

ECMA

EUROPEAN COMPUTER MANUFACTURERS ASSOCIATION

STANDARD ECMA - 129

INFORMATION TECHNOLOGY EQUIPMENT SAFETY

Volume 1

- | | |
|-----------|---|
| Part I | General information, basic requirements and definitions |
| Part II | Protection from electric shock |
| Part III | Protection from energy hazards |
| Part IV | Prevention of fire hazards |
| Part V | Protection from mechanical hazards |
| Part VI | Protection from radiation hazards |
| Part VII | Prevention of chemical hazards |
| Part VIII | Protection from heat hazards |

Second Edition - April 1994

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Brief history

In 1976 ECMA/TC12 started to work on a new document "Safety Requirements for Data Processing Equipment" with two objectives in mind:

- to produce an ECMA Technical Report, incorporating the relevant requirements of IEC 435 and updates, enabling equipment designers to realise safety principles at an early stage, and
- to contribute this Technical Report to IEC TC74 as the basis for a complete second edition of IEC 435.

In December 1977 ECMA published this document as ECMA TR/9, which was superseded in January 1979 by Standard ECMA-57; each document embodied the latest technical thinking in IEC. In 1983 IEC published IEC 435 second edition, being substantially the same as Standard ECMA-57 first edition.

Since 1979 the combined work in IEC TC74 and ECMA/TC12 has advanced in many respects and eventually resulted in a combined IEC 435 and IEC 380 (Safety of Electrically energised office machines) Standard published in 1986 as IEC Publication 950 first edition. This was based on a year's intensive work by TC12, suitably enlarged by participation from the international community.

During the Berlin 1986 plenary meeting, IEC TC74 decided, based on the availability of IEC 950, to declare IEC 435 and IEC 380 as **obsolescent**.

This decision also affected ECMA-57 and during the December 1986 meeting the ECMA General Assembly chartered TC12 with the revision of ECMA-57 in line with IEC 950. Other relevant ECMA publications, such as Standard ECMA-83, "Safety Requirements for DTE-to-DCE Interfaces in Public Data Networks"; Standard ECMA-97, "Local Area Networks-Safety Requirements"; ECMA TR/35, "Particular Safety Requirements for Equipment to be connected to Telecommunication networks", were incorporated in order to provide equipment designers with all the standard requirements for the Safety of Information Technology Equipment in one document.

With the publication of the Second Edition of IEC 950 and related amendments, Standard ECMA 129 was superseded. It was therefore decided by TC12 to replace it with a new edition, taking into account the progress made within IEC/TC74 during the past years. The second edition of ECMA-129 has been prepared in such a way as to make it easier to use by equipment designers, grouping all the requirements related to a specific hazard in a single section. This has, in some cases, resulted in duplication of the text. A new annex, annex ZZ, list the proposals for changes that will, when approved, result in Amendment 3 of IEC 950 2nd Edition.

This ECMA standard reproduces numerous parts of the text of IEC 950, which has been possible thanks to the permission granted by IEC.

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Principles and presentation of this Standard

Principles

This Standard has been derived from IEC-950, second edition (1991), incorporating amendments 1 and 2, and a number of DISs that were considered relevant. In addition, the European differences as per EN 60950; 1992 amendment 2 have been indicated in the relevant clauses.

The purpose of this Standard is to help the designer and not to constitute a basic reference. For this reason the Standard has been divided in parts, and in each part the clauses relevant to a specific hazard have been presented. Clauses may have been repeated, when they deal with more than one specific hazard.

The following parts have been identified:

- Part I: General information, basic requirements and definitions
- Part II: Protection from electric shock
- Part III: Protection from energy hazards
- Part IV: Prevention of fire hazards
- Part V: Protection from mechanical hazards
- Part VI: Protection from radiation hazards
- Part VII: Prevention of chemical hazards
- Part VIII: Protection from heat hazards

The following table gives a reference to the clauses contained in each part,

Part I General information

1.1	1.2	1.3	1.4	1.5	1.6	1.7
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Part II Protection from electric shock

2.1.1	2.1.2	2.1.3	2.1.4	2.1.7	2.1.8	2.1.9	2.1.10	2.2.1	2.2.2	2.2.3	2.2.4	2.2.5
2.2.6	2.2.7	2.3.1	2.3.2	2.3.3	2.3.4	2.3.5	2.4.1	2.4.2	2.4.3	2.5.1	2.5.2	2.5.3
2.5.4	2.5.5	2.5.6	2.5.7	2.5.8	2.5.9	2.5.10	2.5.11	2.6.1	2.6.2	2.6.3	2.6.4	2.6.5
2.6.6	2.6.7	2.6.8	2.6.9	2.6.10	2.6.11	2.6.12	2.7	2.8.1	2.8.2	2.8.3	2.8.4	2.8.5
2.8.6	2.9.1	2.9.2	2.9.3	2.9.4	2.9.5	2.9.6	2.9.7	2.9.8	2.10.1	2.10.2	2.10.3	3.1.2
3.1.3	3.1.4	3.1.5	3.1.6	3.1.7	3.1.8	3.1.9	3.1.10	3.1.11	3.2.1	3.2.2	3.2.3	3.2.4
3.2.5	3.2.6	3.2.7	3.2.8	3.3.1	3.3.4	3.3.8	3.3.9	4.2	4.3.1	4.3.2	4.3.4	4.3.5
4.3.6	4.3.7	4.3.8	4.3.9	4.3.10	4.3.11	4.3.13	4.3.14	4.3.15	4.3.16	4.3.17	4.3.18	5.2.1
5.2.2	5.2.3	5.2.4	5.2.5	5.3.1	5.3.2	5.4	6.1	6.2.1	6.2.2	6.3.1	6.3.2	6.3.3
6.4.1	6.4.2											

Part III Protection from energy hazards

2.1.4	2.1.5	2.1.6	2.4.1	2.4.2	2.4.3	2.6	2.7	2.8	2.10	4.2	5.4
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Part IV Prevention of fire hazards

2.6	2.7.1	2.7.2	2.7.3	2.7.4	2.7.5	2.7.6	2.10	2.11	4.2	4.3.1	4.3.2	4.3.14
4.3.15	4.3.16	4.3.17	4.3.19	4.3.20	4.3.21	4.4.1	4.4.2	4.4.3	4.4.4	4.4.5	4.4.6	4.4.7
4.4.8	5.4											

Part V Protection from mechanical hazards

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4.2.7	4.2.8	4.3.1	4.3.2	4.3.14	4.4.4	5.4						

Part VI Protection from radiation hazards

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Part VII Prevention of chemical hazards

1.3.2 1.7.2 5.4

Part VIII Protection from heat Hazards

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5.1	5.4	5.4.1	5.4.2	5.4.3	5.4.4	5.4.5	5.4.6	5.4.7	5.4.8	5.4.9	5.4.10	

The Annexes to this Standard have been printed only once and are to be found in the second volume.

Presentation

The following rules of presentation have been followed:

- the main body of the Standard is printed in Tms Rmn 10 points (bold for the titles, 11 points for some main titles);
- the Notes and the conditions applicable to tables are printed in Arial 8 points (this font);
- *the conformance clauses and failure criteria are printed in Tms Rmn 10 points italics (this font) and are boxed in;*
- the European differences coming from EN 60950 are printed in Tms Rmn 10 points and are double boxed in;
- a shaded portion of a clause means that the shaded text is not relevant to the part;
- terms defined in 1.2 are printed in ARIAL 8 POINTS SMALL CAPITALS, except in titles.

Clauses 2.3, 2.9.6 and 4.2 have been re-arranged to improve clarity. These changes are purely editorial, and do not change the contents of the clauses.

Principles of safety

0.1 General principles of safety

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

The following is 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.

0.2 Hazards

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

- Electric shock (see part II)
- Energy hazards (see part III)
- Fire hazards (see part IV)
- Mechanical hazards (see part V)
- Radiation hazards (see part VI)
- Chemical hazards (see part VII)
- Heat hazards (see part VIII)

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.

0.2.1 Electric shock: causes and prevention

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 60 V 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" (also referred to in this Standard as USER) 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 (SELV 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.

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.

Cause	Prevention
Contact with parts normally at HAZARDOUS VOLTAGE.	Prevent OPERATOR access to parts at HAZARDOUS VOLTAGE 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 over-current 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 SELV CIRCUITS. Separate by earthed metal screens or DOUBLE or REINFORCED INSULATION. Earth SELV 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 of CLASS I EQUIPMENT carrying leakage current. (Leakage current includes current due to RFI filter components connected between PRIMARY CIRCUITS and frame.)	Limit leakage current to BODY to a safe value, or provide high integrity protective earth connection.

0.2.2 Energy hazards

Short-circuiting between adjacent poles of high current supplies or high capacitance circuits may cause arcing or ejection of molten metal resulting in burns. Even low voltage circuits may be dangerous in this respect. Protect by separation, by shielding or by using SAFETY INTERLOCKS.

