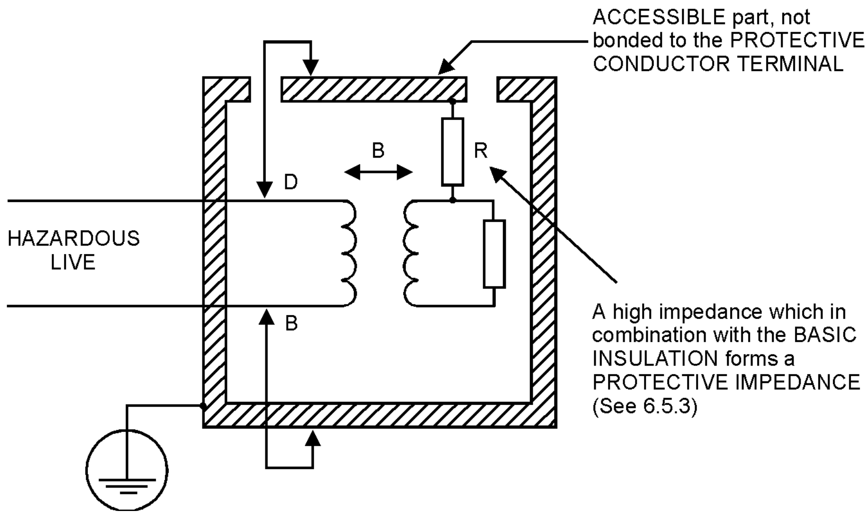


Figure E.1.4

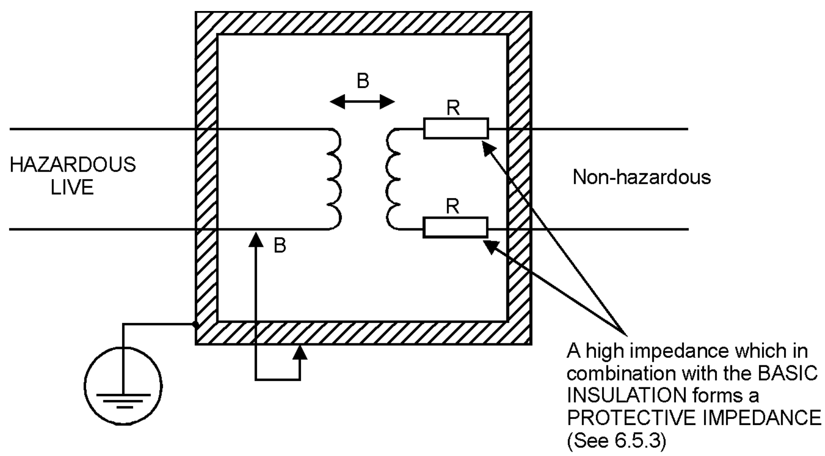


Figure E.1.5

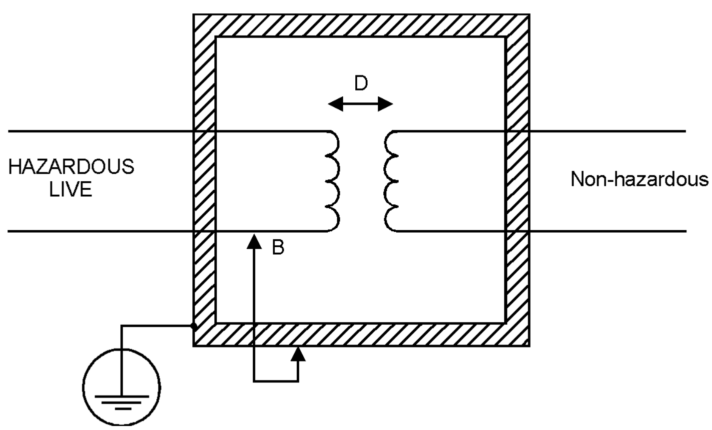


Figure E.1.6

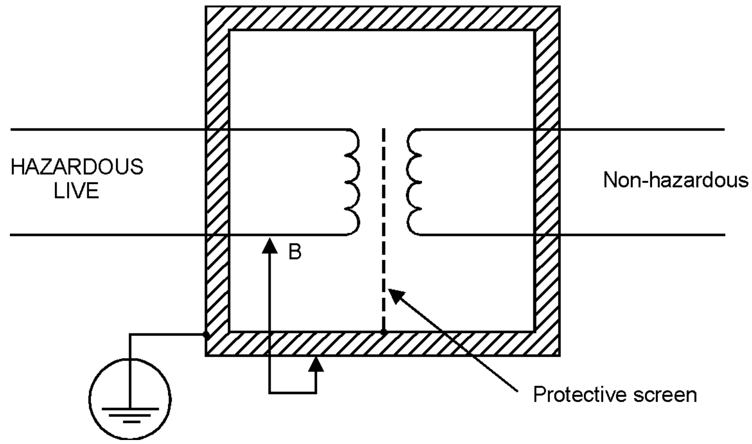


Figure E.1.7

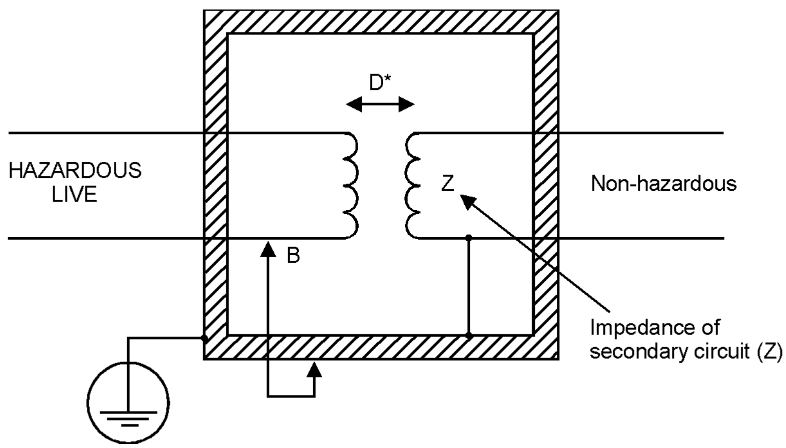


Figure E.1.8

* May be B if Z is sufficiently low (see 6.6.1).

E.2 Protection against HAZARDOUS LIVE internal circuits and circuits not exceeding the values of 6.3.2 in NORMAL CONDITIONS and having external TERMINALS or ACCESSIBLE parts (see Figures E.2.1 to E.2.4)

NOTE – Other means of protection are also possible for circuits E.2.3 and E.2.4, such as protective screening, PROTECTIVE BONDING or circuits (see 6.6.1), and PROTECTIVE IMPEDANCE

