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Draft for Development

**Safety of information technology equipment
including electrically operated
business equipment**

British Standards Institution

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This publication is not to be regarded as a British Standard.

It is being issued in the Draft for Development series of publications and is of a provisional nature because it employs the text of an IEC Six Month Rule voting document rather than that of a published international standard. It should be applied on this provisional basis, so that information and experience of its practical application may be obtained.

A review of this Draft for Development will be carried out not later than two years after its publication. Notification

of the start of the review period, with a request for the submission of comments from users of this Draft for Development will be made in an announcement in the appropriate issue of *BSI News*. Attention is drawn to the request for early comments made in the foreword.

According to the replies received, the responsible BSI Committee will judge whether the Draft for Development can be converted into a British Standard or what other action should be taken.

Foreword

This Draft for Development has been prepared under the direction of the Office and Information Standards Committee. It is identical with the text of the Six Month Rule voting document, 74(Central Office)64 'Proposed IEC standard for safety of information technology equipment including electrically operated business equipment' published by the International Electrotechnical Commission (IEC) except that minor editorial inconsistencies have been corrected.

For the purposes of responding to document 74(Central Office)64 comments are required on this Draft for Development, in the same way as for BSI Drafts for Public Comment, no later than 31 December 1985. Publication of this Draft for Development should not be taken as a presupposition that the UK will approve 74(Central Office)64. Any comments will be reviewed by the BSI Technical Committee (OIS/20) responsible for this area of work in order to decide the UK position on the IEC draft.

In addition, however, and because of the nature of the IEC draft standard and its subject matter, this Draft for Development has been prepared rather than a Draft for Public Comment in order to give readers the opportunity over a longer period of time to try out and to assess the requirements proposed in this Draft for Development, especially in comparison with existing International and British Standards, each covering some of the subject matter of this Draft for Development. Of particular relevance are the following.

IEC Publication 380, second edition (1977) 'Safety of electrically energized office machines'. A third edition is in preparation and scheduled for publication by September 1985 to incorporate recently approved amendments. A major amendment to IEC Publication 380, third edition, is concurrently being circulated as a Six Month Rule voting document and that amendment proposes changes to Clause 29 to bring the text into line with 74(Central Office)64.

IEC Publication 435, second edition (1983) 'Safety of data processing equipment'. An amendment to this edition is also concurrently being circulated as a Six Month Rule document to bring IEC Publication 435, second edition into line with 74(Central Office)64.

BS 5850 : 1981 'Specification for safety of electrically energized office machines'. This British Standard is the national standard corresponding with CENELEC Harmonization Document HD 372, which is based on IEC Publication 380 : 1977. As described in the foreword to BS 5850 it is related to IEC Publication 380.

BS 6204 : 1982 'Specification for safety of data processing equipment'. As described in the foreword of BS 6204, this British Standard is based on the final text, before publication, of IEC Publication 435, second edition, but is not identical.

It should be noted that the IEC Committee (IEC/TC 74) responsible for document 74(Central Office)64 and also for IEC Publications 380 and 435 has decided already that 74(Central Office)64 represents only the first stage in amalgamating the requirements specified in IEC Publications 380 and 435 into a single standard covering all information technology equipment. The need for further

work has already been identified to enhance the new standard, and also to update IEC Publications 380 and 435 in line with the new standard until such time as IEC Publications 380 and 435 can be withdrawn.

Readers of this Draft for Development, therefore, should treat the contents as the basic text intended eventually to supersede both BS 5850 and BS 6204. Those British Standards will be retained, however, at least until the new IEC standard is approved and until it is appropriate for the British Standards to be withdrawn.

The attention of readers is alerted to the intention of CENELEC (Comité Européen de Normalisation Electrotechnique) to commence work on the approval within CENELEC of 74(Central Office)64, or the form in which it is eventually published as an international standard, as a new European Standard. In general terms, the British Electrotechnical Committee has approved this, in principle, but again, until a formal text is available, the approval in principle should not presuppose that the British Electrotechnical Committee will approve the CENELEC European Standard. It should be noted that if the IEC text is accepted as a European Standard, BSI will be under an obligation to publish an identical British Standard. As each of the developments in IEC and CENELEC become known, suitable announcements will be made in *BSI News* and, if necessary, amendments will be proposed to this Draft for Development.

Although comments on any aspect of this Draft for Development are welcome at any time, the Technical Committee responsible for this draft urges readers to make known to OIS/20 (through its Secretary) all comments as soon as possible, especially those that deal with technical matters or questions of interpretation. Such comments will be used as a guide to our participation in the relevant international and European work.

Terminology and conventions. The text of the IEC Six Month Rule voting document 74(Central Office)64 has been approved as suitable for publication as a Draft for Development. Some terminology and certain conventions are not identical with those used in Drafts for Development. Attention is drawn especially to the following.

Wherever the words 'This standard' appear, referring to this Draft for Development, they should be read as 'This Draft for Development'.

In addition, where the indicators 'n' and 'c' appear in the left-hand margin, they have the following meaning:

- n = note;
- c = compliance statements and tests.

Cross-references

International standards	Corresponding British Standards
IEC 112 : 1979	BS 5901 : 1980 Method of test for determining the comparative and the proof tracking indices of solid insulating materials under moist conditions (Identical)
IEC 309 : 1979	BS 4343 : 1968 Industrial plugs, socket-outlets and couplers for a.c. and d.c. supplies (Technically equivalent)

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IEC 417 : 1973	BS 6217 : 1981 Guide to graphical symbols for use on electrical equipment (Identical)	ISO 4046-1978	BS 3203 : 1979 Glossary of paper, board, pulp and related terms (Identical)
IEC 529 : 1976	BS 5490 : 1977 Specification for degrees of protection provided by enclosures (Identical)	The Technical Committee has reviewed the provisions of IEC 83, IEC 364*, IEC 364-7-707*, IEC 664A, ISO 7000 and ICRP 26, together with those listed below which are related to British Standards, and has decided that they are acceptable for use in conjunction with this Draft for Development.	
IEC 540 : 1982	BS 6469 : 1984 Methods of test for insulation and sheaths of electric cables (Technically equivalent)	International standards IEC 65	Related British Standards BS 415 : 1979 Specification for safety requirements for mains-operated electronic and related apparatus for household and similar general use
IEC 664 : 1980	PD 6499 : 1981 Guide to insulation coordination within low voltage systems including clearances and creepage distances for equipment (Identical)	IEC 85	†BS 2757 : 1956 Classification of materials for electrical machinery and apparatus on the basis thermal stability in service
IEC 695-2-2 : 1980	BS 6458 Fire hazard testing for electrotechnical products Part 2 : Section 2.1 : 1984 Glow-wire test (Identical)	IEC 227	BS 6500 : 1984 Specification for insulated flexible cords and cables BS 6004 : 1984 Specification for PVC-insulated cables (non-armoured) for electric power and lighting
IEC 707 : 1981	BS 6334 : 1983 Methods of test for the determination of the flammability of solid electrical insulating materials when exposed to an igniting source (Identical)	IEC 245	BS 6500 : 1984 Specification for insulated flexible cords and cables BS 6977 : 1981 Specification for insulated flexible cables for lifts and for other flexible connections
ISO 216-1975	BS 1360 : 1973 Personal stationery (terms and sizes) (Technically equivalent) BS 4000 : 1983 Specification for sizes of paper and board (Technically equivalent)	IEC 320	BS 4491 : 1969 Method for assessing black light used in non-destructive testing
ISO 261-1973 } ISO 262-1973 }	BS 3643 ISO metric screw threads Part 1 : 1981 Principles and basic data (Technically equivalent)	IEC 328	BS 3955 Electrical controls for domestic appliances Part 3 : 1979 General and specific requirements
ISO 306-1974	BS 2782 Methods of testing plastics Methods 120A to 120E : 1976 Determination of the Vicat softening temperature of thermoplastics (Technically equivalent)	IEC 380	BS 5850 : 1981 Specification for safety of electrically energized office machines

*IEC 364 and IEC 364-7-707 are covered in the UK by the Institution of Electrical Engineers (IEE) Regulations for electrical installations – 15th Edition.

†The current edition of BS 2757 is not equivalent to IEC 85, but a revision of the British Standard is in hand which is expected to be identical with IEC 85.

PRINCIPLES OF SAFETY

General principles

It is essential that designers understand the underlying principles of safety requirements in order that they can engineer safe equipment.

The following notes are not an alternative to the detailed requirements of this standard, but are intended to provide designers with an appreciation of the principles on which these requirements are based.

Hazards

Application of this standard is intended to prevent injury or damage due to the following hazards:

- Electric shock
- Fire
- Energy hazards
- Mechanical and heat hazards
- Radiation hazards
- Chemical hazards

Electric shock is due to current passing through the human body. Currents of the order of a milliampere can cause a reaction in persons in good health and may cause indirect danger due to involuntary reaction. Higher currents can have more damaging effects. Voltages up to about 40 V (peak or d.c.) are not generally regarded as dangerous under dry conditions, but parts which have to be touched or handled should be at earth potential or properly insulated.

There are two types of persons who are normally concerned with information technology equipment, operators and service personnel.

'Operator' is the term applied to all other than service personnel, and requirements for protection assume that the operator is oblivious to electrical hazards, but does not act intentionally in the sense of creating a hazard. Consequently, the requirements provide protection for cleaners and casual visitors as well as the assigned operators.

It is assumed that service personnel will be reasonably careful in dealing with obvious hazards, but the design should protect against mishap by use of warning labels, shields for hazardous voltage terminals, segregation of safety extra low voltage circuits from hazardous voltages, etc. More important, service personnel should be protected against unexpected hazards.