0.2.3 Fire hazards

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, if necessary, to limit the spread of fire within the equipment,
- using suitable materials for the outer ENCLOSURES of the equipment.

0.2.4 Heat hazards

Requirements are included to prevent injury due to high temperatures of parts accessible to the OPERATOR.

0.2.5 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, infra-red, high intensity visible and coherent light, ultraviolet and ionising, etc.

0.2.6 Chemical hazards

Hazardous chemicals 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.

0.2.7 Mechanical hazards

Requirements are included 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.

Part I - General information

Foreword

This part contains general information, the definitions and general requirements related to this Standard. Referenced annexes are to be found in volume 2 of this Standard.

1 General

1.1 Scope

1.1.1 Equipment covered by this Standard

This standard is applicable to information technology equipment, including electrical business equipment and associated equipment, with a RATED VOLTAGE not exceeding 600 V.

This standard is also applicable to such equipment designed and intended to be connected directly to a TELECOMMUNICATION NETWORK and forming part of a subscriber's installation, regardless of ownership and of responsibility for installation and maintenance.

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.

Examples of equipment which is within the scope of this standard are:

Data and text processing equipment, personal computers, visual display units, data preparation equipment, data terminal equipment, data circuit terminating equipment (e.g. modems), PABXs, key telephone systems, telephone answering machines, facsimile equipment, typewriters, calculators, accounting and book-keeping machines, cash registers, point of sale terminals, paper tape readers and punchers, 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.

This list is not intended to be comprehensive, and equipment that is not listed is not necessarily excluded from the scope.

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. However, this standard does not include requirements for performance or functional characteristics of equipment.

1.1.2 Additional requirements

Requirements additional to those specified in this standard may be necessary for:

- equipment intended for operation while exposed, for example, to extremes of temperature; to excessive dust, moisture, or vibration; to flammable gases; to corrosive or explosive atmospheres;
- electromedical applications with physical connections to the patient;
- equipment intended to be used in vehicles, on board ships or aircraft, in tropical countries, or at elevations greater than 2 000 m;
- equipment subject to transient overvoltages exceeding those for Installation Category II according to IEC 664; additional protection might be necessary in the mains supply to the equipment;
- equipment intended for use where ingress of water is possible; for guidance on such requirements, and on relevant testing, see annex T.

NOTE

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

1.1.3 Exclusions

This standard does not apply to:

- support equipment, such as air conditioning, fire detection or fire extinguishing systems; power supply systems, such as motor-generator sets, battery back-up systems and transformers, which are not an integral part of the equipment; building branch wiring;
- duplicating machines, including offset lithographic machines, which are intended primarily for sizes larger than A3 as specified in ISO 216;
- equipment which depends on a TELECOMMUNICATION NETWORK as its only source of electrical power for its operation, and passive devices requiring no source of electrical power.

EN 60950 - European differences

Switzerland

(Swiss Telecommunications law SR 784.10)

This standard applies also to all equipment designed and intended to be connected to a TELECOMMUNICATION NETWORK terminal.

1.2 Definitions

For the purpose of this standard the following definitions apply. Where the terms "voltage" and "current" are used, they imply the r.m.s. values, unless otherwise specified.

Definitions in alphabetical order of nouns

Area, operator access	1.2.7.1	INSULATION, REINFORCED	1.2.9.5
Area, service access	1.2.7.2	INSULATION, SUPPLEMENTARY	1.2.9.3
Body	1.2.7.5	INTERLOCK, SAFETY	1.2.7.6
Circuit, extra-low voltage (ELV)	1.2.8.4	LIMIT, EXPLOSION	1.2.13.10
Circuit, limited current	1.2.8.6	LIMITER, TEMPERATURE	1.2.11.3
Circuit, primary	1.2.8.1	LOAD, NORMAL	1.2.2.1
Circuit, safety extra-low voltage (SELV)	1.2.8.5	LOCATION, RESTRICTED ACCESS	1.2.7.3
Circuit, secondary	1.2.8.2	MATERIAL, 5V CLASS	1.2.13.5
Circuit, telecommunication network voltage (TNV)	1.2.8.8	MATERIAL, HB CLASS	1.2.13.8
Classification, flammability, of materials	1.2.13.1	MATERIAL, HBF CLASS FOAMED	1.2.13.9
Clearance	1.2.10.2	MATERIAL, HF-1 CLASS FOAMED	1.2.13.6
Cord, detachable power supply	1.2.5.4	MATERIAL, HF-2 CLASS FOAMED	1.2.13.7
Cord, non-detachable power supply	1.2.5.5	MATERIAL, V-0 CLASS	1.2.13.2
Creepage distance	1.2.10.1	MATERIAL, V-1 CLASS	1.2.13.3
Current, rated	1.2.1.3	MATERIAL, V-2 CLASS	1.2.13.4
Cut-out, Thermal	1.2.11.4	OPERATION, CONTINUOUS	1.2.2.3
Cut-out, Thermal, Automatique-Reset	1.2.11.5	OPERATION, INTERMITTENT	1.2.2.5
Cut-out, Thermal, Manual Reset	1.2.11.6	OPERATION, SHORT-TIME	1.2.2.4
ENCLOSURE	1.2.6.1	OPERATOR	1.2.14.4
ENCLOSURE, ELECTRICAL	1.2.6.4	PART, DECORATIVE	1.2.6.5
ENCLOSURE, FIRE	1.2.6.2	PERSONNEL, SERVICE	1.2.14.3
ENCLOSURE, MECHANICAL	1.2.6.3	RANGE, RATED FREQUENCY	1.2.1.5
ENERGY LEVEL, HAZARDOUS	1.2.8.7	RANGE, RATED VOLTAGE	1.2.1.2
EQUIPMENT, CLASS I	1.2.4.1	SURFACE, BOUNDING	1.2.10.3
EQUIPMENT, CLASS II	1.2.4.2	SYSTEM, IT POWER	1.2.12.3
EQUIPMENT, CLASS III	1.2.4.3	SYSTEM, TN POWER	1.2.12.1
EQUIPMENT, DIRECT PLUG-IN	1.2.3.6	SYSTEM, TT POWER	1.2.12.2
EQUIPMENT, FIXED	1.2.3.4	TELECOMMUNICATION NETWORK	1.2.14.5
EQUIPMENT, FOR BUILDING-IN	1.2.3.5	TELECOMMUNICATION SIGNAL	1.2.14.6
EQUIPMENT, HAND-HELD	1.2.3.2	TEST, TYPE	1.2.14.1
EQUIPMENT, MOVABLE	1.2.3.1	THERMOSTAT	1.2.11.2
EQUIPMENT, PERMANENTLY CONNECTED	1.2.5.3	TIME, RATED OPERATING	1.2.2.2
EQUIPMENT, PLUGGABLE, TYPE A	1.2.5.1	TOOL	1.2.7.4
EQUIPMENT, PLUGGABLE, TYPE B	1.2.5.2	TRACKING	1.2.9.7
EQUIPMENT, STATIONARY	1.2.3.3	TRANSFORMER, SAFETY ISOLATING	1.2.11.1
FREQUENCY, RATED	1.2.1.4	VOLTAGE, D.C.	1.2.14.2
INSULATION, BASIC	1.2.9.2	VOLTAGE, HAZARDOUS	1.2.8.3
INSULATION, DOUBLE	1.2.9.4	VOLTAGE, RATED	1.2.1.1
INSULATION, OPERATIONAL	1.2.9.1	VOLTAGE, WORKING	1.2.9.6

1.2.1 Equipment electrical ratings

1.2.1.1 Rated voltage

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

1.2.1.2 Rated voltage range

The primary power voltage range as declared by the manufacturer, expressed by its lower and upper RATED VOLTAGES.

1.2.1.3 Rated current

The input current of the equipment as declared by the manufacturer.

1.2.1.4 Rated frequency

The primary power frequency as declared by the manufacturer.

1.2.1.5 Rated frequency range

The primary power frequency range as declared by the manufacturer, expressed by its lower and upper RATED FREQUENCIES.

1.2.2 Operating conditions

1.2.2.1 Normal load

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

NORMAL LOAD conditions for some types of electrical business equipment are given in annex L.

1.2.2.2 Rated operating time

The operating time assigned to the equipment by the manufacturer.

1.2.2.3 Continuous operation

Operation under NORMAL LOAD for an unlimited period.

1.2.2.4 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.

1.2.2.5 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.

1.2.3 Equipment mobility

1.2.3.1 Movable equipment

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.

1.2.3.2 Hand-held equipment

MOVABLE EQUIPMENT intended to be held in the hand during normal use.

1.2.3.3 Stationary equipment

Equipment that is not MOVABLE EQUIPMENT.

1.2.3.4 Fixed equipment

STATIONARY EQUIPMENT which is fastened or otherwise secured at a specific location.

1.2.3.5 Equipment for building-in

Equipment intended to be installed in a prepared recess, such as in a wall, or similar situation.

NOTE

In general, EQUIPMENT FOR BUILDING-IN does not have an ENCLOSURE on all sides, as some of the sides will be protected after installation.