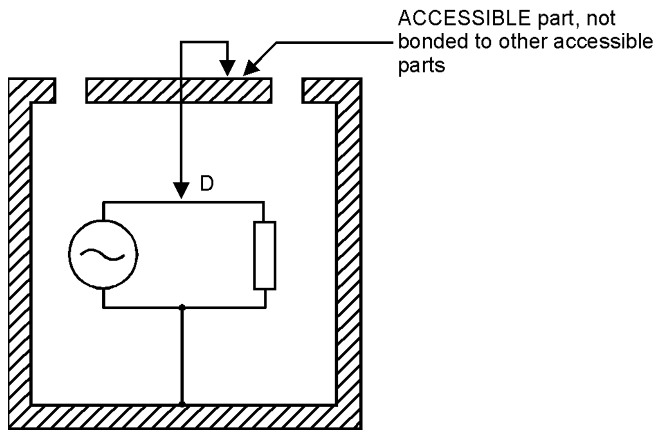


Figure E.2.1

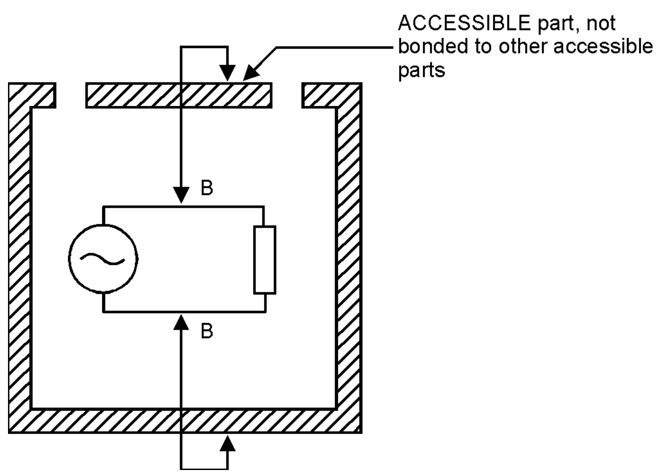


Figure E.2.2

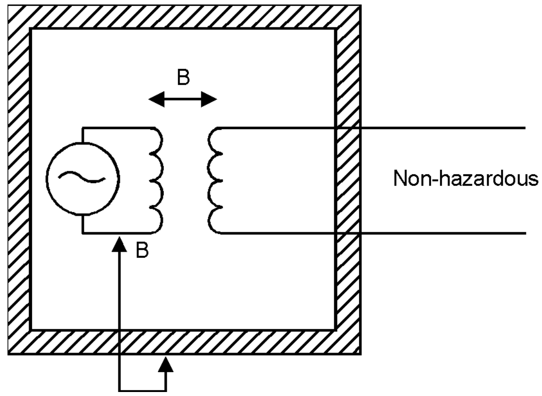


Figure E.2.3

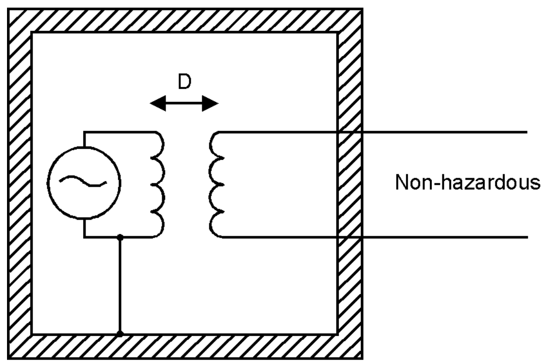


Figure E.2.4

Annex F (normative)

Protection against the spread of fire

F.1 General

This annex provides an alternative means of satisfying the requirements of 9.1 for protection against the spread of fire.

This annex explains methods and procedures to reduce to a safe level by one of the following means the risk of fire associated with equipment:

- eliminating or reducing the sources of ignition within the equipment;
- reducing the fuels provided;
- containment of a fire within the equipment, should it occur.

Rationale:

Equipment or parts of equipment might cause, due to normal or abnormal operation, excessive temperatures that could lead to a risk of fire within the equipment or to the surroundings.

In order for a risk of fire within the equipment to exist, all three of the basic elements below must exist:

- the equipment circuits must have sufficient power or energy to be an ignition source;
- there must be oxygen present (ambient air is about 21% oxygen);
- there must be a fuel present to support the combustion process.

The use of the methods and procedures of this annex offers the following benefits:

- compliance with fire protection requirements without tests;
- reduction of fault condition testing according to 4.4;
- specification of construction methods that allow verification of fire protection by inspection;
- reduction of interpretation differences and testing variables between inspection authorities.

F.2 Circuit classifications

F.2.1 Limited circuit

A limited circuit is a circuit supplied by sources such as a battery or a transformer winding where the open-circuit potential is not more than 30 V r.m.s or 42.4 V d.c., and the energy available to the circuit is limited according to one of the following means:

- the current under any condition of load, including short circuit, is not more than 8 A measured after 1 min of operation;
- the source is RATED or set to limit its power output to 150 VA under any condition of load including short circuit;
- an overload protector or circuit component opens to interrupt the power output at a lower value than 150 VA under any condition of load including short circuit.

F.2.2 Unlimited circuit

An unlimited circuit is a circuit other than a limited circuit (see F.2.1).

NOTE – Examples of unlimited circuits include:

- mains circuits;
- some measuring circuits;
- some circuits supplied by a transformer winding or battery.

F.3 Considerations for risk of fire, fire ignition sources

All circuits of equipment that can be classified as including an unlimited circuit (see F.2.2) shall be considered to be an ignition source of fire.

All electrical components of unlimited circuits are considered likely to be an ignition source of fire.

Limited circuits (F.2.1) are not considered to be an ignition source of fire and there are no requirements for protection against the spread of fire.

F.4 Requirements for unlimited circuits

F.4.1 General

The risk of fire in unlimited circuits shall be considered to have been reduced to a safe level if at least one of the following conditions is present:

- energizing of the equipment is controlled by a switch that is held closed by the OPERATOR, and unlimited circuits of the equipment and the equipment ENCLOSURE comply with the constructional requirements of F.4.2.1 to F.4.2.3;
- the unlimited circuits of the equipment and the equipment ENCLOSURE comply with the constructional requirements of F.4.2 and use only motors, transformers, etc., with provisions for overcurrent protection or overtemperature protection, and which comply with the relevant IEC standard or with 14.2 (motors) and 14.7 (transformers).