It is normal to provide two levels of protection for operators to prevent electric shock caused by a fault. Thus a single fault and its resulting faults will not create a hazard. However, provision of additional protective measures, such as protective earthing or supplementary insulation, is not considered a substitute for, or a relief from, properly designed basic insulation.

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Movable equipment is considered to present a slightly increased risk of shock due to possible extra strain on the supply cord, leading to rupture of the earth conductor and a consequent leakage current hazard. With hand-held equipment, this risk is increased, wear on the cord is more likely, and further hazards could arise if the units were dropped.

Electric shock: Causes and prevention

Cause

Prevention

Contact with parts normally at hazardous voltage.

Prevent operator access to parts at hazardous voltage (or energy levels) by fixed or locked covers, interlocks, etc. Discharge capacitors at hazardous voltages.

Breakdown of insulation between parts normally at hazardous voltage and accessible conductive parts.

Either connect the accessible conductive parts to earth so that the voltage which can develop is limited to a safe value and the circuit overcurrent protection will disconnect the parts having low impedance faults; or use double or reinforced insulation between parts normally at hazardous voltages and accessible conductive parts, so that breakdown is not likely to occur.

Breakdown of insulation between parts normally at hazardous voltages and SELV circuits, thereby putting accessible parts at hazardous voltage.

Segregate hazardous and safety extra low voltage circuits. Separate by earthed metal screens or double or reinforced insulation. Earth safety extra low voltage circuits if capable of carrying possible fault currents.

Breakdown of insulation guarding parts at hazardous voltage.

For parts at hazardous voltage insulation which is accessible to the operator should have adequate mechanical and electrical strength to eliminate this danger.

Leakage current from parts at hazardous voltage to body of class II equipment. Failure of protective earth connection carrying leakage current. (Leakage current includes current due to RFI filter components connected between primary power circuits and frame.)

Limit leakage current to body to a safe value, or provide high integrity protective earth connection.

Energy hazards

Shorting between adjacent poles of high current supplies or high capacitance circuits may cause burns or splashing. Even low voltage circuits may be dangerous in this respect. Protect by separation, by shielding or by using safety interlocks.

Fire

Temperatures which could cause a fire risk may result from overloads, component failure, insulation breakdown, high resistance or loose connections. However, fires originating within the equipment should not spread beyond the immediate vicinity of the source of the fire, nor cause damage to the surroundings of the equipment.

These design objectives should be met by:

- taking all reasonable steps to avoid high temperature which might cause ignition,
- controlling the position of combustible materials in relation to possible ignition sources,
- limiting the quantity of combustible materials used,
- ensuring that if combustible materials are used they have the lowest flammability practicable,
- using enclosures or barriers if necessary to limit the spread of fire within the equipment,
- using suitable materials for the outer enclosures of the equipment.

Mechanical and heat hazards

Requirements are included to prevent injury due to high temperatures of parts accessible to the operator; to ensure that the equipment is mechanically stable and structurally sound; to avoid the presence of sharp edges and points; and to provide adequate guarding or interlocking of dangerous moving parts. Requirements for the protection of the service engineer are under consideration.

Radiation hazards

If equipment emits some forms of radiation, requirements are necessary to keep operator and service personnel exposures to acceptable levels. The types of radiation that can be encountered are sonic, radio frequency, infrared, high intensity visible and coherent light, ultraviolet and ionizing, etc.

Chemical hazards

Hazardous chemicals potentially cause injuries and damage through contact with them, their vapours and fumes. Controls including appropriate warning labels are required to limit such contact, as far as practicable, under normal and abnormal conditions.

Materials

Materials used in the construction of equipment should be selected and arranged such that they can be expected to perform in a reliable manner without a risk of energy hazard or electric shock developing, and such that they would not contribute significantly to the development of a serious fire hazard.

SAFETY OF INFORMATION TECHNOLOGY EQUIPMENT INCLUDING ELECTRICALLY OPERATED BUSINESS EQUIPMENT

1. GENERAL

1.1 Scope

1.1.1 This standard is applicable to information technology equipment including electrically operated business equipment and associated equipment with a rated voltage not exceeding 600 V.

This standard specifies requirements intended to ensure safety for the operator and layman who may come into contact with the equipment and, where specifically stated, for service personnel.

This standard is intended to ensure the safety of installed equipment, whether it consists of a system of interconnected units or independent units, subject to installing, operating and maintaining the equipment in the manner prescribed by the manufacturer.

- n For equipment intended to be used in vehicles, on board ships or aircraft, in tropical countries, or at elevations greater than 2000 m, other requirements may be necessary.
- n For equipment subject to transient overvoltages exceeding those for Installation Category II according to Publication 664 additional protection might be necessary in the mains supply to the equipment.
- n For equipment intended for use where ingress of water is possible, additional requirements may be necessary; for guidance on such requirements, and on relevant testing, see Appendix J.
- n Examples of equipment which is within the scope of this standard are:
 - n Data and text processing equipment, personal computers, visual display units, data preparation equipment, data terminal equipment, data circuit-terminating equipment, typewriters, calculators, accounting and book-keeping machines, cash registers, point of sale terminals, paper tape readers and punches, staplers, duplicators, copying machines, erasers, pencil sharpeners, mail processing machines, document shredding machines, magnetic tape handlers, motor-operated files, dictation equipment, micrographic office equipment, monetary processing machines, electrically operated drawing machines (plotters), paper trimmers (punchers, cutting machines, separators), paper jogging machines, postage machines and teleprinters.
- n This list is not intended to be comprehensive, and equipment that is not listed is not necessarily excluded from the Scope.
- n Equipment complying with the relevant requirements in this standard is considered suitable for use with process control equipment, automatic test equipment and similar systems requiring information processing facilities.
- n This standard does not include requirements for performance or functional characteristics of the equipment.

n Attention is drawn to the fact that the telecommunications authorities
 n of some countries may impose additional requirements on information
 n technology equipment which is to be connected to their networks. Those
 n requirements generally concern the protection of the networks as well as the
 n users of the equipment. It is assumed that adequate transient surge
 n protection has been provided by the authorities.

n Attention is also drawn to the fact that environmental authorities of
 n some countries impose additional requirements.

1.1.2 This standard is not applicable to:

- equipment intended for operation while exposed, for example, to extremes of temperature; to excessive dust, damp, or vibration; to flammable gases; to corrosive or explosive atmospheres.
- electromedical applications with physical connections to the patient.
- support equipment such as air conditioning, fire detection or fire extinguishing systems; power supply systems such as motor generator sets and transformers which are not an integral part of the system or the equipment; or building branch wiring.
- duplicating machines, including offset lithographic machines, which are intended primarily for sizes larger than A3 as specified in ISO 216.

1.2 Definitions

For the purpose of this publication the following definitions apply.

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

(SECRETARIAT NOTE - The sequence and numbering of the following definitions will be changed before publication.)

1.2.1 rated voltage: The primary power voltage (for three-phase supply, the phase-to-phase voltage) as declared by the manufacturer.

1.2.2 rated voltage range: The primary power voltage range as declared by the manufacturer, expressed by its lower and upper rated voltages.

1.2.3 working voltage: The highest voltage to which the insulation under consideration is, or can be, subjected when the equipment is operating at its rated voltage under conditions of normal use (see 2.2.7).

1.2.3a d.c. voltage: The average value of a voltage (as measured by a moving coil meter) having a peak-to-peak ripple not exceeding 10 % of the average value.

n Where peak-to-peak ripple exceeds 10 % of the average value, the
 n requirements related to peak voltage are applicable.

1.2.4 rated current: The input current of the equipment as declared by the manufacturer.

1.2.5 rated frequency: The primary power frequency as declared by the manufacturer.

1.2.6 rated frequency range: The primary power frequency range as declared by the manufacturer, expressed by its lower and upper rated frequencies.

1.2.7 detachable power supply cord: A flexible cord, for supply purposes, intended to be connected to the equipment by means of a suitable appliance coupler.

1.2.8 non-detachable power supply cord: A flexible cord, for supply purposes, fixed to or assembled with the equipment.

The cord may be:

Ordinary: A flexible cord which can be easily replaced without special preparation of the cord or special tools, or

Special: A flexible cord which is specially prepared, or requires the use of specially designed tools for replacement, or such that it cannot be replaced without damage to the equipment.

n The term 'specially prepared' includes for example provision of an
n integral cord guard, or preparation of the conductors by soldering of the
n strands, the use of cable lugs, formation of eyelets etc., but not the
n re-shaping of the conductor before introduction into a terminal or the
n twisting of a stranded conductor to consolidate the end.

1.2.9 insulation, operational: Insulation needed for the correct operation of the equipment.

n Operational insulation by definition does not protect against electric
n shock. It may however serve to minimize exposure to ignition and fire.

1.2.10 insulation, basic: Insulation to provide basic protection against electric shock.

1.2.11 insulation, supplementary: Independent insulation applied in addition to basic insulation in order to ensure protection against electric shock in the event of a failure of the basic insulation.

1.2.12 insulation, double: Insulation comprising both basic insulation and supplementary insulation.

1.2.13 insulation, reinforced: A single insulation system which provides a degree of protection against electric shock equivalent to double insulation under the conditions specified in this standard.

n The term 'insulation system' does not imply that the insulation has to be
n in one homogeneous piece. It may comprise several layers which cannot be
n tested as supplementary or basic insulation.

1.2.14 equipment, class I: Equipment where protection against electric shock is achieved by:

- a) using basic insulation, and also
 - b) providing a means of connecting to the protective earthing conductor in the building wiring those conductive parts that are otherwise capable of assuming hazardous voltages if the basic insulation fails.
- n Class I equipment may have parts with double insulation or reinforced insulation, or parts operating in safety extra-low voltage circuits.
- n For equipment intended for use with a power supply cord, this provision includes a protective conductor as part of the cord.