1.2.3.6 Direct plug-in equipment

Equipment that is intended to be used without a power supply cord; the mains plug forms an integral part of the equipment ENCLOSURE so that the weight of the equipment is taken by the socket-outlet.

1.2.4 Classes of equipment - Protection against electric shock

1.2.4.1 Class I equipment

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.

NOTE 1

CLASS I EQUIPMENT may have parts with DOUBLE INSULATION or REINFORCED INSULATION, or parts operating in SELV CIRCUITS.

NOTE 2

For equipment intended for use with a power supply cord, this provision includes a protective earthing conductor as part of the cord.

EN 60950 - European differences

Denmark

Certain types of Class I appliances (see 3.2.1) may be provided with a plug not establishing earthing continuity when inserted into Danish socket-outlets.

1.2.4.2 Class II equipment

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.

NOTE

CLASS II EQUIPMENT may be of one of the following types:

- 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;
- 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;
- equipment which is a combination of the above two types.

1.2.4.3 Class III equipment

Equipment in which protection against electric shock relies upon supply from SELV CIRCUITS and in which HAZARDOUS VOLTAGES are not generated.

1.2.5 Connection to the supply

1.2.5.1 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.

1.2.5.2 Pluggable equipment type B

Equipment which is intended for connection to the building power supply wiring via industrial plugs and socket-outlets complying with IEC 309, or with national standards for similar applications.

1.2.5.3 Permanently connected equipment

Equipment which is intended for connection to the building power supply wiring by screw terminals.

NOTE

See 3.2.2

1.2.5.4 Detachable power supply cord

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

1.2.5.5 Non detachable power supply cord

A flexible cord, for supply purposes, fixed to or assembled with the equipment.

Such a 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 is such that it cannot be replaced without damage to the equipment.

The term "specially prepared" includes provision of an integral cord guard, the use of cable lugs, formation of eyelets etc., but not the re-shaping of the conductor before introduction into a terminal or the twisting of a stranded conductor to consolidate the end.

1.2.6 Enclosures

1.2.6.1 Enclosure

A part of the equipment providing one or more of the functions described in 1.2.6.2, 1.2.6.3 or 1.2.6.4.

1.2.6.2 Fire enclosure

A part of the equipment intended to minimise the spread of fire or flames from within.

1.2.6.3 Mechanical enclosure

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

1.2.6.4 Electrical enclosure

A part of the equipment intended to prevent contact with parts at HAZARDOUS VOLTAGE or HAZARDOUS ENERGY LEVELS.

1.2.6.5 Decorative part

A part of the equipment, outside the ENCLOSURE, which has no safety function.

1.2.7 Accessibility

1.2.7.1 Operator access area

An area to which, under normal operating conditions, one of the following applies:

- 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.

The terms "access" and "accessible", unless qualified, relate to OPERATOR access as defined above.

1.2.7.2 Service access area

An area, other than an OPERATOR ACCESS AREA, where it is necessary for SERVICE PERSONNEL to have access even with the equipment switched on.

1.2.7.3 Restricted access location

A room or space where equipment is located, and where either

- access can only be gained by SERVICE PERSONNEL with the use of a special TOOL or lock and key, or
- access is controlled.

1.2.7.4 Tool

A screwdriver or any other object which can be used to operate a screw, latch or similar fixing means.

1.2.7.5 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.

1.2.7.6 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.

1.2.8 Circuit characteristics

1.2.8.1 Primary circuit

An internal circuit which is directly connected to the external supply mains or other equivalent source (such as a motor-generator 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.

1.2.8.2 Secondary circuit

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

1.2.8.3 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 either a LIMITED CURRENT CIRCUIT or a TNV CIRCUIT.

1.2.8.4 Extra low-voltage (ELV) circuit

A SECONDARY CIRCUIT with voltages between conductors, and between any conductor and earth, not exceeding 42,4 V peak, or 60 V d.c., under normal operating conditions, which is separated from HAZARDOUS VOLTAGE by at least BASIC INSULATION, and which neither meets all of the requirements for an SELV CIRCUIT nor meets all of the requirements for a LIMITED CURRENT CIRCUIT.

1.2.8.5 Safety extra-low voltage (SELV) circuit-

A SECONDARY CIRCUIT which is so designed and protected that under normal and single fault conditions the voltage between any two parts of the SELV CIRCUIT or CIRCUITS, and, for CLASS I EQUIPMENT, between any one such part and the equipment protective earthing terminal, does not exceed a safe value.

NOTE 1

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.

NOTE 2

This definition of SELV CIRCUIT differs from the term SELV as used in IEC 364.

1.2.8.6 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.

NOTE

The limiting values are specified in 2.4.

1.2.8.7 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.

1.2.8.8 Telecommunication voltage (TNV) circuit

A CIRCUIT that, under normal operating conditions, carries TELECOMMUNICATION SIGNALS.

EN 60950 - European Differences

A TNV CIRCUIT is considered to be a SECONDARY CIRCUIT in the meaning of 1.2.8.2 of this Standard.

1.2.9 Insulation

1.2.9.1 Operational insulation

Insulation needed for the correct operation of the equipment.

NOTE

OPERATIONAL INSULATION by definition does not protect against electric shock. It may however serve to minimise exposure to ignition and fire.

1.2.9.2 Basic insulation

Insulation to provide basic protection against electric shock.

1.2.9.3 Supplementary insulation

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.

1.2.9.4 Double insulation

Insulation comprising both BASIC INSULATION and SUPPLEMENTARY INSULATION.

1.2.9.5 Reinforced insulation

A single insulation system which provides a degree of protection against electric shock equivalent to DOUBLE INSULATION under the conditions specified in this standard.

NOTE

The term "insulation system" does not imply that the insulation has to be in one homogeneous piece. It may comprise several layers which cannot be tested as SUPPLEMENTARY or BASIC INSULATION.

1.2.9.6 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 .

NOTE

See 2.2.7.

1.2.9.7 Tracking

The progressive formation of conducting paths on the surface of a solid insulating material due to the combined effects of electric stress and electrolytic contamination on this surface.

1.2.10 Creepage distances and clearances

1.2.10.1 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.

1.2.10.2 Clearance

The shortest distance between two conductive parts, or between a conductive part and the BOUNDING SURFACE of the equipment, measured through air.

1.2.10.3 Bounding surface

The outer surface of the ELECTRICAL ENCLOSURE, considered as though metal foil were pressed into contact with accessible surfaces of insulating material.

1.2.11 Components

1.2.11.1 Safety isolating transformer

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

1.2.11.2 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 OPERATOR.

1.2.11.3 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 OPERATOR.

NOTE

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

1.2.11.4 Thermal cut-out

A temperature-sensing control intended to operate under abnormal operating conditions and which has no provision for the OPERATOR to change the temperature setting.

NOTE

A THERMAL CUT-OUT may be of the automatic reset or of the manual reset type.

1.2.11.5 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.

1.2.11.6 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.

1.2.11.7 Interconnecting cables

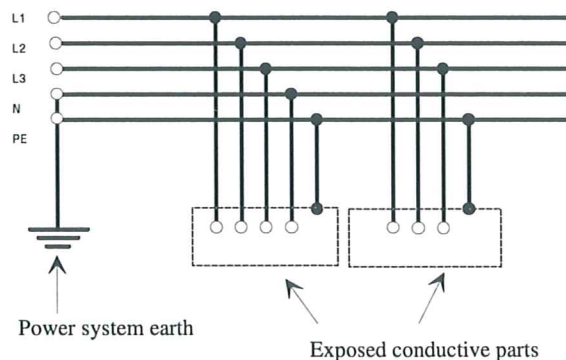
Cables that are external to the equipment and that are used to electrically connect accessories to units of Information Technology Equipment, to interconnect units in a system or to connect units to a TELECOMMUNICATION NETWORK; such cables may carry any type of circuit from one unit to another.

1.2.12 Power distribution

1.2.12.1 TN power system

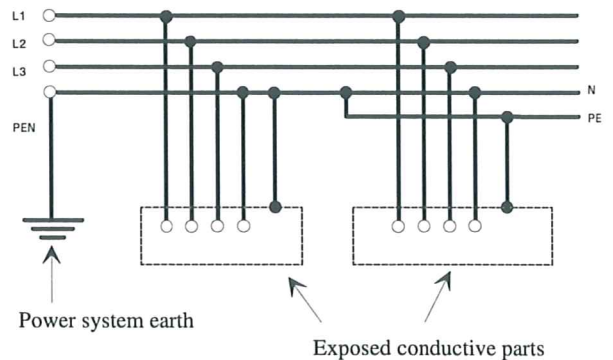
A power distribution system having one point directly earthed, the exposed conductive parts of the installation being connected to that point by protective earth conductors. Three types of TN systems are recognised according to the arrangement of neutral and protective earth conductors, as follows:

- 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.