Compliance is checked by inspection. If these requirements are not fulfilled, the tests of 4.4.4.3 shall be performed, together with any other relevant fault condition tests of 4.4.

F.4.2 Constructional requirements

F.4.2.1 Connectors, wiring, and other current-carrying parts of unlimited circuits shall be types meeting the relevant IEC standard.

Compliance is checked by inspection.

F.4.2.2[NF] Printed boards of unlimited circuits shall be RATED to have a flammability classification of FV 0, FV 1, or FV 2 in accordance with IEC 707.

Compliance is checked by inspection.

F.4.2.3 The equipment ENCLOSURE containing unlimited circuits or part of an equipment ENCLOSURE surrounding unlimited circuits shall comply with the requirements of 6.2 and F.4.3.

Compliance is checked by inspection.

[NF] See corresponding clause in National Foreword.

F.4.2.4 The insulation of wire used for unlimited circuits shall have flame retardant properties in accordance with the relevant IEC standard.

Compliance is checked by inspection.

F.4.3 ENCLOSURES

In addition to the rigidity requirements for flame BARRIERS and ENCLOSURES of 6.4 for basic protection against electric shock, the flame BARRIERS and ENCLOSURES shall meet the requirements of F.4.3.1 to F.4.3.3.

F.4.3.1 High current devices such as fuse holders and circuit breakers designed for use only with a supplementary ENCLOSURE shall be covered by a door or cover, which is hinged or otherwise permanently attached and meets the following requirements:

- means shall be provided to hold the door in a closed position;
- the door or cover shall fit in such a manner that the gap between the door or cover and the ENCLOSURE shall not exceed 1.6 mm.

Compliance is checked by inspection.

F.4.3.2 The bottom of an ENCLOSURE containing unlimited circuits or the part of an ENCLOSURE surrounding unlimited circuits shall have no openings or shall be constructed in accordance with one of the following:

- Figure F.1 and Table F.1;
- Figure F.2 for components of unlimited circuits.

Compliance is checked by inspection.

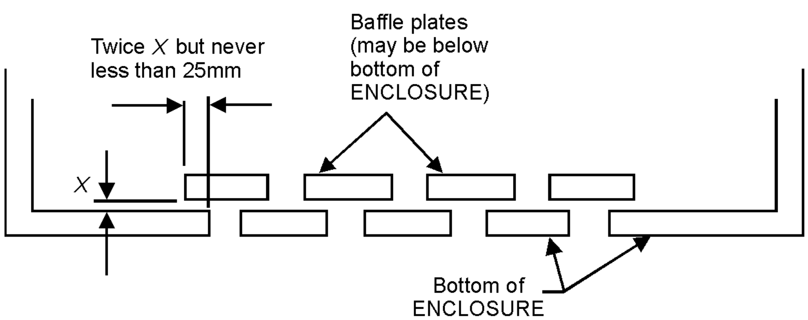


Figure F.1 — Baffle (see F.4.3.2 and F.4.3.3)

Table F.1 — Acceptable perforated metal plates

Minimum thickness mm	Maximum diameter of holes mm	Minimum spacing of holes center to center mm
0.76	1.1	1.7 (35 holes/100 mm^2)
0.76	1.2	2.4
0.89	1.9	3.2 (10 holes/100 mm^2)
0.99	1.6	2.7

F.4.3.3NF The ENCLOSURE, baffle, or flame BARRIER shall be made of metal (except magnesium) or of non-metallic materials having a flammability classification of FV 0, FV 1, or FV 2 in accordance with IEC 707.

Compliance is checked by inspection of data on the materials used for ENCLOSURES, baffles, or flame BARRIERS. Alternatively, compliance is checked by performing the FV test of IEC 707 on three samples of the relevant parts. The samples may be any of the following:

- complete parts;
- sections of the part, including the area with the least wall thickness and any vent openings;
- specimens in accordance with IEC 707.