1.2.15 equipment, class II: Equipment in which protection against electric shock does not rely on basic insulation only, but in which additional safety precautions, such as double insulation or reinforced insulation, are provided, there being no provision for protective earthing or reliance upon installation conditions.

n Such equipment may be of one of the following types:

- n - Equipment having a durable and substantially continuous electrical enclosure of insulating material which envelops all conductive parts, with the exception of small parts, such as nameplates, screws and rivets, which are isolated from parts at hazardous voltage by insulation at least equivalent to reinforced insulation; such equipment is called insulation-encased class II equipment.
- n - Equipment having a substantially continuous metallic electrical enclosure, in which double or reinforced insulation is used throughout; such equipment is called metal-encased class II equipment.
- n - Equipment which is a combination of the above two types.

1.2.15A equipment, class III: Equipment in which protection against electric shock relies upon supply from SELV circuits and in which hazardous voltages are not generated.

1.2.16 safety extra-low voltage (SELV) circuit: A circuit which is so designed and protected that under normal and single fault conditions the voltage between any two accessible parts, one of which may be the body or earth, does not exceed a safe value.

- n Under normal conditions this limit is either 42.4 V peak, or 60 V d.c. Under fault conditions higher limits are specified in this standard for transient deviation.
- n This definition of SELV circuit differs from the term SELV as in IEC Publication 364.

1.2.17 safety isolating transformer: A transformer in which windings supplying SELV circuits are isolated from other windings such that an insulation breakdown either is unlikely or does not cause a hazardous condition on SELV windings.

1.2.18 equipment, movable: Equipment which is either:

- 18 kg or less in mass and not fixed, or
- equipment with wheels, castors or other means to facilitate movement by the operator as required to perform its intended use.

1.2.19 equipment, hand-held: Movable equipment intended to be held in the hand during normal use.

1.2.20 equipment, stationary: Equipment that is not movable equipment.

1.2.21 equipment, fixed: Stationary equipment which is fastened or otherwise secured at a specific location.

1.2.107 equipment for building-in: Equipment intended to be installed in a prepared recess, such as in a wall, or similar situation.

n In general, equipment for building-in does not have an enclosure on all sides, as some of the sides will be protected after installation.

1.2.22 thermostat: A cycling temperature sensing control, which is intended to keep a temperature between two particular values under normal operating conditions and which may have provision for setting by the user.

1.2.23 tool: A screwdriver or any other object which may be used to operate a screw, latch or similar fixing means.

1.2.24 body: All accessible conductive parts, shafts of handles, knobs, grips and the like, and metal foil in contact with all accessible surfaces of insulating material.

1.2.25 clearance: The shortest distance between two conductive parts, or between a conductive part and the bounding surface of the equipment, measured through air.

1.2.116 bounding surface: The outer surface of the electrical enclosure considered as though metal foil were pressed into contact with accessible surfaces of insulating material.

1.2.26 creepage distance: The shortest path between two conductive parts, or between a conductive part and the bounding surface of the equipment, measured along the surface of the insulation.

1.2.27 secondary circuit: A circuit which has no direct connection to primary power and derives its power from a transformer, converter or equivalent isolation device situated within the equipment.

n Some solid state devices may provide equivalent isolation.

1.2.28 access area, operator: An area to which, under normal operating conditions, either:

- access can be gained without the use of a tool, or
- the means of access is deliberately provided to the operator, or
- the operator is instructed to enter regardless of whether or not tools are needed to gain access.

n In this standard the terms 'access' and 'accessible', unless qualified,
n relate to operator access as defined above.

1.2.110 access area, service: An area to which operators have no access when the area is energized but where it is necessary for service personnel to have access for maintenance purposes with the equipment switched on.

1.2.29 hazardous voltage: A voltage exceeding 42.4 V peak, or 60 V d.c., existing in a circuit which does not meet the requirements for a limited current circuit.

1.2.30 hazardous energy level: A stored energy level of 20 J or more, or an available continuous power level of 240 VA or more at a potential of 2 V or more.

1.2.32 flammability classification of materials: The recognition of the ignition and burning resistance characteristics of materials other than metal or ceramic. Materials are classified as in 1.2.33 to 1.2.38 and 1.2.115 when tested in accordance with Appendix A.

n When applying the requirements in this standard foamed materials of
n class HF-1 are regarded as better than those of class HF-2, and HF-2 better
n than HBF.

n Similarly, other materials, including rigid (engineering structural) foam,
n of classes 5V or V-0 are regarded as better than those of class V-1, V-1
n better than V-2, and V-2 better than HB.

1.2.32.1 V-0 class material: A material that, when tested in accordance with A.5, may flame or glow but will extinguish in an average period of time not exceeding 5 s; and glowing particles or flaming drops released do not ignite surgical cotton.

1.2.33 V-1 class material: A material that, when tested in accordance with A.5, may flame or glow but will extinguish in an average period of time not exceeding 25 s; and glowing particles or flaming drops released do not ignite surgical cotton.

1.2.34 V-2 class material: A material that, when tested in accordance with A.5, may flame or glow but will extinguish within an average period of time not exceeding 25 s; glowing particles or flaming drops released may ignite surgical cotton.

1.2.115 5V class material: A material that, when tested in accordance with A.8, may flame or glow but will extinguish within a prescribed period of time; and glowing particles or flaming drops released do not ignite surgical cotton.

Appendix A.8 may be withdrawn as soon as IEC 707 is amended to include flammability class 5V or its possible substitute.

1.2.35 HF-1 class foamed material: A foamed material that, when tested in accordance with A.6, may flame or glow but will extinguish within a prescribed period of time; and flaming or glowing particles or flaming drops do not ignite surgical cotton.

1.2.36 HF-2 class foamed material: A foamed material that, when tested in accordance with A.6, may flame or glow but will extinguish within a prescribed period of time; flaming or glowing particles or flaming drops released may ignite surgical cotton.

1.2.37 HB class material: Material that, when tested in accordance with A.7, does not exceed a specified maximum burning rate.

1.2.38 HBf class foamed material: A foamed material that, when tested in accordance with A.6, does not exceed a specified maximum burning rate.

1.2.39 enclosure: A part of the equipment providing one or more of the functions described in 1.2.39.1, 1.2.39.2 or 1.2.39.3.

1.2.39.1 fire enclosure: A part of the equipment intended to minimize the spread of fire or flames from within.

1.2.39.2 mechanical enclosure: A part of the equipment intended to prevent injury due to mechanical and other physical hazards.

1.2.39.3 electrical enclosure: A part of the equipment intended to prevent contact with parts at hazardous voltage or hazardous energy levels.

1.2.39a decorative part: A part of the equipment, outside the enclosure, which has no safety function.

1.2.40 safety interlock: A means either of preventing access to a hazardous area until the hazard is removed, or of automatically removing the hazardous condition when access is gained.

1.2.41 limited current circuit: A circuit which is so designed and protected that under both normal conditions and a likely fault condition the current which can be drawn is not hazardous.

n The limiting values are specified in 2.4.

1.2.42 thermal cut-out: A temperature sensing control intended to operate under abnormal operating conditions and which has no provision for the user to change the temperature setting.

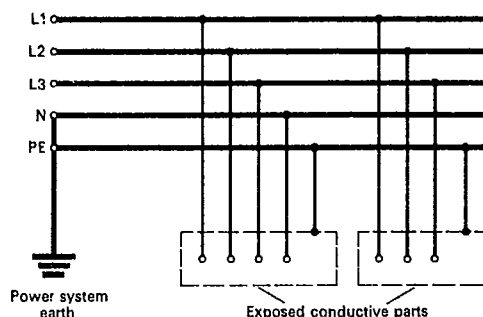
n A thermal cut-out may be of the automatic reset or of the manual reset type.

1.2.43 primary circuit: An internal circuit which is directly connected to the external supply mains or other equivalent source (such as motor-alternator set) which supplies the electric power. It includes the primary windings of transformers, motors, other loading devices and the means of connection to the supply mains.

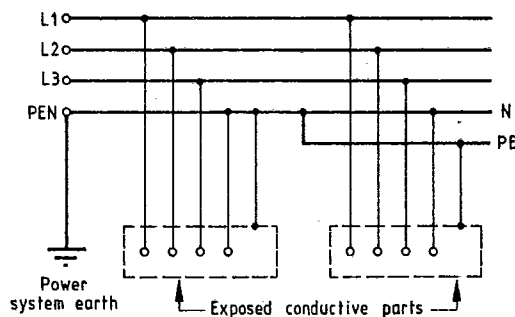
1.2.44 extra-low voltage (ELV): A voltage between conductors or between a conductor and earth not exceeding 42.4 V peak, or 60 V d.c., existing in a secondary circuit which is separated from hazardous voltages by at least basic insulation, but which does not meet the requirements for a SELV circuit nor those for a limited current circuit.

1.2.45 power system, TN: A power distribution system having one point directly earthed, the exposed conductive parts of the installation being connected to that point by protective earth conductors. Three types of TN systems are recognized according to the arrangement of neutral and protective earth conductors, as follows:

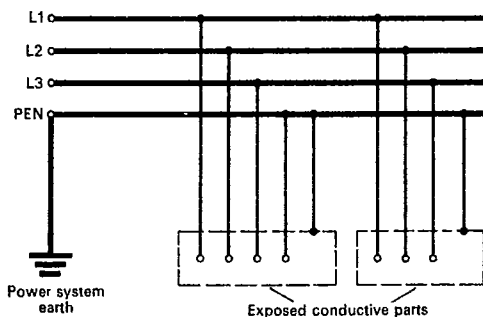
- TN-S system: having separate neutral and protective earth conductors throughout the system;
- TN-C-S system: in which neutral and protective functions are combined in a single conductor in a part of the system;
- TN-C system: in which neutral and protective functions are combined in a single conductor throughout the system.



