

ANSI/ISA-S82.01-1994
Approved June 1, 1994

American National Standard

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

Harmonized Standard to IEC Publication 1010-1



Instrument Society of America

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National Foreword

This American National Standard has been prepared under the direction of the Instrument Society of America 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 multilayer 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, in.	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:

$$W = (M - 0.5 \cdot C \cdot L) / L$$

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

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

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

Normal Mounting Plane of ENCLOSURE Surface (a)	Conduit Size Inches	Bending Moment (b),(c) inch-pounds (N m)	
		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 towards the load. The ACCESSIBLE contact or screw shell of fuseholders connected in the neutral (grounded) conductor shall be located towards 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 which 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;
- 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.

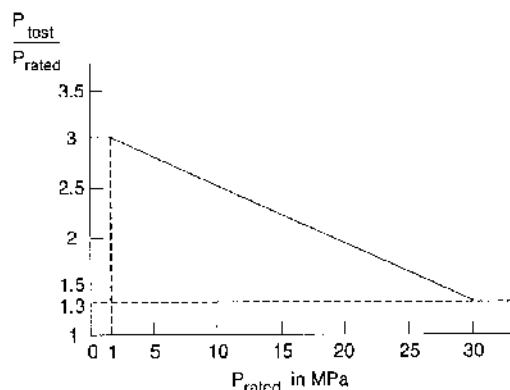


Figure NF-1 Ratio Between Hydraulic Test Pressure and Maximum Permissible Working Pressure (P_{rated})

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 towards 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; and
- 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 roman type
- NOTES in smaller roman type
- compliance in italic type
- terms used throughout this standard which have been defined in clause 3 in small roman 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 which 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 sterilisers;
- 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 which 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 which controls one or more output quantities to specific values, with each value determined by manual setting, by local or remote programming, or by one or more input variables.

c) Electrical laboratory equipment

This is equipment which measures, indicates, monitors or analyses 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 which 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 which 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, which 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 $\pm 10\%$ of 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

^{NF} See corresponding clause in National Foreword

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.
- 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 which 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 which 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 which 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].

^{NF} See corresponding clause in National Foreword

3.4 Tests

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

NOTE - This is an amplification of the IEC 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 which 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 which 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 which provides protection against electric shock not less than that provided by DOUBLE INSULATION. It may comprise several layers which 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) which 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 which 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 which can be removed without using a TOOL shall be removed or not removed. Covers which 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 which 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 which are liable to result in hazards within the meaning of this Part 1 and which, 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 which 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 CONDITION. Individual parts 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 which 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 which 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 overtemperature 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 which interrupts or limits the current during operation is included to limit the temperature of parts which can easily be touched, the maximum temperature attained by 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 6.6.4 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 which 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 which 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 which can be removed by an OPERATOR without the use of a TOOL.

For rack or panel mounted equipment, markings are permitted to be on 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;

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.

^{NF} See corresponding clause in National Foreword

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		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 REINFORCED INSULATION (equivalent to Class II of IEC 536 –see annex H)
12		ISO 3864, No. B.3.6	Caution, risk of electric shock
13			Easily-touched higher temperature parts
14		ISO 3864, No. B.3.1	Caution (refer to accompanying documents)

NOTE - Color requirements for symbols 12 and 14 do not apply to markings on equipment, providing that the symbol is moulded 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

- d) Equipment which 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%.

5.1.4 Fuses

For any fuses which 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) which 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 which 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 which 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 which 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 which has means for charging rechargeable batteries, and where nonrechargeable 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 which are ACCESSIBLE according to the exceptions of 6.1.1.

TERMINALS which 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 which 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.

^{NF} See corresponding clause in National Foreword

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; and
- 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 which 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.