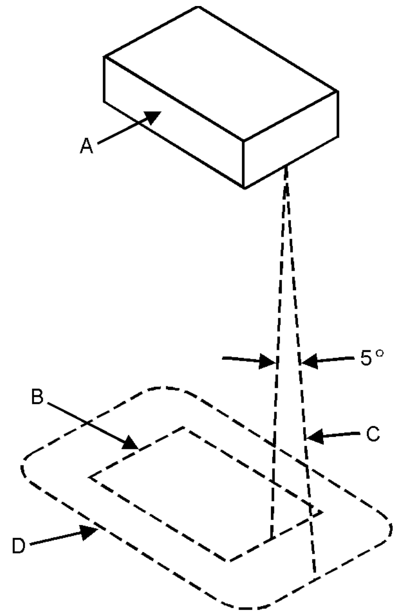


Figure F.2 — Location and extent of a non-combustible flame BARRIER (see F.4.3.2 and F.4.3.3)

A. Region to be shielded by the flame BARRIER. This consists of the entire component, if it is not otherwise shielded, or the unshielded portion of a component that is partially shielded by its casing.

B. Projection of the outline of the component on the horizontal plane.

C. Inclined line that traces out the minimum area of the flame BARRIER. This line projects at a 5° angle from the vertical at every point around the perimeter of the component and is oriented so as to trace out the maximum area.

D. Minimum area for the flame BARRIER.

NF See corresponding clause in National Foreword

Annex G (normative)

Circuits between which the adequacy of insulation shall be tested for protection against fire

(See 9.1)

Tests shall be made between the following circuits:

Table G.1

1-2	2-2	3-3	4-4	5-5
1-3	2-3	3-4	4-5	5-6
1-4	2-4	3-5	4-6	
1-5	2-5	3-6		
1-6	2-6			

1) Mains circuits (including measuring and control circuits connected to the mains supply).

2) Circuits with external TERMINALS that carry or are intended for connection to HAZARDOUS LIVE voltage or current exceeding the values of 6.3.2 in NORMAL CONDITION (other than mains, e.g., measuring or control circuits).

3) Circuits connected to ACCESIBLE parts, but without external TERMINALS, that carry HAZARDOUS LIVE voltage or current exceeding the values of 6.3.2 in NORMAL CONDITION (internal circuits).

4) Circuits without external TERMINALS that carry voltage or current not exceeding the values 6.3.2 in NORMAL CONDITION (internal circuits).

5) Circuits with external TERMINALS which carry or are intended for connection to voltage or current not exceeding the values of 6.3.2 in NORMAL CONDITION (for example TERMINALS of measuring, control, data, and supply circuits).

6) The PROTECTIVE CONDUCTOR TERMINAL and ACCESSIBLE conductive parts connected to it.

NOTE – For testing protection against fire, no tests are required between the following parts and any other parts:

- floating internal circuits without external TERMINALS, even if they carry HAZARDOUS LIVE voltage or current exceeding the values of 6.3.2 in NORMAL CONDITION;
- ACCESIBLE conductive parts that are not connected to other ACCESSIBLE conductive parts or to the PROTECTIVE CONDUCTOR TERMINAL.

Annex H (informative)

Explanatory remarks on the classification of electrical equipment with regard to protection against electric shock (see Clause 6)

H.1 General

The principle of protection against electric shock is the provision of two separate and independent protective means:

- a basic protection which safeguards against electric shock in normal service;
- a supplemental protection that maintains protection against electric shock in case of failure of the basic protection.

These two protections are achieved by the appropriate protective means specified in Clause 6.

The particular combination of protective provisions employed in equipment determines the equipment class as defined in IEC 536.

In this Part 1, protective provisions do not apply to live parts but rather to parts that are HAZARDOUS LIVE.

For this Annex H:

- an "exposed conductive part" is a part that can readily be touched and that is not a live part, but may become live in the case of a fault. It corresponds to an ACCESSIBLE conductive part that could become HAZARDOUS LIVE in SINGLE FAULT CONDITION;
- "indirect contact" is the prevention of dangerous contact of persons with exposed conductive parts or with extraneous conductive parts that may become live in the case of a fault. It corresponds to an ACCESSIBLE part that could become HAZARDOUS LIVE in SINGLE FAULT CONDITION;
- an "extraneous conductive part" is a part not forming a part of the electrical installation. It corresponds to an ACCESSIBLE conductive part that could become HAZARDOUS LIVE in SINGLE FAULT CONDITION.