TN-S system: Separate neutral and protective earthing conductors throughout system

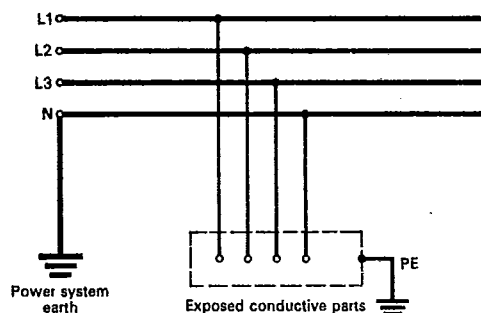


TN-C-S system: Neutral and protective functions combined in a single conductor in a part of the system



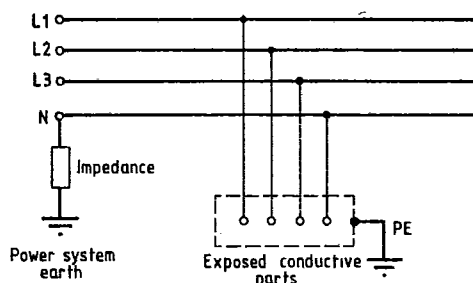
TN-C system: Neutral and protective functions combined in a single conductor throughout system

1.2.46 power system, TT: A power distribution system having one point directly earthed, the exposed conductive parts of the installation being connected to earth electrodes electrically independent of the earth electrodes of the power system.



TT system

1.2.47 power system, IT: A power distribution system having no direct connection to earth, the exposed conductive parts of the electrical installation being earthed.



IT system

1.2.48 thermal cut-out, automatic reset: A thermal cut-out which automatically restores the current after the relevant part of the equipment has cooled down sufficiently.

1.2.49 thermal cut-out, manual reset: A thermal cut-out which requires resetting by hand, or replacement of a part, in order to restore the current.

1.2.50 tracking: The progressive formation of conducting paths, which are produced on the surface of a solid insulating material, due to the combined effects of electric stress and electrolytic contamination on this surface.

1.2.101 normal load: The mode of operation which approximates as closely as possible to the most severe conditions of normal use in accordance with the manufacturer's user instructions except when the conditions of actual use can obviously be more severe than the maximum load conditions recommended by the manufacturer, in which case a load is used that is representative of the maximum that can be applied.

n For examples of typical normal load conditions for electrically operated
n business machines attention is drawn to 2.2.25 in IEC Publication 380.

1.2.102 rated operating time: The operating time assigned to the equipment by the manufacturer.

1.2.103 continuous operation: Operation under normal load for an unlimited period.

1.2.104 short-time operation: Operation under normal load for a specified period, starting from cold, the intervals after each period of operation being sufficient to allow the equipment to cool down to room temperature.

1.2.105 intermittent operation: Operation in a series of specified identical cycles each composed of a period of operation under normal load, followed by a rest period with the equipment switched off or running idle.

1.2.108 pluggable equipment type A: Equipment which is intended for connection to the building power supply wiring via non-industrial plugs and socket-outlets or via appliance couplers, or both.

1.2.108a pluggable equipment type B: Equipment which is intended for connection to the building power supply wiring via industrial plugs and socket-outlets.

n Industrial plugs and socket-outlets are those complying with IEC
n Publication 309 or similar nationally approved standards.

1.2.109 permanently connected equipment: Equipment which is intended for connection to the building power supply wiring via screw terminals.

1.2.111 type test: Testing of a representative sample of the equipment with the objective of determining if the equipment, as designed and manufactured, can meet the requirements of this standard.

1.2.112 temperature limiter: A temperature sensing control which is intended to keep a temperature below or above one particular value during normal operating conditions and which may have provision for setting by the user.

A temperature limiter may be of the automatic or of the manual reset type. It does not make the reverse operation during the normal duty cycle of the equipment.

1.3 General requirements

1.3.1 Equipment shall be so designed and constructed that, under all conditions of normal use and under a likely fault condition, it protects against risk of personal injury from electric shock and other hazards, including serious fire originating in the equipment, within the meaning of this standard.

c In general, compliance is checked by inspection or by carrying out all the c relevant tests specified, or both.

n Where the equipment involves safety situations not specifically covered,
n the design should provide a level of safety not less than that generally
n afforded by this standard.

n The need for additional detailed requirements to cope with a new
n situation should be brought promptly to the attention of the appropriate
n committee.

1.3.2 Equipment is classified according to its protection from electric shock as:

Class I, or
Class II, or
Class III.

- n Equipment containing ELV or hazardous voltage is class I or class II.
- n There are no requirements in this standard for protection against electric shock for class III.

1.3.3 Sufficient information shall be provided to the user concerning any condition necessary to ensure that, when used as prescribed by the manufacturer, the equipment will not present a hazard within the meaning of this standard (see 1.7.2).

c Compliance is checked by inspection.

1.4 General conditions for tests

1.4.1 The requirements and tests detailed in this standard shall be applied only if safety is involved. If it is evident from the design of the equipment that a particular test is not applicable, the test shall not be made.

- n In order to establish whether or not safety is involved, a careful investigation of the circuit and construction is recommended, to take into account the consequences of possible failure of components.

1.4.2 Except where otherwise stated tests specified in this standard are type tests.

1.4.3 Unless otherwise specified in this standard, the tests shall be made on a single sample which shall withstand all the relevant tests.

The sample shall be representative of the equipment the user would receive or shall be the equipment ready for shipment to the user.

- n In view of the large cost involvement in samples, discussion of the test programme with the manufacturer is recommended.

As an alternative to carrying out tests on the complete equipment, tests may be carried out separately on components and sub-assemblies, provided that inspection of the equipment and circuit arrangements ensure that such testing will indicate that the assembled equipment would conform to the requirements of the standard.

- n The tests should be carried out in the following order:

- n - component or material pre-selection;
- n - component or sub-assembly bench tests;
- n - those where the equipment is not energized;

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n - live tests:

- n a) under normal operating conditions;
- n b) under abnormal operating conditions;
- n c) involving likely destruction.

n When a test specified in this standard could be destructive a model may be
n used to represent the condition to be evaluated.

1.4.4 Except where specific test conditions are stated elsewhere in the standard and, where it is clear that there is a significant impact on the results of the test, the tests shall be carried out under the most unfavourable combination within the manufacturer's operating specifications of the following parameters:

- supply voltage,
- supply frequency,
- physical location of equipment and position of movable parts,
- operating mode,
- adjustment of thermostats, regulating devices or similar controls in operator access areas, which are
 - a) adjustable without the use of a tool, or
 - b) adjustable using a means, such as a key or a tool, deliberately provided to the operator.

1.4.5 In determining the most unfavourable supply voltage for a test, the following variables shall be taken into account:

- multiple rated voltages,
- extremes of rated voltage ranges,
- tolerance on rated voltage as specified by the manufacturer. If tolerance is not specified, it shall be taken as +6 % and -10 % (see 1.6.4).

When testing equipment designed for d.c. only, the possible influence of polarity shall be taken into account.

1.4.6 In determining the most unfavourable supply frequency for a test, different nominal frequencies within the rated frequency range shall be taken into account (e.g. 50 Hz and 60 Hz) but consideration of the tolerance on a rated frequency (e.g. 50 ± 0.5 Hz) is not normally necessary.

1.4.7 In this standard, limits for maximum temperatures or maximum temperature rises are specified for compliance with certain tests. The ambient room air temperature during the tests need not be controlled, but shall be monitored and recorded.

n Where temperatures are measured under local ambient conditions of
n atmospheric pressure and relative humidity, the temperature limits should
n be adjusted to allow for adverse limits of pressure and humidity.

Where maximum temperatures or temperature rises are specified, they are based on the assumption that the room ambient air temperature will be 25 °C when the equipment is in operation. If the equipment, in its final application, is intended to be operated in a higher room ambient temperature, the limits of temperature rise shall be reduced by the difference between the higher ambient temperature and 25 °C. When maximum temperatures are specified, they shall not be exceeded with the equipment operating at its maximum specified room ambient temperature.

n This may be checked by calculation if measurement at maximum ambient
n temperature is impractical.

n The classification of insulating materials (classes A, E, B, F and H) is
n in accordance with IEC Publication 85.

1.4.8 Unless a particular method is specified, temperatures of windings shall be determined either by the thermocouple method or by the resistance method (appendix E). Temperatures of parts other than windings shall be determined by the thermocouple or a similar method. The choice and position of temperature sensors shall be made so that they have minimum effect on the temperature of the part under test.

1.4.9 Equipment for which optional features are offered by the manufacturer shall be tested with those features which give the most unfavourable results, or suitable simulation of those features.

1.4.10 Where the equipment is fitted with standard power supply outlets which are accessible to the operator, resistive loads to the value indicated in the marking required by 1.7.5 shall be connected to these outlets, where necessary, during any test whose results could be affected.

1.4.11 Where the equipment is designed to supply mains power to other units of a system, the input current of the equipment shall include the sum of the rated currents of those other units where this could have an influence on the test results. Artificial loads may be used to simulate the other units.

1.4.12 For the electrical requirements of this standard, conducting liquids shall be treated as conductive parts.

1.5 Components

1.5.1 Where safety is involved, components shall comply either with the requirements of this standard or with the safety aspects of the relevant IEC components standards.

n An IEC component standard is considered relevant only if the component in
n question clearly falls within its scope.

Components which are to be connected to SELV circuits and either to ELV or to a hazardous voltage shall comply with the requirements of 2.3.

n An example of such a component is a relay with different supplies connected
n to different elements (coils and contacts).