ECMA-93-0057-B

Figure 1 - Example of TN-S POWER SYSTEM



ECMA-93-0058-B

Figure 2 - Example of TN-C-S POWER SYSTEM

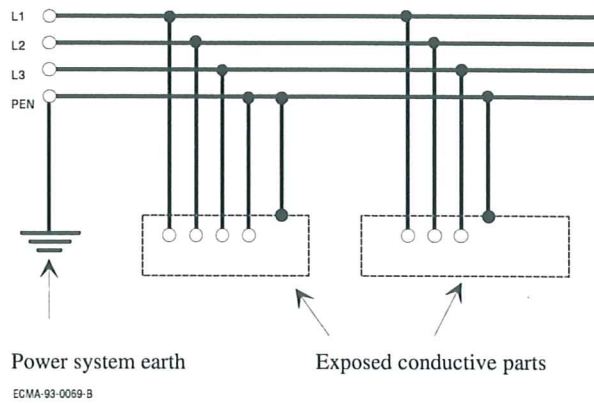


Figure 3 - Example of TN-C POWER SYSTEM

1.2.12.2 TT power system

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.

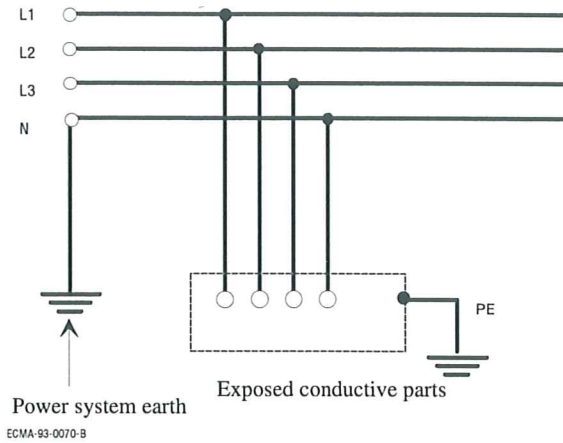


Figure 4 - Example of TT POWER SYSTEM

1.2.12.3 IT power system

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

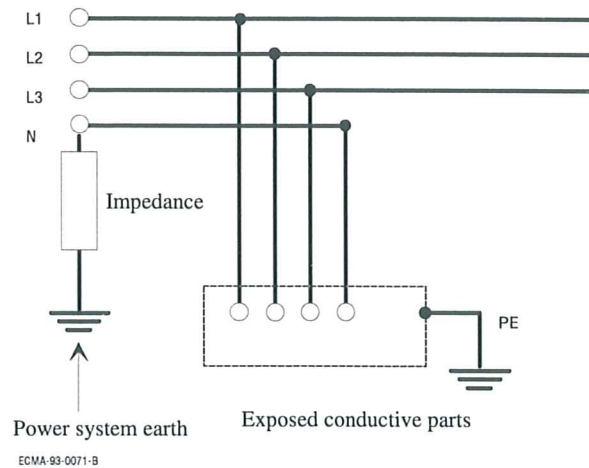


Figure 5 - Example of IT POWER SYSTEM

1.2.13 Flammability

1.2.13.1 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 1.2.13.2 to 1.2.13.9 when tested in accordance with annex A.

NOTE 1

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

NOTE 2

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

1.2.13.2 V-0 class material

A material that, when tested in accordance with clause A.6, may flame or glow but will extinguish in an average period of time not exceeding 5 s; glowing particles or flaming drops released do not ignite surgical cotton.

1.2.13.3 V-1 class material

A material that, when tested in accordance with clause A.6, may flame or glow but will extinguish in an average period of time not exceeding 25 s; glowing particles or flaming drops released do not ignite surgical cotton.

1.2.13.4 V-2 class material

A material that, when tested in accordance with clause A.6, 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.

1.2.13.5 5V class material

A material that, when tested in accordance with clause A.9, may flame or glow but will extinguish within a prescribed period of time; glowing particles or flaming drops released do not ignite surgical cotton.

NOTE

Clause A.9 may be withdrawn as soon as IEC 707 is amended to include flammability Class 5V or its possible substitute.

1.2.13.6 HF-1 class foamed material

A foamed material that, when tested in accordance with clause A.7, may flame or glow but will extinguish within a prescribed period of time; flaming or glowing particles or flaming drops released do not ignite surgical cotton.

1.2.13.7 HF-2 class foamed material

A foamed material that, when tested in accordance with clause A.7, 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.

1.2.13.8 HB class material

Material that, when tested in accordance with clause A.8, does not exceed a specified maximum burning rate.

1.2.13.9 HBF class foamed material

A foamed material that, when tested in accordance with clause A.7, does not exceed a specified maximum burning rate.

1.2.13.10 Explosion limit

The lowest concentration of a combustible material in a mixture containing any of the following: gases, vapours, mists or dusts, in which a flame is able to propagate after removal of the ignition source.

1.2.14 Miscellaneous

1.2.14.1 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.

1.2.14.2 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.

NOTE

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

1.2.14.3 Service personnel

Persons having appropriate technical training and experience necessary to:

- perform tasks in SERVICE ACCESS AREAS of the equipment, and
- be aware of hazards to which they are exposed in performing a task, and of measures to minimise the danger to themselves or other persons.

1.2.14.4 Operator

Any person, other than SERVICE PERSONNEL.

NOTE

The term "OPERATOR" in this standard is the same as the term "user" and the two can be used interchangeably.

1.2.14.5 Telecommunication network

A metallicly terminated circuit intended to carry TELECOMMUNICATION SIGNALS for voice, data or other communication. Such networks may be publicly or privately owned. They may be subjected to overvoltages due to atmospheric discharges and power line failures.

NOTE

It is assumed that adequate measures according to CCITT Recommendation K.11 have been taken to reduce the risk that the overvoltages presented to the equipment exceed 1,5 kV peak.

Excluded are:

- the mains system for supply, transmission and distribution of electrical power, if used as telecommunication transmission medium;
- TV distribution systems using cable;
- SELV CIRCUITS connecting units of data processing equipment;
- public or private mobile radio systems;
- radio paging systems.

1.2.14.6 Telecommunication signal

A steady state, varying amplitude, or intermittent voltage or current intended for use on a TELECOMMUNICATION NETWORK.

NOTE

The limiting values are specified in 6.2.1.1.

1.3 General requirements

1.3.1 Equipment design and construction

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 and against serious fire originating in the equipment, within the meaning of this standard.

Where the equipment involves technologies and materials or methods of construction not specifically covered, the equipment shall provide a level of safety not less than that generally afforded by this standard and the Principles of Safety contained herein.

Unless otherwise specified, compliance is checked by inspection and by carrying out all the relevant tests.

NOTE

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

1.3.2 User information

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).

Compliance is checked by evaluation of the documentation provided by the manufacturer.

1.3.3 Classification of equipment

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

CLASS I, or
CLASS II, or
CLASS III.

NOTE

Equipment containing ELV CIRCUITS or parts at HAZARDOUS VOLTAGE is CLASS I or CLASS II. There are no requirements in this standard for protection against electric shock for CLASS III EQUIPMENT.

1.4 General conditions for tests

1.4.1 Applicability of requirements

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

In order to establish whether or not safety is involved, the circuits and construction shall be carefully investigated to take into account the consequences of possible failure of components.

1.4.2 Type of tests

Except where otherwise stated, tests specified in this standard are TYPE TESTS.

1.4.3 Test samples

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

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

As an alternative to carrying out tests on the completed equipment, tests may be carried out separately on circuits, components or sub-assemblies outside the equipment, provided that inspection of the equipment and circuit arrangements ensures that such testing will indicate that the assembled equipment would conform to the requirements of the standard. If any such test indicates the likelihood of non conformance in the complete equipment, the test shall be repeated in the equipment.

If a test specified in this standard could be destructive, it is permitted to use a model to represent the condition to be evaluated.

NOTE 1

The tests should be carried out in the following order:

- component or material pre-selection;
- component or sub-assembly bench tests;
- those where the equipment is not energised;
- live tests:
 - under normal operating conditions;
 - under abnormal operating conditions;
 - involving likely destruction.

NOTE 2

In view of the amount of resource involved in testing and in order to minimise waste, it is recommended that all parties concerned jointly consider the test programme, the test samples and the test sequence.

1.4.4 Conditions for tests

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:
 - adjustable without the use of a TOOL, or
 - adjustable using a means, such as a key or a TOOL, deliberately provided for the OPERATOR.

1.4.5 Supply voltage for tests

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 declared by the manufacturer.

If no tolerance is declared by the manufacturer, it shall be taken as +6% and -10%. If the RATED VOLTAGE is 230 V single phase or 400 V three phase, the tolerance shall not be less than +10% and -10% (see 1.6.5).

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

1.4.6 Supply frequency for tests

In determining the most unfavourable supply frequency for a test, different RATED FREQUENCY 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 Hz \pm 0,5 Hz) is not normally necessary.

1.4.7 Temperature measurement conditions

Where a maximum temperature (T_{max}) or a maximum temperature rise (ΔT_{max}) is specified for compliance with tests, it is based on the assumption that the room ambient air temperature will be 25°C when the equipment is operating. However, the manufacturer may specify a higher ambient air temperature.