H.2 Class I equipment

Class I equipment is equipment with BASIC INSULATION between live parts and in which exposed conductive parts are bonded to a connecting means for a protective conductor (see 6.5.1). In this context, bonding is the joining of exposed conductive parts and screens to form a path for electrical continuity on the connecting means for a protective conductor.

Equipment partly protected according to class I but also partly to class II is classified as class I.

H.3 Class II equipment

Class II equipment is equipment in which protection against indirect contact does not depend on BASIC INSULATION only, but where additional constructional dispositions are provided to avoid a fault between live parts or REINFORCED INSULATION throughout.

For class II equipment, additional constructional requirements are given in 6.5 and 6.9.2. PROTECTIVE IMPEDANCES are also included in this concept (see 6.5).

Equipment partly protected according to class II but also partly according to class I is classified as class I.

H.4 Class III equipment

Class III equipment is equipment for connection to SELV or SELV-E circuits only or with internal SELV or SELV-E only and in which voltages higher than those of SELV are not generated.

SELV (separated extra-low voltage) is a measure of protection against electric shock by limiting voltage values in a circuit and by separating this circuit from other circuits and from earth. In this part 1, SELV corresponds to ACCESSIBLE voltage (SELV was originally known as "safety extra low voltage" in the first editions of IEC 364 1 and IEC 536).

SELV-E (separated extra-low voltage earthed) is any circuit that has one point connected to earth but which satisfies all other requirements for a SELV circuit. In this Part 1, SELV-E corresponds to ACCESSIBLE voltage.

Annex J (informative)

Insulation co-ordination

Insulation co-ordination can only be achieved if transient overvoltages are controlled to specified levels. Subclause 5.6 of IEC 664 establishes standardized impulse voltage levels. These levels are assigned to four different installation categories (overvoltage categories). They cover decreasing levels in the impulse voltage, since a natural damping normally occurs in an electrical distribution system.

IEC 664 gives the following examples:

> INSTALLATION CATEGORY (OVERVOLTAGE CATEGORY) I: Signal level, special equipment or parts of equipment, telecommunication, electronic, etc., with smaller transient overvoltages than INSTALLATION CATEGORY (OVERVOLTAGE CATEGORY) II.
>
> INSTALLATION CATEGORY (OVERVOLTAGE CATEGORY) II: Local level, appliances, PORTABLE EQUIPMENT, etc., with smaller transient overvoltages than INSTALLATION CATEGORY (OVERVOLTAGE CATEGORY) III.
>
> INSTALLATION CATEGORY (OVERVOLTAGE CATEGORY) III: Distribution level, fixed installation, with smaller transient overvoltages than INSTALLATION CATEGORY (OVERVOLTAGE CATEGORY) IV.
>
> INSTALLATION CATEGORY (OVERVOLTAGE CATEGORY) IV: Primary supply level, overhead lines, cable systems, etc. This category is not relevant to this standard.

The correlation between nominal system voltage, overvoltage level (impulse withstand voltage), and INSTALLATION CATEGORY (OVERVOLTAGE CATEGORY) is given by Table J.1 (based on Table 1 of IEC 664).

Most equipment covered by this Part 1 is connected to the supply mains and is, therefore, in INSTALLATION CATEGORY (OVERVOLTAGE CATEGORY) II, but PERMANENTLY CONNECTED EQUIPMENT may belong to INSTALLATION CATEGORY (OVERVOLTAGE CATEGORY) II or III. Dimensioning of insulation according to INSTALLATION CATEGORY (OVERVOLTAGE CATEGORY) III is necessary when equipment is intended to be connected closer to the power supply than the loads to be connected to the power supply system and where overvoltages of INSTALLATION CATEGORY (OVERVOLTAGE CATEGORY) III may occur. In this case, no significant diversion absorption or dissipation of the transient energy occurs.

Table J.1^{NF} — Impulse withstand voltages

Voltage 3-phase 4-wire systems V	Voltage 3-phase 3-wire systems V	Voltage Phase-to-earth V	Preferred series of impulse withstand voltages for installation categories (overvoltage categories) I to III V		
			I	**II**	**III**
		50	330	500	800
66/115	120	100	500	800	1500
120/208 120/240	240	150	800	1500	2500
230/400 277/480	500	300	1500	2500	4000
400/690	1000	600	2500	4000	6000
		1000	4000	6000	8000

Overvoltages within one of the installation categories (overvoltage categories) of a distribution system may be caused either by events in the higher categories or by events within the same category. Equipment can only be considered as belonging to a particular INSTALLATION CATEGORY (OVERVOLTAGE CATEGORY) if it does not cause overvoltages increasing the level specified for that category.