1.5.2 Evaluation and testing of components shall be carried out as follows:

- a component certified by a recognized testing authority for compliance with a standard harmonized with the relevant IEC component standard shall be checked for correct application and use in accordance with its rating. It shall be subjected to the applicable tests of this standard as part of the equipment with the exception of those tests which are part of the relevant IEC component standard;
- a component which is not certified for compliance with a relevant standard as above shall be checked for correct application and use in accordance with its specified rating. It shall be subjected to the applicable tests of this standard, as part of the equipment, and to the applicable tests of the component standard, under the conditions occurring in the equipment;

n The applicable test for compliance with a component standard is, in
n general, carried out separately. The number of test samples is, in
n general, the same as that required in the component standard.

- where no IEC component standard exists, or where components are used in circuits not in accordance with their specified ratings, the components shall be tested under the conditions occurring in the equipment. The number of samples required for test is, in general, the same as required by an equivalent standard;

- thermal controls shall be tested in accordance with Appendix M.

1.5.3 Transformers shall be of a type suitable for their intended application and shall comply with the relevant requirements of this standard.

A safety isolating transformer shall be so constructed that a single insulation fault and its consequences will not cause a hazardous voltage to appear on SELV windings.

n This may be achieved by separating the SELV windings from all other windings
n in conformity with the principles stated in 2.3.

Safety isolating transformers shall comply with the requirements of C.1 and C.2.

1.5.4 High voltage components operating at peak-to-peak voltages exceeding 4 kV either shall have a flammability class of V-2 or better or of HF-2 or better, or they shall comply with 14.4 in IEC Publication 65.

1.6 Power interface

1.6.1 The steady state input current of the equipment shall not exceed the rated current by more than 10 % under normal load.

c Compliance is checked by measuring the input current of the equipment at
c normal load and at rated voltage or at the lowest voltage of the rated
c voltage range, when the input current has stabilized. If the current varies
c during the normal operating cycle the steady state input current shall be
c taken as the mean value, measured on a recording ammeter, during a
c representative period.

1.6.2 The rated voltage of hand-held equipment shall not exceed 250 V.

1.6.3 The neutral conductor, if any, shall be insulated from earth and the body throughout the equipment as if it were a phase conductor. Components connected between neutral and earth shall be rated for a working voltage equal to the phase-to-neutral voltage.

1.6.4 Equipment intended to operate directly from the mains supply shall be designed for a minimum supply tolerance of +6 % -10 %.

1.6.5 For equipment to be connected to IT power systems, components connected between phase and earth shall be capable of withstanding the stress due to a working voltage equal to the phase-to-phase voltage.

1.7 Marking and instructions

1.7.1 Equipment shall be provided with a power rating marking, the purpose of which is to specify a supply of correct voltage and frequency and of adequate current carrying capacity.

For equipment intended to be installed by anyone other than service personnel the marking shall be readily visible either in an operator access area or shall be located on an outside surface of the equipment. If located on an outside surface of fixed equipment, the marking shall be discernable after the equipment has been installed as in normal use.

n Markings that are not visible from the outside of the equipment are
n considered to be in compliance if they are directly visible when opening a
n door or cover. If the area behind the door or cover is not an operator
n access area, a readily visible marker should be attached to the equipment to
n clearly indicate the location of the marking. The marker may be of a
n temporary nature.

The marking shall include the following:

- rated voltage(s) or rated voltage range(s), in V.

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The voltage range shall have a hyphen (-) between the maximum and minimum rated voltages. When multiple rated voltages or voltage ranges are given, they shall be separated by a solidus (/).

n Examples of voltage ratings:

n Rated voltage range: 220 V-240 V. This means that the equipment is
n designed to be connected to any supply having a nominal voltage between
n 220 V and 240 V.

n Multiple rated voltage: 120 V/220 V/240 V. This means that equipment
n is designed to be connected to a supply having a nominal voltage of
n 120 V or 220 V or 240 V, usually after internal voltage adjustment.

- symbol for nature of supply, for d.c. only,
- rated frequency or rated frequency range, in Hz, unless the equipment is designed for d.c. only,
- rated current, in mA or A.

For equipment with multiple rated voltages, the corresponding rated currents shall be marked such that the different current ratings are separated by a solidus (/) and the relation between rated voltage and associated rated current appears distinctly.

The marking for rated current of a group of units having a single supply connection shall be placed on the unit which is directly connected to the supply mains. The rated current marked on that unit shall be the total maximum current that can be on circuit at the same time and shall include the combined currents to all units in the group that may be supplied simultaneously through the unit and that can be operated simultaneously.

If a unit is not provided with a means for connection direct to the supply mains, it need not be marked with its rated current.

- manufacturer's name, trade mark or identification mark,
- manufacturer's model or type reference,
- symbol for class II construction, for class II equipment only.

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

Where symbols are used, they shall conform with ISO 7000 and IEC Publication 417 where appropriate symbols exist.

1.7.2 If it is necessary to take special precautions to avoid the introduction of hazards when operating, installing, maintaining, transporting or storing equipment the manufacturer shall have available the necessary instructions.

n Special precautions may be necessary, e.g. for connection of the equipment
n to the supply and the inter-connection of separate units, if
n any.

n Maintenance information is normally made available only to service
n personnel.

The operating instructions and, for pluggable equipment intended for user installation also the installation instructions, shall be made available to the user.

When the disconnect device is not incorporated in the equipment (see 2.6.3) or when the plug on the power supply cord is intended to serve as the disconnect device the installation instructions shall state that:

- for permanently connected equipment, a readily accessible disconnect device shall be incorporated in the fixed wiring;
- for pluggable equipment the socket outlet shall be installed near the equipment and shall be easily accessible.

For equipment that may produce ozone the installation and operating instructions shall refer to the need to take precautions to ensure that the concentration of ozone is limited to a safe value.

n The present recommended long term exposure limit for ozone is 0.1 ppm
n (0.2 mg/cu.m) calculated as an 8-hour time-weighted average concentration.
n It should be noted that ozone is heavier than air.

1.7.3 Equipment intended for short-time operation or for intermittent operation shall be marked with rated operating time, or rated operating time and rated resting time respectively, unless the operating time is limited by the construction or by the definition of its normal load.

The marking of short-time operation or intermittent operation shall correspond to normal use.

The marking of intermittent operation shall be such that the rated operating time precedes the rated resting time, the two markings being separated by a solidus (/).

1.7.4 For equipment intended for connection to multiple rated voltages or frequencies the method of adjustment shall be fully described in the service manual or installation instructions. Unless the means of adjustment is a simple control near the power rating marking, and the setting of this control is obvious by inspection, the following instruction or a similar one shall appear in or near the power rating marking:

SEE INSTALLATION INSTRUCTIONS BEFORE CONNECTING TO THE SUPPLY

1.7.5 If any standard power supply outlet in the equipment is accessible to the operator, a marking shall be placed in the vicinity of the standard supply outlet to show the maximum permissible load that may be connected to the outlet.

1.7.6 Marking shall be located on, or adjacent to, each fuseholder (or in another location provided that it is clear to which fuseholder the marking applies) giving the fuse rated current and, where fuses of different voltage rating could be fitted, the fuse rated voltage.

The marking shall not be placed on removeable parts which can be replaced in such a way that the marking would become misleading.

Where fuses with special fusing characteristics such as time delay are necessary, the type shall also be indicated.

1.7.7 The wiring terminal intended for connection of the protective earthing conductor associated with the supply wiring shall be indicated by the symbol $\oplus$ defined in IEC Publication 417 No. 5019a.

This symbol shall not be used for other earthing terminals.

n This requirement is applicable to terminals for connection of a protective
n earthing conductor whether run as an integral part of a power supply cord
n or with supply conductors in a raceway.

n Because the symbol $\oplus$ has been used widely by equipment manufacturers
n and by manufacturers of components such as terminal blocks, it is expected
n that its use will continue to be permitted.

Terminals intended exclusively for connection of the primary power neutral conductor, if any, shall be indicated by the capital letter N.

On three-phase equipment, if incorrect phase rotation could cause overheating or other hazard, terminals intended for connection of the primary power phase conductors shall be marked in such a way that, in conjunction with any installation instructions, the sequence of phase rotation is unambiguous.

These indications shall not be placed on screws, or other parts which might be removed when conductors are being connected.

1.7.8 Unless it is obviously unnecessary, switches and other controls affecting safety shall be marked or placed so as to indicate clearly which function they control.

Indications used for this purpose shall, wherever practicable, be comprehensible without a knowledge of languages, national standards, etc.

Where symbols are used on or near controls, e.g. switches, push buttons, etc., to indicate 'ON' and 'OFF' conditions of the equipment they shall be the vertical line | for 'ON' and circle $\bigcirc$ for 'OFF' (IEC Publication 417 Nos. 5007a and 5008a). For push-push type switches, the symbol shall be IEC Publication 417 No. 5010a.

n The symbols $\bigcirc$ and | may be used as Off and On markings on any primary
n power switches, including isolator switches.

If figures are used for indicating different positions of any control, the OFF position shall be indicated by the figure 0 (ZERO) and higher figures shall be used to indicate greater output, input, etc.

A STANDBY condition shall be indicated by the appropriate symbol $\downarrow$ (IEC Publication 417 No.5009-a).

Markings and indications for switches and other controls shall be located either:

- on or adjacent to the switch or control, or
- so that it is obvious to which switch or control the marking applies.

The marking shall not be placed on removeable parts which can be replaced in such a way that the marking would become misleading.

1.7.9 Where there is more than one connection supplying hazardous voltages or energy levels to equipment, a prominent marking close to the service access to the hazardous parts shall indicate which disconnect device isolates the equipment completely and which disconnect devices may be used to isolate each section of the equipment.