It is not necessary to maintain the ambient temperature (T_{amb}) at a specific value during tests, but it shall be monitored and recorded.

Temperatures measured on the equipment shall conform with one of the following conditions, all temperatures being in °C:

if T_{max} is specified $(T - T_{amb}) \leq (T_{max} - T_{mra})$

if ΔT_{max} is specified $(T - T_{amb}) \leq (\Delta T_{max} + 25 - T_{mra})$

where:

T the temperature of the given part measured under the prescribed test conditions, and

T_{mra} the maximum room ambient temperature permitted by the manufacturer's specification or 25 °C, whichever is greater.

During the test, the room ambient temperature should not exceed T_{mra} unless agreed by all parties involved.

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

1.4.8 Temperature measurement methods

Unless a particular method is specified, temperatures of windings shall be determined either by the thermocouple method or by the resistance method (Annex E). Temperatures of parts other than windings shall be determined by the thermocouple method. Any other suitable method of temperature measurement which does not noticeably influence the thermal balance and which achieves an accuracy sufficient to show compliance is also permitted.

The choice of 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 Input current

In determination of the input current, and where other test results could be affected, the following variables shall be considered and adjusted to give the most unfavourable results:

- loads due to optional features, offered or provided for by the manufacturer for inclusion in or with the equipment under test;
- loads due to other units of equipment intended by the manufacturer to draw power from the equipment under test;
- loads which could be connected to any standard supply outlets in OPERATOR ACCESS AREAS on the equipment, up to the value indicated in the marking required by 1.7.5.

It is permitted to use artificial loads to simulate such loads during testing.

1.4.10 Conductive liquids

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

1.4.11 Electrical measuring instruments

Electrical measuring instruments shall have adequate bandwidth to provide accurate readings, taking into account all components (d.c., mains supply frequency, high frequency and harmonic content) of the parameter being measured. If the r.m.s. value is being measured, care shall be taken that measuring instruments give true r.m.s. readings of non-sinusoidal waveforms as well as of sinusoidal waveforms.

1.4.12 Simulated faults and abnormal conditions

Where it is required to apply simulated faults or abnormal operating conditions, these shall be applied in turn one at a time. Faults which are the direct consequence of the deliberate fault or abnormal operating condition are considered to be part of that deliberate fault or abnormal operating condition.

The equipment, circuit diagrams and component specifications are examined to determine those fault conditions that might reasonably be expected to occur. Examples include:

- short circuits and open circuits of semiconductor devices and capacitors;
- faults causing continuous dissipation in resistors designed for intermittent dissipation;
- internal faults in integrated circuits causing excessive dissipation;
- failure of BASIC INSULATION between current-carrying parts of the PRIMARY CIRCUIT and
 - accessible conductive parts;
 - earthed conductive screens;
 - parts of SELV CIRCUITS;
 - parts of LIMITED CURRENT CIRCUITS.

1.5 Components

1.5.1 General

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

NOTE 1

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

A component which is to be connected to an SELV CIRCUIT and also to an ELV CIRCUIT or to a part at HAZARDOUS VOLTAGE shall comply with the requirements of 2.3.

NOTE 2

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

EN 60950 - European Differences

Sweden (Ordinance SFS 1991:1290)

Add the following:

NOTE

Switches containing mercury such as thermostats, relays and level controllers are not allowed

1.5.2 Evaluation and testing of components

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

- *a component certified by a recognised testing authority for compliance with a standard harmonised 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;*

NOTE

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

- *where no relevant 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 annex K.*

1.5.3 Transformers

Transformers, including SAFETY ISOLATING TRANSFORMERS, shall be of a type suitable for their intended application and shall comply with the relevant requirements of this standard, particularly those of annex C.

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.

1.5.4 High voltage components

High voltage components operating at peak-to-peak voltages exceeding 4 kV shall either have a flammability CLASS of V-2, or better, or of HF-2, or better, or shall comply with 14.4 of IEC 65 :1985.

1.5.5 Interconnecting cables

Interconnecting cables provided as part of the equipment shall comply with the relevant requirements of this standard and they shall not present a hazard within the meaning of this standard whether they are detachable or non-detachable.

1.5.6 Mains capacitors

A capacitor connected between two phase conductors or between one phase conductor and the neutral conductor of the mains supply, shall be one of the following:

- an X1 capacitor complying with IEC 384-14;
- an X2 capacitor which passes the pulse test of IEC 384-14, 12.11.2, as applied to X1 capacitors, with the test voltage reduced to 2,5 kV;
- an X2 capacitor which passes the endurance test of IEC 384-14, 12.11.2, with the 220 Ω resistor short circuited (Appendix B of IEC 384-14).

1.6 Power interface

1.6.1 Input current

The steady state input current of the equipment shall not exceed the RATED CURRENT by more than 10% under NORMAL LOAD.

Compliance is checked by measuring the input current of the equipment at NORMAL LOAD under the following conditions:

- where an equipment has one or more RATED VOLTAGES the input current is measured at each RATED VOLTAGE;*
- where an equipment has one or more RATED VOLTAGE RANGES, the input current is measured at each end of each RATED VOLTAGE RANGE. Where a single value of RATED CURRENT is marked, (see 1.7.1) it is compared with the higher value of the input current measured in the associated voltage range. Where two values of RATED CURRENT are marked, separated by a hyphen, they are compared with the two values measured in the associated voltage range.*

In each case, the readings are taken when the input current has stabilised. If the current varies during the normal operating cycle, the steady state current is taken as the mean indication of the value, measured on a recording r.m.s. ammeter, during a representative period.

1.6.2 Voltage limits of hand-held equipment

The RATED VOLTAGE of HAND-HELD EQUIPMENT shall not exceed 250 V.

1.6.3 Neutral conductor requirements

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 Components in equipment for IT power systems

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. However, capacitors intended to be operated in such applications and complying with IEC 384-14 are permitted if they are rated for the applicable phase-to-neutral voltage.

NOTE

Capacitors meeting IEC 384-14 are endurance tested at 1,7 times the RATED VOLTAGE of the capacitor.

1.6.5 Mains supply tolerances

Equipment intended to operate directly from the mains supply shall be designed for a minimum supply tolerance of +6%, -10%. If the RATED VOLTAGE is 230 V single phase or 400 V three phase, the equipment shall operate safely within a minimum supply tolerance of +10% and -10%.

1.7 Marking and instructions

1.7.1 Power rating

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.

If a unit is not provided with a means for direct connection to the supply mains, it need not be marked with any electrical rating, such as its RATED VOLTAGE, RATED CURRENT or RATED FREQUENCY.

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 discernible after the equipment has been installed as in normal use.

Markings that are not visible from the outside of the equipment are considered to be in compliance if they are directly visible when opening a door or cover. If the area behind the door or cover is not an OPERATOR ACCESS AREA, a readily visible marker shall be attached to the equipment to indicate clearly the location of the marking. It is permitted to use a temporary marker.

The marking shall include the following:

- RATED VOLTAGE(s) or RATED VOLTAGE RANGE(s), in volts.

The voltage range shall have a hyphen (–) between the minimum and maximum RATED VOLTAGES. Where multiple RATED VOLTAGES or RATED VOLTAGE RANGES are given, they shall be separated by a solidus (/).

NOTE 1

Some examples of RATED VOLTAGE markings are:

- RATED VOLTAGE RANGE: 220-240 V. This means that the equipment is designed to be connected to a mains supply having any nominal voltage between 220 V and 240 V.
 - Multiple RATED VOLTAGE: 120/220/240 V. This means that equipment is designed to be connected to a mains supply having a nominal voltage of 120 V or 220 V or 240 V, usually after internal adjustment.
- symbol for nature of supply, for d.c. only,
 - RATED FREQUENCY or RATED FREQUENCY RANGE, in hertz, unless the equipment is designed for d.c. only,
 - RATED CURRENT, in milliamperes or amperes.

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.

Equipment with a RATED VOLTAGE RANGE shall be marked with either the maximum RATED CURRENT, or with the current range.

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 can be supplied simultaneously through the unit and that can be operated simultaneously.

NOTE 2

Some examples of RATED CURRENT markings are:

- for equipment with multiple RATED VOLTAGES:
120/240 V; 2,4/1,2 A
- for equipment with a RATED VOLTAGE RANGE:
 - 100-240 V; 2,8 A
 - 100-240 V; 2,8-1,1 A
 - 100-120 V; 2,8 A
 - 200-240 V; 1,4 A
- manufacturer's name, trade mark or identification mark,
- manufacturer's model or type reference,
- symbol for CLASS II construction, for CLASS II EQUIPMENT only.

Additional markings are permitted, provided that they do not give rise to misunderstanding.

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

EN 60950 - European differences

United Kingdom

Marking shall refer to 240 V or 415 V, these being the voltages of the public supply system.

1.7.2 Safety instructions

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.

NOTE 1

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

NOTE 2

Where appropriate, installation instructions should include reference to national wiring rules.

NOTE 3

Maintenance information is normally made available only to SERVICE PERSONNEL.