It is only the overvoltage that determines the INSTALLATION CATEGORY (OVERVOLTAGE CATEGORY) and thus influences the clearance dimensions. There are several alternatives for guarding against overvoltages. IEC 664 describes interface requirements for the transition from one INSTALLATION CATEGORY (OVERVOLTAGE CATEGORY) to the next lower category.

Interface elements for the transition can be placed within an equipment, which means that different INSTALLATION CATEGORIES (OVERVOLTAGE CATEGORIES) may exist within the same equipment.

For further explanation see IEC 664.

Annex K[NF] (informative)

ROUTINE TESTS

It is recommended that the manufacturer should perform the following ROUTINE TESTS on all equipment:

a) A voltage applied between ACCESSIBLE conductive parts and both sides connected together of each input and output circuit in turn, where these circuits may be HAZARDOUS LIVE in NORMAL USE. The value of the voltage for mains circuits to be that specified and for input and output circuits to be 1.5 times the working voltage (see Annex D).

b) An a.c. or d.c. dielectric strength test performed by raising the test voltage to its specified value within 2 s and maintaining it for a period of 2 s. Wrapping the equipment in foil is not required nor is humidity preconditioning necessary. Earth referenced circuits need not be tested. Tests requiring the disconnection of components should not be performed. Circuits that include semiconductor components that may be damaged by electric field effects may be tested at half the values specified in Annex D.

c) A continuity test to verify bonding of ACCESSIBLE conductive parts to the PROTECTIVE CONDUCTOR TERMINAL; the test current to be at the discretion of the manufacturer.

NF See corresponding clause in National Foreword

Annex L (informative)

Bibliography

IEC Standards

79: Electrical apparatus for explosive gas atmospheres.

112: 1979, Method for determining the comparative and the proof tracking in indices of solid insulating materials under moist conditions.

127: 1974, Cartridge fuse-links for miniature fuses.

204: Electrical equipment of industrial machines.

270: 1981, Partial discharge measurements.

320: 1981, Appliance couplers for household and similar general purposes.

335: Safety of household and similar electrical appliances.

364-1: 1972, Electrical installations of buildings - Part 1: Scope, object and definitions.

364-4-41:1982, Electrical installations of buildings - Part 4: Protection for safety Chapter 41:Protection against electric shock.

405: 1972, Nuclear instruments - Constructional requirements to afford personal protection against ionizing radiation.

414: 1973, Safety requirements for indicating and recording electrical measuring instruments and their accessories.

439-1: 1985, Low-voltage switchgear and controlgear assemblies - Part 1: Requirements for type-tested and partially type-tested assemblies.

445: 1988, Identification of equipment terminals and of terminations of certain designated conductors, including general rules of an alphanumeric system.

447: 1974, Standard directions of movement for actuators which control the operation of electrical apparatus.

521: 1988, Class 0.5. 1 and 2 alternating-current watt-hour meters.

536: 1976, Classification of electrical and electronic equipment with regard to protection against electric shock.

601: Medical electrical equipment.

742: 1983, Isolating transformers and safety isolating transformers - Requirements.

950: 1986, Safety of information technology equipment including electrical business equipment.

Annex M (informative)

Index of defined terms

Annex N (informative)

National foreword

The following is a cross reference of Canadian standards that may be applicable for products marketed in Canada:

National Foreword Clause	Standard	Title
6.10.4	CAN/CSA C22.1-1990	Canadian Electrical Code, Part I
	CSA C22.2 No. 0.1-M1985	General Requirements for Double-Insulated Equipment
	CSA C22.2 No. 0.4-M1982	Bonding and Grounding of Electrical Equipment (Protective Grounding)
F.4.2.2/.3	CSA C22.2 No. 0.6-M1982	Flammability Testing of Polymeric Materials
6.10.1 (a)	CSA C22.2 No. 21-M1984	Cord Sets and Power-Supply Cords
6.10.1 (b)	CSA C22.2 No. 42-M1984	General Use Receptacles, Attachment Plugs, and Similar Wiring Devices
6.10.1	CSA C22.2 No. 49-M1989	Flexible Cords and Cables
1.4	CSA C22.2 No. 142	Process Control Equipment
6.10.1	CSA C22.2 No.182.3-M1987	Special Use Attachment Plugs, Receptacles, and Connectors
14.7	CSA C22.2 No. 223	Power Supplies with Extra-Low-Voltage-Class 2 Outputs