1.7.10 If the equipment has been designed or, when required, modified for connection to an IT power system the equipment installation instructions shall so state.

1.7.11 The equipment installation instructions shall state if the equipment relies upon the building installation for protection of internal wiring and shall specify the maximum intended over-current protection rating where necessary (see 2.7.1).

1.7.12 Equipment in which leakage current exceeding 3.5 mA exists (see 5.2.5 and G.5) shall carry a warning label as defined in 5.2.5 or G.5.

n Attention is drawn to IEC 364-7-707: Earthing requirements for the
n installation of data processing equipment.

1.7.13 Thermostats and similar regulating devices intended to be adjusted during installation or in normal use, shall be provided with an indication for the direction of adjustment to increase or decrease the value of the characteristic being adjusted.

n An indication of + and - is acceptable.

1.7.14 Instructions and equipment marking related to safety shall be in a language which is acceptable in the country in which the equipment is to be installed.

1.7.15 Marking required by this standard shall be durable and legible. In considering the durability of the marking, the effect of normal use shall be taken into account.

c Compliance is checked by inspection and by rubbing the marking by hand for
c 15 s with a piece of cloth soaked with water and again for 15 s with a piece
c of cloth soaked with petroleum spirit. After all the tests of this standard,
c the marking shall be legible; it shall not be easily possible to remove
c marking plates and they shall show no curling.

2. FUNDAMENTAL DESIGN REQUIREMENTS

2.1 Protection against electric shock and energy hazards

2.1.1 This standard specifies two categories of requirements for protection against electric shock from energized parts. Requirements for protection against energy hazards are specified in 2.1.5.

The two categories of requirements are based on the following principles:

1) The operator may be permitted to have access to:

- bare parts in SELV circuits;
- bare parts in limited current circuits;
- insulation of wiring normally operating at ELV under the conditions specified in 2.1.3.

2) The operator shall be prevented from having access to:

- bare parts or circuits normally operating at ELV or hazardous voltages;
- operational or basic insulation of such parts except under the conditions specified in 2.1.3;
- unearthed conductive parts separated from parts at ELV or hazardous voltages by operational or basic insulation only.

2.1.2 Equipment shall be so constructed that there is adequate protection against operator contact with:

- bare parts at ELV or hazardous voltage;

n Parts at ELV or hazardous voltages, protected only by lacquer, enamel, ordinary paper, cotton, oxide film, beads or sealing compounds other than self-hardening resin, are considered to be bare conductive parts.

- operational or basic insulation of parts or wiring at ELV or hazardous voltages, except as permitted in 2.1.3;
- unearthed conductive parts separated from parts at ELV or hazardous voltages by operational or basic insulation only.

This requirement applies for all positions of the equipment when it is wired and operated as in normal use, even after removal of operator detachable parts, except lamps, and with operator access doors and covers open.

n This requirement precludes the use in operator access areas of fuseholders, connectors, socket outlets and the like which are unable to pass the following accessibility test with the test finger (figure 10).

Protection shall be effected by insulation or by guarding or by the use of interlocks.

c Compliance is checked:

c - by inspection, and

c - by a test with the test finger (figure 10), which shall not contact parts described above, and

c - by a test with the test pin (figure 11), which shall not contact bare parts at hazardous voltage when applied to apertures in an insulating or unearthed conductive electrical enclosure. The test pin is not applied to fuseholders, connectors, socket outlets and the like.

n For the purpose of this test an electrical enclosure treated with a non-conductive coating, for example, painting or anodizing, is not considered to be a conductive enclosure.

c The test finger and the test pin shall be applied, without appreciable force, in every possible position, except that floor-standing equipment having a mass exceeding 40 kg shall not be tilted. Operator-detachable connectors shall be tested during and after disconnection.

c Equipment intended for building-in, rack-mounting, or incorporation in larger equipment shall be tested with access to the equipment limited according to the method of mounting detailed by the manufacturer.

c Apertures preventing the entry of the test finger (figure 10) shall be further tested by means of a straight unjointed version of the test finger applied with a force of 30 N; if this finger enters, the test with the finger (figure 10) shall be repeated, the finger being pushed through the aperture if necessary.

n An electrical contact indicator may be used to show contact. In such a case care should be taken to ensure that the application of the test does not damage components of electronic circuits.

c If components are movable, for instance, for the purpose of belt tensioning, the test with the test finger shall be made with each component in its most unfavourable position within the range of adjustment, the belt being removed, if necessary, for this purpose.

2.1.3 Where the insulation of internal wiring at ELV is accessible to an operator, this wiring shall:

- not be subject to damage nor to stress, and shall not need to be handled by the operator in performing normal operator functions, and
- be routed and fixed so as not to touch unearthed accessible metal parts, and

- have distance through insulation not less than 0.17 mm for voltage over 50 V r.m.s. (71 V peak or d.c.) and up to 250 V r.m.s. (350 V peak or d.c.) and not less than 0.31 mm for voltage over 250 V r.m.s. (350 V peak or d.c.) where the voltages referred to are the maximum occurring across the insulation in case of failure of basic insulation, and
- withstands on its insulation an electric strength test with a voltage specified for supplementary insulation (see 5.3). The test voltages shall be related to the voltages which occur across the insulation in case of failure of basic insulation.

c Compliance is checked by inspection.

2.1.4 In service access areas bare parts operating at more than 42.4 V peak, or 60 V d.c., and which are not connected to limited current circuits, shall be so located or guarded that unintentional contact with such parts is unlikely during servicing operations involving other parts of the equipment.

n In deciding whether or not unintentional contact with bare parts would be likely, account should be taken of the way service personnel need to gain access past, or near to, the bare parts in order to service other parts.

n Precautions against unintentional contact by service personnel are not required for any secondary circuits that operate at less than 42.4 V peak, or 60 V d.c. (see 1.2.3a).

Bare parts that involve an energy hazard shall be located, enclosed, guarded or provided with a barrier to take into account the possibility of unintentional bridging by conductive materials that might be present during service operations.

n Required guards should be easily removable and replaceable if removal is necessary to service the protected parts.

c Compliance is checked by inspection.

2.1.5 There shall be no energy hazard in operator access areas.

c Compliance is checked by means of the test finger (figure 10) in a straight position applied without appreciable force. It shall not be possible to bridge with this test finger two bare parts, one of which may be an earthed conductive part, between which a hazardous energy level exists.

2.1.6 Clearances behind earthed or unearthed conductive enclosures shall be adequate to ensure that no energy hazard arises during the relevant tests of 4.2 involving a force of 250 N, in equipment to which this test is applicable.

2.1.7 Shafts of operating knobs, handles, levers and the like shall not be at ELV or hazardous voltages.

c Compliance is checked by inspection.

2.1.8 Conductive handles, levers, control knobs and the like which are manually moved in normal use and which are earthed only through a pivot or bearing shall be either:

- separated from hazardous voltages within the component or elsewhere by creepage distances and clearances of double or reinforced insulation; or
- covered by supplementary insulation over accessible parts.

c Compliance is checked by inspection and by the applicable electric strength c tests of 5.3.2.

2.1.9 Conductive casings of capacitors operating in circuits at ELV or hazardous voltages shall not be connected to unearthed conductive parts in operator access areas and shall be separated from these parts by supplementary insulation or earthed metal.

c Compliance is checked by inspection and, where necessary, by the applicable c tests of 2.9 and 5.3.2.

2.1.10 Equipment shall be so designed that at an external point of disconnection of the mains supply, there is no risk of electric shock from stored charge on capacitors connected to the mains circuit.

c Compliance is checked by inspection of the equipment and relevant circuit c diagrams, taking into account the possibility of disconnection of the supply c with the On/Off switch in either position.

c Equipment shall be considered to comply if any capacitor having a rated c capacitance exceeding $0.1 \mu\text{F}$ and connected to the external mains circuit, has c a means of discharge resulting in a time-constant not exceeding:

- c - 1 s for pluggable equipment type A,
- c - 10 s for permanently connected equipment and for pluggable equipment c type B.

n The relevant time-constant is the product of the effective
n capacitance in microfarads and the effective discharge resistance in M .
n Where it is difficult to determine the effective capacitance and resistance
n values, a measurement of voltage decay may be used. In one time-constant the
n voltage will have decayed to 37 % of its original value.

2.2 Insulation

2.2.1 Electrical insulation shall be achieved by provision of either one of the following, or a combination of the two:

- solid or laminated insulating materials having adequate thickness and adequate creepage distances over their surfaces;
- adequate clearances through air.

2.2.2 The choice and application of insulating materials shall take into account the needs for electrical, thermal and mechanical strength, and the working environment.

Neither natural rubber nor material containing asbestos shall be used as insulation.

Hygroscopic material shall not be used as insulation.

Compliance is checked by inspection. In case of doubt, the hygroscopic nature of an insulating material shall be determined by subjecting the component or sub-assembly employing the insulation in question to the humidity treatment of 2.2.3.

The insulation shall then be subjected to the electric strength test of 5.3.2 or appendix C.2, as appropriate, while still in the humidity cabinet, or in the room in which the samples were brought to the prescribed temperature.

c 2.2.3 Humidity treatment shall be carried out for 48 h in a cabinet or room c containing air with a relative humidity of 91 % to 95 %. The temperature of c the air, at all places where samples can be located, shall be maintained c within 1 °C of any convenient value t between 20 °C and 30 °C such that c condensation does not occur. During this treatment the component or c sub-assembly shall not be energized.

c Before the humidity treatment the sample shall be brought to a temperature c between t °C and (t + 4) °C.

2.2.4 Insulation in equipment shall comply with the applicable electric strength requirements of 5.3, with the creepage distance, clearance and distance through insulation requirements of 2.9, and with the heating requirements of 5.1.