NOTE 4

In Norway and Sweden, pluggable CLASS I EQUIPMENT intended for connection to a telephone network or a similar communications system may require a marking stating that the equipment must be connected to an earthed mains socket-outlet.

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:

- for PERMANENTLY CONNECTED EQUIPMENT, that a readily accessible disconnect device shall be incorporated in the fixed wiring;
- for PLUGGABLE EQUIPMENT, that 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.

NOTE 5

The present recommended long term exposure limit for ozone is 0,1 ppm (0,2 mg/m³) calculated as an 8 h time-weighted average concentration. It should be noted that ozone is heavier than air.

EN 60950 - European differences

Delete note 4.

Norway

If separation between the mains and a communication system/network other than the public telecommunications networks, relies upon the connection to safety earth, the equipment shall have a marking stating that it must be connected to an earthed mains socket-outlet.

NOTE

For requirements for equipment to be connected to a public TELECOMMUNICATION NETWORK see 6.2.1.4

Sweden

If the separation between the mains and a SELV terminal relies upon connection to the safety earth, the apparatus shall have a marking stating that it must be connected to an earthed mains socket-outlet when a SELV CIRCUIT is connected to a network passing both unearthed and earthed electrical environment.

The marking text shall be in Swedish and as follows:

"Apparaten skall anslutas till jordat uttag när den ansluts till ett nätverk."

Denmark (Heavy Current Regulations)

Supply cords of Class I appliances, which are delivered without a plug, must be provided with a visible tag with the following text:

‘Vigtigt!
Lederen med grøn/gul isolation
må kun tilsluttes en klemme mærket



If essential for the safety of the appliance, the tag must in addition be provided with a diagram, which shows the connection of the other conductors, or be provided with the following text:

‘For tilslutning af de øvrige ledere, se medfølgende installationsvejledning.’

United Kingdom (Statutory Instrument 931:1977)

Power supply cords of CLASS I EQUIPMENT must be provided with a label with the following text in legible characters:

"IMPORTANT

The cores in this mains lead are coloured in accordance with the following code:

green and yellow:	earth
blue:	neutral
brown:	live"

1.7.3 Short duty cycles

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 Mains voltage adjustment

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 Power outlets on the equipment

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 load that is permitted to be connected to the outlet.

Socket-outlets conforming to IEC 83 are examples of standard power supply outlets.

EN 60950 - European differences

Denmark

Socket-outlets for providing power to other appliances shall be in accordance with the Heavy Current Regulations, Section 107-2-DI, Standard Sheet DK 1-3a, DK 1-5a or DK 1-7a, when used on appliances of Class I.

Denmark (Heavy Current Regulations)

Class II appliances shall not be fitted with socket-outlets for providing power to other appliances.


1.7.6 Fuses on the equipment


Marking shall be located on, or adjacent to, each fuseholder (or in another location provided that it is obvious to which fuseholder the marking applies) giving the fuse RATED CURRENT and, where fuses of different RATED VOLTAGE value could be fitted, the fuse RATED VOLTAGE.

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





For fuses not located in OPERATOR ACCESS AREAS, and for soldered-in fuses located in OPERATOR ACCESS AREAS, it is permitted to provide an unambiguous cross-reference (e.g. F1, F2 etc.) to the service documentation which shall contain the relevant instructions.

1.7.7 Wiring terminals

The wiring terminal intended for connection of the protective earthing conductor associated with the supply wiring shall be indicated by the symbol  (IEC 417 No. 5019-a). This symbol shall not be used for other earthing terminals.

It is not a requirement to mark other terminals for protective earthing conductors, but where such terminals are marked, the symbol  (IEC 417 No. 5017-a) shall be used.

The following situations are exempt from the above requirements:

- where the terminals for external supply connection are provided on a component (e.g., terminal block) or sub assembly (e.g., power supply), the symbol  is permitted for the protective earthing terminal instead of .
- on subassemblies or component, the symbol  is permitted in place of the symbol  provided that it does not give rise to confusion.

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

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 Controls and indicators



1.7.8.1 Identification and location


Unless it is obviously unnecessary, indicators, switches and other controls affecting safety shall be identified 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.


1.7.8.2 Colours

Where safety is involved, colours of controls and indicators shall comply with IEC 73. Where colours are used for functional controls or indicators, any colour, including red, is permitted provided that it is clear that safety is not involved.

1.7.8.3 Symbols

Where symbols are used on or near controls, for example switches, push buttons, etc., to indicate "ON" and "OFF" conditions, they shall be the line | for "ON" and  for "OFF" (IEC 417, Nos. 5007 and 5008). For push-push type switches the symbol  shall be used (IEC 417, No. 5010).

It is permitted to use the symbols  and | as OFF and ON markings on any primary power switches, including isolating switches.

A "STAND-BY" condition shall be indicated by the symbol  (IEC 417, No. 5009).

1.7.8.4 Controls marking using figures

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.

1.7.8.5 Location of markings for controls

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.

1.7.9 Isolation of multiple power sources

Where there is more than one connection supplying HAZARDOUS VOLTAGES OR HAZARDOUS ENERGY LEVELS to equipment, a prominent marking close to the access for SERVICE PERSONNEL to the hazardous parts shall indicate which disconnect device isolates the equipment completely and which disconnect devices can be used to isolate each section of the equipment.

1.7.10 IT power systems

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 Protection in building installation

If PLUGGABLE EQUIPMENT TYPE B or PERMANENTLY CONNECTED EQUIPMENT relies on protective devices in the building installation for protection in accordance with 2.7.2, the equipment installation instructions shall so state and shall also specify the requirements for short-circuit protection or over-current protection or, where necessary, for both.

EN 60950 - European differences

Replace "2.7.2" with "2.7".

1.7.12 High leakage current

Equipment in which leakage current exceeding 3,5 mA exists shall carry a warning label as defined in 5.2.5 or clause G.5.

NOTE

Attention is drawn to IEC 364-7-707.

1.7.13 Thermostats and other regulating devices

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. Indication by the symbols + and - is permitted.

1.7.14 Language

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.

NOTE

Documentation intended for use only by SERVICE PERSONNEL is permitted to be in the English language.

EN 60950 - European differences

Germany

(Gesetz über technische Arbeitsmittel (Gerätesicherheitsgesetz) [Law on technical labour equipment (Equipment safety law)], of 24th June 1968 in the version of 18 February 1986. Article 3, 3rd paragraph, 2nd sentence, together with the "Allgemeine Verwaltungsvorschrift zum Gesetz über technische Arbeitsmittel" [General administrative regulation on the law on technical labour equipment]), Article 2, 2nd paragraph, item 2.)

Directions for use with rules to prevent certain hazards for (among others) maintenance of the technical labour equipment, also for imported technical labour equipment shall be written in the German language.

NOTE

Of this requirement, rules for use even only by service personnel are not exempted

1.7.15 Durability testing

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.

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

The petroleum spirit to be used for the test is aliphatic solvent hexane having a maximum aromatics content of 0,1 % by volume, a kauri-butanol value of 29, an initial boiling point of approximately 65°C, a dry point of approximately 69°C and a mass per unit volume of approximately 0,7 kg/l.

1.7.16 Removable parts

Marking required by this standard shall not be placed on removable parts which can be replaced in such a way that the marking would become misleading.

1.7.17 Lithium batteries

If an equipment is provided with a replaceable lithium battery, the following applies:

- if the battery is placed in an OPERATOR ACCESS AREA, there shall be a warning close to the battery or in both the operating and the service instructions;
- if the battery is placed elsewhere in an equipment, there shall be a warning close to the battery or in the service instructions.

This warning shall include the following or similar text:

CAUTION

Danger of explosion if battery is incorrectly replaced.

Replace only with the same or equivalent type recommended by the manufacturer.


Dispose of used batteries according to the manufacturer's instructions.

EN 60950 - European differences

Switzerland (Ordinance on environmentally hazardous substances SR 814.013)
Annex 4.10 of SR 814.013 applies for batteries.

1.7.18 Operator access with a tool

If a TOOL is necessary to gain access to an OPERATOR ACCESS AREA, either all other compartments within that area containing a hazard shall be inaccessible to the OPERATOR by the use of the same TOOL, or such compartments shall be marked to discourage OPERATOR access.

An acceptable marking for an electric shock hazard is  (ISO 3864, No. 5036).

EN 60950 - European differences

Sweden (Ordinance SFS 1989:974)

Equipment provided with built-in batteries, not replaceable by the user, shall be marked with the following symbol if the batteries have a content of mercury or cadmium exceeding 0,025 % by weight.



Part II - Protection from electric shock

Foreword

This part contains all the requirements related to protection against electric shock. These requirements shall be applied in conjunction of the requirements of clause 1, and making reference to the definitions of clause 1. Referenced annexes are to be found in volume 2 of this Standard.

2 Fundamental design requirements

2.1 Methods of protection against electrical shock

2.1.1 Access to energised parts

This standard specifies two categories of requirements for protection against electric shock from energised parts. Additional requirements are specified:

- for protection against energy hazards in 2.1.5, and
- for protection against contact with TNV CIRCUITS in 6.2.2.