Annex O (informative)

National Foreword

The following is a matrix that provides a cross-reference between CSA, ANSI, and IEC standards for high-integrity components. This cross-reference is not meant to imply that the standards are equivalent. Errors in the listing should be brought to the attention of the ISA SP82.02 subcommittee.

Component	UL Std	C22.2 CSA Std	IEC Std
Cabinets and Boxes, Electrical	50	No. 94	529
Capacitors	810		252
Circuit Breakers	489	No. 5.1	947 Pt 2
Double Insulation Systems	1097	No. 0.1	
Flexible Cord and Fixture Wire	62	No. 21	227-5
			245-4
Fuseholders	512	No. 39	257
Fuses, Plug	198F	No. 59.1	
Lampholders, Edison-Base	496	No. 43	238
Marking and Labeling Systems	969		
Motors	1004		34.1
Motors, Impedance-Protected	519	No. 77	
Polymeric Materials - Fabricated Parts	746D		
Polymeric Materials - Long-Term Property	746B	No. 0.11	216
Polymeric Materials - Short-Term Property	746C	No. 0.11	216
Power Supplies	1012		
Printed-Wiring Boards	796		
Protectors for Motors, Thermal	547		730 Pt 2-2
Switches, Clock-Operated	917	No. 177	
Switches, Enclosed	98	No. 4	1020
Switches, Snap, General-Use	20	No. 111	1020 Pt 2
Switches, Special-Use	1054		1058
Systems of Insulating Material	1446		85
Tapes, Insulating	510		454
Temperature-Indicating & Regulating Equipment	873		
Terminal Blocks	1059	No. 158	947 Pt 7-1
Terminals, Quick Connect	310		760
Transformers, Specialty	506	No. 66	742
Tubing, Extruded Insulating	224		
Wire Connectors and Soldering Lugs	486A	No. 65	998 series
Wire Connectors for Aluminum Conductors	486B		998 series
Wires and Cables, Rubber Insulated	44		245
Wires and Cables, Thermoplastic Insulated	83		227

Annex P (informative)

Changes to IEC 1010-1 due to Amendment 1

The IEC text of this standard uses the 1990 first edition of IEC 1010-1 and Amendment 1 1992-09. The following clauses were affected by Amendment 1:

Foreword revised
Introduction revised

1.1.1	added fourth dash
1.1.3	revised
1.2	revised
1.4	revised
2.1	corrected
3.2.1	corrected
3.5.8	revised
3.7.1	revised
4.1	revised
4.3.5	revised
4.4.1	corrected
4.4.2	revised
4.4.2.1	revised
4.4.2.6	revised
4.4.2.11	corrected
4.4.2.12	revised
4.4.4.4	revised
Table 1	added note
5.1.1	revised
5.1.3	revised
5.1.5	revised
5.1.6	revised
5.2	revised
5.4.3	revised
5.4.4	revised
5.4.5	revised
6.1.1	revised
6.2	revised
6.3	revised
6.4	revised
6.5.1	revised
6.5.1.2	revised
6.5.1.4	added subclause
6.5.2	revised
6.7	revised
6.8.2	corrected
6.9.1	added third dash
6.9.4	revised
6.10	revised
6.10.1	added second and third paragraphs
6.10.3	revised
6.10.4	revised
6.12.2.1	revised
6.12.3.1	revised
6.12.3.2	revised
8	revised
8.3	revised
8.4.1	revised
9.1	added note and corrected
Table 3	revised
9.4	corrected
11	revised title
11.1	revised
11.5	revised
11.6	revised
11.7	added subclause
12.5.1	revised
12.5.2	revised
13.2.2	revised
14.1	revised
14.3	revised
14.7	added new subclause
15	added new clause
Annex A	revised
Fig A.2	revised
Annex D	revised
F.4.1	revised
F.4.3.3	revised

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