2.2.5 For the purpose of determining the test voltages, creepage distances, clearances and distance through insulation for a given piece of insulation, two parameters shall be considered:

- Application (see 2.2.6)
- Working voltage (see 2.2.7)

2.2.6 Application of insulation shall be considered to be:

- Operational
- Basic
- Supplementary
- Reinforced or double.

n Examples of situations where these types of insulation are required are
n as follows:

n Operational:

- n - Between parts of different potential.
- n - Between ELV or SELV circuits and earthed conductive parts.
- n - Between any part of an earthed secondary circuit at hazardous
- n voltage and an accessible earthed conductive part.

n Basic:

- n - Between a part at hazardous voltage and an earthed conductive
n part.
n - Between a part at hazardous voltage and an SELV circuit
n which relies on being earthed for its integrity.
n - Between a primary power conductor and the earthed screen or core
n of a primary power transformer.
n - As an element of double insulation.

n Supplementary:

- n - Generally, between an accessible conductive part and a part
n which could assume a hazardous voltage in the event of a
n failure of basic insulation, e.g.:

n between the outer surface of handles, knobs, grips and the
n like, and their shafts unless earthed,

n between the equipment body and the surface of a flexible
n supply cord where the cord enters metal-encased class II
n equipment,

n between an unearthed non-SELV secondary circuit and an
n unearthed conductive part of the body and as an element of
n double insulation.

n Double or reinforced:

- n - Generally, between an unearthed accessible conductive part or a
n floating SELV circuit, and a primary circuit:

n Where double insulation is used, ELV circuits or unearthed
n conductive parts are permitted between the two layers
n provided that the overall level of insulation is maintained.

n Double insulation may have the basic and supplementary layers
n interchanged.

2.2.7 For the purpose of determining working voltage:

- where the r.m.s. value is used, a sinusoidal a.c. wave form shall be assumed;
- where the d.c. value is used, the peak value of any superimposed ripple shall be included;
- transients shall be disregarded;
- the voltage of an ELV or SELV circuit or transformer winding shall be disregarded;
- unearthed accessible conductive parts shall be assumed to be earthed;

- where a transformer winding or other part is floating, i.e. not connected to a circuit which establishes its potential relative to earth, it shall be assumed to be earthed at the point by which the highest working voltage is obtained;
- where double insulation is used, the working voltage across the basic insulation shall be determined by imagining a short-circuit across the supplementary insulation, and vice-versa. For insulation between transformer windings, the short-circuit shall be assumed to take place at the point by which the highest working voltage is produced in the other insulation;
- for insulation between two transformer windings, taking into account external voltages to which the windings may be connected, the highest voltage between any two points in the two windings shall be used;
- for insulation between a transformer winding and another part the highest voltage between any point on the winding and the other part shall be used;
- nominal values of mains supply voltage shall be used.

2.3 Safety extra-low voltage (SELV) circuits

2.3.1 SELV circuits, whose uninsulated parts may be accessible to touch by operators, shall exhibit voltages safe to touch both under normal operating conditions and after a single fault, such as breakdown of a layer of basic insulation, or failure of a single component.

2.3.2 In a single SELV circuit or in interconnected SELV circuits, the voltage between any accessible circuit parts or between any accessible circuit part and either earth or body shall not exceed 42.4 V peak, or 60 V d.c., under normal conditions.

2.3.3 In the event of a single failure of basic or supplementary insulation or of a component (excluding components with double or reinforced insulation), the voltages in accessible parts of a SELV circuit shall not exceed 42.4 V peak or 60 V d.c. for longer than 0.2 s with a limit of 65 V peak or d.c.

One of the following methods shall be used:

Method 1 separation of the SELV circuit from parts at hazardous voltage by double or reinforced insulation as detailed in 2.3.4;

Method 2 separation of the SELV circuit from other circuits by an earthed conductive screen or other earthed conductive parts, as detailed in 2.3.5 (class I equipment only);

Method 3 adequate earthing of the SELV circuit as detailed in 2.3.6 (class I equipment only);

Method 4 provision of a means of protection which prevents the voltage limits from being exceeded, as detailed in 2.3.7.

- n Methods 1) and 2) can be provided by a safety isolating transformer
- n (see 1.5.3).

n Method 1) can be provided by two separate transformers in tandem, where
 n one transformer provides basic insulation and the other transformer provides
 n supplementary insulation. The two transformers should follow, as a pair, the
 N principles of construction for a single safety isolating transformer in
 n appendix C2, taking into account the voltage in the intermediate circuit.

n In a single circuit, (e.g. transformer-rectifier circuit) it is possible
 n for some parts to comply with the requirements for SELV circuits and to be
 n operator accessible, while other parts are not.

n Different parts of the same SELV circuit may be protected by different
 n methods, e.g.

- n - method 2) within a power transformer feeding a bridge rectifier;
- n - method 1) for the a.c. secondary circuit;
- n - method 3) at the output of the bridge rectifier;
- n - method 4) at a remote part of the SELV circuit.

n For normal conditions the SELV circuit voltage limit is the same for ELV;
 n a SELV circuit may be regarded as an ELV circuit with additional protection
 n under fault conditions.

2.3.4 (Method 1 of 2.3.3) Where an SELV circuit is separated from other
 circuits by double or reinforced insulation only, one of the following methods
 shall be employed:

- provide permanent separation by barriers, routing or fixing;
- provide insulation of all adjacent wiring involved that is rated for the
 highest working voltage present;
- provide insulation on either the wiring of the SELV circuit or that of the
 other circuits that meets the insulation requirements for supplementary or
 reinforced insulation, as appropriate, for the highest working voltage
 present;
- provide an additional layer of insulation, where required, over either the
 wiring of the SELV circuit or that of the other circuits;
- use any other means providing equivalent insulation.

2.3.5 (Method 2 of 2.3.3) Where parts of SELV circuits are separated from parts
 at hazardous voltage by an earthed screen or other earthed conductive parts, the
 parts at hazardous voltage shall be separated from the earthed parts by at least
 basic insulation. The earthed parts shall comply with 2.5.

2.3.6 (Method 3 of 2.3.3) Parts of SELV circuits protected by earthing shall be
 connected to the protective earth terminal in such a way that the requirements
 of 2.3.3 are met by relative circuit impedances or by the operation of a
 protective device or both; and shall be separated from parts of other non-SELV
 circuits by at least basic insulation. The SELV circuit shall have adequate
 current carrying capacity to ensure operation of the protective device.

2.3.7 (Method 4 of 2.3.3) Where unearthed SELV circuits are separated from other circuits by only basic insulation, protection shall be provided where necessary to ensure that the requirements of 2.3.3 are met in the event of failure of the basic insulation.

n Such protection may be achieved by using components or circuits such as
n fuses, circuit breakers, electronic over-voltage protection or electronic
n over-current protection.

n In Denmark, Finland, Norway and Sweden Method 4 is not acceptable.

2.3.8 The equipment shall also be constructed as follows:

- Ring-tongue and similar termination shall be prevented from any pivoting that would reduce creepage distances and clearances between SELV circuits and parts at hazardous voltage below the specified minimum values.
- In multiway plugs and sockets and wherever shorting could otherwise occur, means shall be provided to prevent contact between parts at hazardous voltage and SELV circuits due to loosening of a terminal or breaking of a wire at a termination.
- Uninsulated parts at hazardous voltage shall be so located or guarded as to avoid accidental shorting to SELV circuits, e.g. by tools or test probes.
- SELV circuits shall not use connectors compatible with those specified in IEC Publications 83 or 320.

2.3.9 If SELV circuits are connected to other circuits they shall continue to comply with the requirements of 2.3.2 and 2.3.3. SELV circuits shall not be conductively connected to any primary circuit (including the neutral) within the equipment.

2.4 Limited current circuits

2.4.1 For frequencies not exceeding 1 kHz the steady-state current drawn through a non-inductive resistor of 2000 Ω connected between an accessible part of a limited current circuit and either pole of the limited current circuit or earth shall not exceed 0.7 mA peak a.c. or 2 mA d.c. For frequencies above 1 kHz, the limit of 0.7 mA is multiplied by the value of the frequency in kHz but shall not exceed 70 mA peak.

2.4.2 For accessible parts not exceeding 450 V peak or d.c., the circuit capacitance shall not exceed 0.1 μF .

2.4.3 For accessible parts not exceeding 15 kV peak or d.c., the available stored charge shall not exceed 45 μC .

2.4.4 For accessible parts exceeding 15 kV peak or d.c., the available energy shall not exceed 350 mJ.

2.4.5 Limited current circuits shall be so designed that the limits specified above are not exceeded in the event of breakdown of any basic insulation or a single component failure, together with any faults which are the direct consequence of such breakdown or failure.

Segregation of accessible parts of limited current circuits from other circuits shall be as described in 2.3 for SELV circuits.

c Compliance is checked by inspection and measurement.

(SECRETARIAT NOTE. This sub-clause will be modified when TC 74/WG 5 concludes its work.)

2.5 Provisions for protective earthing

2.5.1 Accessible conductive parts of class I equipment which might assume a hazardous voltage in the event of a single insulation fault shall be reliably connected to a protective earthing terminal within the equipment.

n In service access areas, conductive parts such as motor frames, electronic chassis etc., which might assume a hazardous voltage in the event of a single insulation fault, either should be connected to the protective earthing terminal or, if this is impossible or impracticable, a suitable warning label should indicate to service personnel that such parts are not earthed and should be checked for hazardous voltages before being touched.

This standard assumes that conductive parts are not likely to acquire a hazardous voltage if they and the parts at hazardous voltage are separated by:

- earthed metal parts, or
- solid insulation or an air gap, or a combination of the two, meeting the requirements for double or reinforced insulation.