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

- 1 The OPERATOR is permitted to have access to:
 - bare parts in SELV CIRCUITS;
 - bare parts in LIMITED CURRENT CIRCUITS;
 - insulation of wiring in ELV CIRCUITS under the conditions specified in 2.1.3.
- 2 The OPERATOR shall be prevented from having access to:
 - bare parts of ELV CIRCUITS or of circuits at HAZARDOUS VOLTAGES;
 - OPERATIONAL or BASIC INSULATION of such parts except under the conditions specified in 2.1.3;
 - unearthed conductive parts separated from ELV CIRCUITS or from parts at HAZARDOUS VOLTAGES by OPERATIONAL or BASIC INSULATION only.

2.1.2 Protection in operator access areas

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

- bare parts of ELV CIRCUITS or bare parts at HAZARDOUS VOLTAGES;
- parts of ELV CIRCUITS or parts at HAZARDOUS VOLTAGES protected only by lacquer, enamel, ordinary paper, cotton, oxide film, beads or sealing compounds other than self-hardening resin;
- OPERATIONAL or BASIC INSULATION of parts or wiring in ELV CIRCUITS or at HAZARDOUS VOLTAGES, except as permitted in 2.1.3;
- unearthed conductive parts separated from ELV CIRCUITS or from parts at HAZARDOUS VOLTAGES by OPERATIONAL or BASIC INSULATION only.

NOTE 1
See also 6.2.2.

This requirement applies for all positions of the equipment when it is wired and operated as in normal use. Protection shall be achieved by insulation or by guarding or by the use of interlocks.

Compliance is checked:

- *by inspection;*
- *by a test with the test finger, figure 19, which shall not contact parts described above when applied to apertures in the ENCLOSURES after removal of OPERATOR detachable parts, including fuseholders, and with OPERATOR access doors and covers open. It is permitted to leave lamps in place for this test. OPERATOR-separable connectors, other than plugs and socket-outlets complying with IEC 83, shall also be tested during disconnection;*
- *by a test with the test pin, figure 20, which shall not contact bare conductive parts at HAZARDOUS VOLTAGES when applied to apertures in an external ELECTRICAL ENCLOSURE. OPERATOR-detachable parts, including fuseholders and lamps, are left in place, and OPERATOR access doors and covers are closed during this test.*

The test finger and the test pin are applied as above, without appreciable force, in every possible position, except that floor-standing equipment having a mass exceeding 40 kg is not tilted.

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

Apertures preventing the entry of the test finger, figure 19, are 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 19, is repeated, the finger being pushed through the aperture if necessary.

NOTE 2

If an electrical contact indicator is used to show contact, care should be taken to ensure that the application of the test does not damage components of electronic circuits.

The above requirements regarding contact with parts at HAZARDOUS VOLTAGE apply only to HAZARDOUS VOLTAGES not exceeding 1000 V a.c. or 1500 d.c. For higher voltages, there shall be a CLEARANCE between the parts at HAZARDOUS VOLTAGE and the test finger (figure 19) or the test pin (figure 20), placed in the most unfavourable position. This CLEARANCE shall be as specified in 2.9.2 for BASIC INSULATION, or it shall withstand the relevant electric strength test in 5.3 (see figure F.14, point A).

If components are movable, for instance, for the purpose of belt tensioning, the test with the test finger is 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 Requirements for operator accessible ELV wiring

Where the insulation of internal wiring in an ELV CIRCUIT is accessible to an OPERATOR, this wiring shall:

- not be subject to damage nor to stress;
- not need to be handled by the OPERATOR;
- be routed and fixed so as not to touch unearthed accessible metal parts;
- 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;
- withstand on its insulation an electric strength test with a voltage specified for SUPPLEMENTARY INSULATION (see 5.3). The test voltage shall be related to the voltage which occurs across the insulation in case of failure of BASIC INSULATION.

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

2.1.4 Protection in service access areas

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.

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

NOTE

Precautions against unintentional contact by SERVICE PERSONNEL are not required for any SECONDARY CIRCUITS, including ELV CIRCUITS that operate at less than 42,4 V peak, or 60 V d.c. (see 1.2.14.2).

Bare parts that involve an energy hazard (see 2.1.5) 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.

Any guards required for compliance with this sub-clause shall be easily removable and replaceable if removal is necessary for servicing.

Compliance is checked by inspection.

2.1.7 Shafts of manual controls

Shafts of operating knobs, handles, levers and the like shall not be connected to a HAZARDOUS VOLTAGE nor to an ELV CIRCUIT.

Compliance is checked by inspection.

2.1.8 Isolation of manual controls

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.

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

2.1.9 Conductive casings of capacitors

Conductive casings of capacitors operating in ELV CIRCUITS or CIRCUITS at 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.

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

2.1.10 Discharge of capacitors connected to the mains supply

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.

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

Equipment is considered to comply if any capacitor having a marked or nominal capacitance exceeding 0,1 μ F and connected to the external mains circuit, has a means of discharge resulting in a time-constant not exceeding:

- 1 s for PLUGGABLE EQUIPMENT TYPE A;
- 10 s for PERMANENTLY CONNECTED EQUIPMENT and for PLUGGABLE EQUIPMENT TYPE B.

The relevant time-constant is the product of the effective capacitance in microfarads and the effective discharge resistance in megohms. If it is difficult to determine the effective capacitance and resistance values, a measurement of voltage decay can be used. During an interval equal to one time-constant the voltage will have decayed to 37% of its original value.

2.2 Insulation

2.2.1 Methods for insulation

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 Properties of insulating materials

The choice and application of insulating materials shall take into account the needs for electrical, thermal and mechanical strength, frequency of the WORKING VOLTAGE, and the working environment (temperature, pressure, humidity and pollution).

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

Hygroscopic material shall not be used as insulation.

Compliance is checked by inspection and by evaluation of the data for the material. If such data is not available, the hygroscopic nature of an insulating material is determined by subjecting the component or sub-assembly employing the insulation in question to the humidity treatment of 2.2.3.

The insulation is then subjected to the electric strength test of 5.3.2 or clause C.3, as appropriate, while still in the humidity cabinet, or in the room in which the samples were brought to the prescribed temperature.

2.2.3 Humidity conditioning

Where required by 2.2.2 or 2.9.6, humidity treatment is carried out for 48 h in a cabinet or room containing air with a relative humidity of 91% to 95%. The temperature of the air, at all places where samples can be located, is maintained within 1°C of any convenient value t between 20°C and 30°C such that condensation does not occur. During this treatment the component or sub-assembly is not energised.

Before the humidity treatment the sample is brought to a temperature between t °C and $(t + 4)$ °C.

2.2.4 Requirements for insulation

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 Insulation parameters

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 Categories of insulation

Application of INSULATION shall be considered to be OPERATIONAL, BASIC, SUPPLEMENTARY, REINFORCED or DOUBLE.

Where DOUBLE INSULATION is used, ELV CIRCUITS or unearthed conductive parts are permitted between the two layers provided that the overall level of insulation is maintained.

For DOUBLE INSULATION it is permitted to interchange the basic and supplementary layers.

NOTE

Some examples of situations where these types of insulation are required are as follows:

OPERATIONAL:

- Between parts of different potential.
- Between an ELV CIRCUIT or an SELV CIRCUIT and an earthed conductive part.

BASIC:

- Between a part at HAZARDOUS VOLTAGE and an earthed conductive part.
- Between a part at HAZARDOUS VOLTAGE and an SELV CIRCUIT which relies on being earthed for its integrity.
- Between a primary power conductor and the earthed screen or core of a primary power transformer.
- As an element of DOUBLE INSULATION.

SUPPLEMENTARY:

- Generally, between an accessible conductive part and a part which could assume a HAZARDOUS VOLTAGE in the event of a failure of BASIC INSULATION, for example:
 - between the outer surface of a handle, a knob, a grip and the like, and its shaft unless the shaft is earthed,
 - between the equipment BODY and the surface of a flexible supply cord where the cord enters metal-encased CLASS II EQUIPMENT,
 - between an ELV CIRCUIT and an unearthed conductive part of the BODY.
- as an element of DOUBLE INSULATION.

DOUBLE or REINFORCED:

- Generally, between a PRIMARY CIRCUIT and
 - an unearthed accessible conductive part, or
 - a floating SELV CIRCUIT, or
 - a TNV CIRCUIT.

2.2.7 Determination of working voltage

For the purpose of determining WORKING VOLTAGE (see also 1.4.11):

- if the d.c. value is used, the peak value of any superimposed ripple shall be included;
- non-repetitive transients (due, for example, to atmospheric disturbances) shall be disregarded;
- the voltage of an ELV CIRCUIT or SELV CIRCUIT is regarded as zero for determination of CLEARANCES and electric strength test voltages. However, the voltage of an ELV CIRCUIT or SELV CIRCUIT shall be taken into account for determination of CREEPAGE DISTANCES.
- 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, the highest voltage between any two points in the two windings shall be used, taking into account external voltages to which the windings may be connected;
- 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 General requirements

SELV CIRCUITS 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 Voltages under normal conditions

In a single SELV CIRCUIT or in interconnected SELV CIRCUITS, the voltage between any two parts of the SELV CIRCUIT or CIRCUITS and, for CLASS I EQUIPMENT, between any such part and the equipment protective earthing terminal, shall not exceed 42,4 V peak, or 60 V d.c., under normal operating conditions.