Such parts shall be so fixed and so rigid that the minimum distances are maintained during the 10 N and 30 N tests of 2.9.2 and the 250 N tests of 4.2.3.

2.5.2 Class II equipment shall have no provision for protective earthing except that it may be provided with a means for maintaining the continuity of protective earthing circuits to other equipment in a system. If class II equipment has an earth connection for functional purposes the functional earth circuit shall be separated from parts at hazardous voltages by double or reinforced insulation.

n In Denmark, a national deviation will apply.

c Compliance is checked by inspection and by the applicable requirements of c 2.5.11 and 5.3.

2.5.3 Protective earthing conductors shall not contain switches or fuses.

2.5.4 If a system comprises class I and class II equipment, interconnection of the equipment shall be such that earthing connection is assured for all class I equipment regardless of the arrangement of equipment in the system.

2.5.5 Protective earthing conductors may be bare or insulated. If insulated the insulation shall be green/yellow except in the following two cases:

- a) for earthing braids, the insulation shall be either green/yellow or transparent;
- b) for internal protective conductors in assemblies such as ribbon cables, busbars, flexible printed wiring etc., any colour may be used provided that no misinterpretation of the use of the conductor is likely to arise.

2.5.6 Protective earth connections shall be such that disconnection of a protective earth at one assembly does not break the protective earthing connection to other assemblies, if this might cause hazard.

2.5.7 If operator-removable parts have a protective earth connection, this connection shall be made before the current-carrying connections are established when placing the part in position, and the current-carrying connections shall be separated before the earth connection is broken when removing the part.

2.5.8 Protective earth connections shall be so designed that they do not have to be disconnected for servicing other than for the removal of the part which they serve or where removal of hazardous voltages from that part is accomplished at the same time.

c Compliance is checked by inspection.

2.5.9 Protective earthing terminals for fixed supply conductors or for non-detachable power supply cords shall comply with the requirements of 3.3.

The clamping means, if any, of such terminals shall prevent accidental loosening of the conductor.

c Compliance is checked by inspection and manual test.

n In general, the designs commonly used for current-carrying terminals,
 n other than some terminals of the pillar type, provide sufficient
 n resilience to comply with the latter requirement: for other designs
 n special provisions, such as the use of an adequately resilient part which
 n is not likely to be removed inadvertently, may be necessary.

2.5.10 Conductive parts in contact at protective earth connections shall not be subject to significant corrosion due to electro-chemical action in any working, storage or transport environment conditions as specified in the manufacturers' instructions. Combinations above the line in appendix L shall be avoided.

The protective earthing terminal shall be resistant to significant corrosion.

n Corrosion resistance may be achieved by a suitable plating or coating
 n process.

c Compliance is checked by inspection and by reference to the table of
 c electro-chemical potentials (appendix L).

2.5.11 The resistance of the connection between the earthing terminal or earthing contact, and parts required to be earthed, shall not exceed 0.1Ω .

c Compliance is checked by the following test:

c The test current shall be 1.5 times the current capacity of any hazardous voltage circuit at the point where failure of basic insulation would make the earthed part live. The test voltage shall not exceed 12 V and the test current may be either a.c. or d.c. but not more than 25 A.

c The voltage drop between the earthing terminal or earthing contact and the part to be earthed shall be measured and the resistance calculated from the current and this voltage drop. The resistance of the protective earthing conductor of the power supply cord shall not be included in the resistance measurement.

c On equipment where the protective earth connection to a sub-assembly or to a separate unit is by means of one core of a multicore cable which also supplies mains power to that sub-assembly or unit, the resistance of the protective earthing conductor in that cable shall not be included in the resistance measurement. However, the cable shall be protected by a suitably rated protective device which takes into account the impedance of the cable.

c When an SELV circuit is achieved by earthing in accordance with 2.3.6, the 0.1 ohm earth path resistance applies between the earthed side of the SELV circuit and the earthing terminal or earthing contact and not from the unearthed side of the SELV circuit.

c Care shall be taken that the contact resistance between the tip of the measuring probe and the metal part under test does not influence the test results.

2.6 Primary power isolation

2.6.1 A disconnect device shall be provided to disconnect the equipment from the supply for servicing.

2.6.2 The disconnect device shall have a contact separation of at least 3 mm and, when incorporated in the equipment, shall be connected as closely as practicable to the incoming supply.

n Functional switches may serve as disconnect devices provided that they comply with all the requirements for disconnect devices. However, these requirements do not apply to functional switches where other means of isolation are provided.

n Examples of disconnect devices are:

- n - the plug on the power supply cord,
- n - an appliance coupler,
- n - isolating switches,
- n - circuit breakers,
- n - any equivalent device offering a degree of safety equal to the above.

n Disconnect devices complying with IEC Publication 328 are examples of those considered to comply with the requirements of this standard.

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2.6.3 For permanently connected equipment the disconnect device shall be incorporated in the equipment, unless the equipment is accompanied by installation instructions in accordance with 1.7.2 stating that the disconnect device shall be provided as part of the building installation.

n External disconnect devices will not necessarily be supplied with the
n equipment.

2.6.4 Parts on the supply side of a disconnect device in the equipment which remain energized when the disconnect device is switched off shall be guarded so as to prevent accidental contact by service personnel.

2.6.5 When an isolating switch is used it shall not be fitted in a flexible cord.

2.6.6 For single-phase equipment the disconnect device shall disconnect both poles simultaneously, except that a single-pole disconnecting device may be safely used to disconnect the phase conductor when it is possible to rely on the identification of the neutral in the mains supply. In this case instructions shall be given for the provision of an additional two pole disconnecting device in the building installation when the equipment is used where such identification is not possible.

n Two examples of cases where a two-pole disconnect device is required are:

2.6.11 Where a group of units having individual supply connections is interconnected in such a way that it is possible for hazardous voltage or energy levels to be transmitted between units, a disconnect device shall be provided to disconnect hazardous parts likely to be contacted while the unit under consideration is being serviced, unless these parts are guarded and marked with appropriate warning labels. In addition a prominent label shall be provided on each unit giving adequate instructions for the removal of all power from the unit.

2.6.12 Where a unit receives power from more than one source (e.g. different voltages/frequencies or as redundant power), there shall be a prominent marking at each disconnect device giving adequate instructions for the removal of all power from the unit.

When more than one such disconnect device is provided on a unit, all these devices shall be grouped together.

n It is not necessary that the devices be mechanically linked.

2.6.13 Compliance with the requirements of 2.6 is checked by inspection.

2.7 Overcurrent and earth fault protection in primary circuits

2.7.1 To protect against excess current, short circuits and earth faults in primary circuits protection devices shall be included either as integral parts of the equipment or as part of the building installation, but if reliance is placed on the building installation the installation instructions shall comply with 1.7.11.

Where single phase equipment is to be connected to standard supply outlets the building installation shall be regarded as providing this protection in accordance with the rating of the wall outlet and the installation instructions are exempt from compliance with 1.7.11.

c Compliance is checked by inspection.

2.7.2 Protective devices shall:

- operate automatically at current values which are suitably related to the safe current ratings of the circuits,
- be capable of reliably breaking the maximum fault current which may flow, unless appropriate back-up protection is provided as an integral part of the equipment or is specified in the installation instructions,
- be so constructed and positioned that their operation does not cause a hazard,
- be so constructed and positioned that their characteristics are not adversely affected by normal operating conditions,
- be correctly mounted, e.g. if special mounting positions are required.

Where protective devices are used in more than one pole of a supply to a given load, those devices shall be located together.

c Compliance is checked by inspection

n Two or more protective devices may be combined in one component.

2.7.3 Protection systems or devices shall be in such a number and so located as to detect and to interrupt the excessive current flowing in any possible fault current path (e.g. phase to phase, phase to neutral and, for class I only, phase to protective earth conductor).

n In IT power systems the unearthed neutral is considered as a phase conductor.

Suitable warning shall be provided, to alert service personnel to a possible hazard, under the following conditions 1) and 2):

1) where fuses are employed in the neutral of class I single phase equipment connected to a polarized supply; and

2) where, after operation of the protective device, parts of the equipment that remain under voltage might represent a hazard during servicing.

n The following, or similar, wording is regarded as suitable: 'CAUTION.
n Double-pole/neutral fusing'.

In a supply to a three-phase load, if a protective device interrupts the neutral conductor it shall also interrupt all other supply conductors. Fuses, therefore, shall not be used in such cases.

c Compliance is checked by inspection and, where necessary, by simulation of c fault conditions.

n Examples of the minimum number and location of fuses or circuit breaker poles when they are an integral part of the equipment are given in table 1
n for single phase equipment or sub-assemblies and in table 2 for
n three-phase equipment.

TABLE 1 - Protective devices in single phase equipment or sub-assemblies

Destination of the equipment	Protection against:	Minimum number of fuses or circuit breaker poles	Location
To be connected to any supply	Earth faults	2	Both conductors
	Overcurrent	1	Either of the two
To be connected only to power systems with earthed neutral reliably identified	Earth faults	1	Phase conductor
	Overcurrent	1	Either of the two

TABLE 2 - Protective devices in three phase equipment

Power system	Number of supply conductors	Protection against	Minimum number of fuses or circuit breaker poles	Location
Three phase without neutral	3	Earth faults	3	All 3 conductors
		Overcurrent	2	Any 2 conductors
With earthed neutral (TN/TT)	4	Earth faults	3	Each phase conductor
		Overcurrent	3	Each phase conductor
With unearthed neutral	4	Earth faults	4	All 4 conductors
		Overcurrent	3	Each phase conductor

n Attention is called to the fact that, in IT power systems, in case of
n interruption of the neutral fuse in the building installation, components
n from phase to neutral can be subjected to higher than normal voltage: in
n such a case the requirements of 4.4.2 relative to fire risk apply.