Compliance is checked by inspection and appropriate tests .

2.3.3 Voltages under single fault conditions

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. Moreover, a limit of 71 V peak, or 120 V d.c., shall not be exceeded.

Except as permitted in 2.3.5, one of the four methods defined in 2.3.3.1 to 2.3.3.4 shall be used.

In a single circuit, (e.g. transformer-rectifier circuit) it is permitted for some parts to comply with all of the requirements for SELV CIRCUITS and to be OPERATOR-accessible, while other parts of the same circuit do not comply with all of the requirements for SELV CIRCUITS and are therefore not permitted to be OPERATOR-accessible.

NOTE 1

Different parts of the same SELV CIRCUIT may be protected by different methods, for example:

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

NOTE 2

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

EN 60950 - European differences

Delete method 4 and the line in note 1 relating to this method.

2.3.3.1 Method 1 - Separation by double or reinforced insulation

This method consists of separating the SELV CIRCUIT from parts at HAZARDOUS VOLTAGE by DOUBLE or REINFORCED INSULATION.

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.

It is permitted to implement this method by two separate transformers in tandem, where one transformer provides BASIC INSULATION and the other transformer provides SUPPLEMENTARY INSULATION. The two transformers shall follow, as a pair, the principles of construction for a single SAFETY ISOLATING TRANSFORMER in clause C.2, taking into account the voltage in the intermediate circuit.

Compliance is checked by inspection and appropriate tests .

2.3.3.2 Method 2 - Separation by earthed conductive screen

This method consists of separating the SELV CIRCUIT from other circuits by an earthed conductive screen or other earthed conductive parts (CLASS I EQUIPMENT only).

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.

Compliance is checked by inspection and appropriate tests .

2.3.3.3 Method 3 - Protection by earthing of the SELV CIRCUITS

This method consists of providing an adequate earthing of the SELV CIRCUIT as detailed in 2.3.6 (CLASS I EQUIPMENT only);

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. They shall also be separated from parts of other NON-SELV CIRCUITS by at least BASIC INSULATION. The SELV CIRCUIT shall have adequate fault current-carrying capacity to ensure operation of the protective device, if any, and to ensure that the fault current path to earth will not open.

NOTE

In Denmark, Method 3 is not considered acceptable.

Compliance is checked by inspection and appropriate tests .

EN 60950 - European differences

Delete the note.

Denmark

Finland

France

Method 3 is not acceptable

2.3.3.4 Method 4 - Protection by protective devices

This method consists of the provision of a means of protection which prevents the voltage limits from being exceeded.

Where 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.

NOTE 1

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

NOTE 2

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

Compliance is checked by inspection and appropriate tests .

EN 60950 - European differences

This method is not permitted in European countries.

2.3.4 Additional construction requirements

The equipment shall also be constructed as follows:

- Ring-tongue and similar terminations 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 SELV CIRCUITS and parts at HAZARDOUS VOLTAGE 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, for example by tools or test probes used by SERVICE PERSONNEL.
- SELV CIRCUITS shall not use connectors compatible with those specified in IEC 83 or IEC 320.

Compliance is checked by inspection and appropriate tests .

2.3.5 Connection to other circuits

SELV CIRCUITS are permitted to be supplied from or connected to other circuits provided that all the following conditions are met:

- the SELV CIRCUIT is not be conductively connected to any PRIMARY CIRCUIT (including the neutral) within the equipment;
- the SELV CIRCUIT meets the limits of 2.3.2 under normal operating conditions;
- except as specified in 6.2.1.3, the SELV CIRCUIT meets the limits of 2.3.3 in the event of a single failure of any component or insulation of the SELV CIRCUIT, or of any component or insulation of the SECONDARY CIRCUIT to which it is connected.

If an SELV CIRCUIT is connected to one or more other circuits, the SELV CIRCUIT is that part which complies with the requirements of 2.3.2 and 2.3.3.

Where an SELV CIRCUIT obtains its supply conductively from a SECONDARY CIRCUIT which is separated from the PRIMARY CIRCUIT or other HAZARDOUS VOLTAGE circuit by

- DOUBLE INSULATION or by
- the use of an earthed conductive screen that is separated from the PRIMARY CIRCUIT by BASIC INSULATION,

the SELV CIRCUIT shall be considered as being separated from the PRIMARY CIRCUIT or other HAZARDOUS VOLTAGE by the same method.

Compliance is checked by inspection and appropriate tests .

2.4 Limited current circuits

2.4.1 General requirements

LIMITED CURRENT CIRCUITS shall be so designed that the limits specified in 2.4.2 are not exceeded under normal operating conditions and 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.

Except as permitted in 2.4.3, segregation of parts of LIMITED CURRENT CIRCUITS from other circuits shall be as described in 2.3 for SELV CIRCUITS.

Compliance is checked by inspection and measurement.

2.4.2 Limiting values

For frequencies not exceeding 1 kHz, the steady-state current drawn through a non-inductive resistor of 2 000 Ω connected between any two parts of a LIMITED CURRENT CIRCUIT, or between any such part and the equipment protective earthing terminal, shall not exceed 0,7 mA peak, 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 kilohertz but shall not exceed 70 mA peak.

2.4.3 Connection of limited current circuits to other circuits

LIMITED CURRENT CIRCUITS are permitted to be supplied from or connected to other circuits, provided that the following conditions are met:

- the LIMITED CURRENT CIRCUIT meets the limits of 2.4.2 under normal operating conditions;
- the LIMITED CURRENT CIRCUIT continues to meet the limits of 2.4.2 in the event of a single failure of any components or insulation in the LIMITED CURRENT CIRCUIT, or of any component or insulation in the other circuit to which it is connected.

If a LIMITED CURRENT CIRCUIT is connected to one or more other circuits, the LIMITED CURRENT CIRCUIT is that part which complies with the requirements of 2.4.1.

EN 60950 - European differences

Norway

Marking and insulation requirements according to annex ZB, subclauses 1.7.2 and 6.2.1.4.b) apply.

2.5 Provisions of protective earthing

2.5.1 Class I equipment

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.

In SERVICE ACCESS AREAS, where conductive parts such as motor frames, electronic chassis etc., might assume a HAZARDOUS VOLTAGE in the event of a single insulation fault, either these conductive parts shall be connected to the protective earthing terminal or, if this is impossible or impracticable, a suitable warning label shall indicate to SERVICE PERSONNEL that such parts are not earthed and should be checked for HAZARDOUS VOLTAGES before being touched.

This requirement does not apply to accessible conductive parts that are separated from parts at HAZARDOUS VOLTAGE 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. In this case the parts involved shall be so fixed and so rigid that the minimum distances are maintained during the application of force as required by the relevant tests of 2.9.2 and 4.2.3.

Compliance is checked by inspection and by application of the appropriate requirements of 2.5.11 and 5.3.

2.5.2 Class II equipment

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.

NOTE

In Denmark, a national deviation will apply.

Compliance is checked by inspection.

EN 60950 - European differences

Delete the note.

Denmark

The first sentence is replaced by the following:

Class II equipment shall have no provision for protective earthing, except that permanently connected equipment may be provided with a means for maintaining the continuity of protective earthing circuits to other equipment in a system, if the earth connection is separated from parts at hazardous voltages by double or reinforced insulation.

2.5.3 Continuity of protective earthing conductors

Protective earthing conductors shall not contain switches or fuses.

2.5.4 Interconnection of Class I and Class II equipment

If a system comprises CLASS I EQUIPMENT 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 Insulation of protective earthing conductors

NOTE

See also 3.1.6.

Protective earthing conductors are permitted to be bare or insulated. Insulation, if used, shall be green/yellow except in the following two cases:

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

2.5.6 Disconnection of protective earth

Protective earthing connections shall be such that disconnection of a protective earth at one assembly does not break the protective earthing connection to other assemblies, unless hazardous voltages are removed from the other assemblies at the same time.

2.5.7 Operator-removable parts

If OPERATOR-REMOVABLE parts have a protective earthing connection, this connection shall be closed 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 opened when removing the part.

2.5.8 Parts removed during servicing

Protective earthing 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 protect unless HAZARDOUS VOLTAGE is removed from that part at the same time.

Compliance is checked by inspection.

2.5.9 Protective earthing terminals

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

Compliance is checked by inspection and by manual test.

2.5.10 Corrosion resistance of protective earthing conductors

Conductive parts in contact at protective earthing connections shall not be subject to significant corrosion due to electrochemical action in any working, storage or transport environment conditions as specified in the manufacturer's instructions. Combinations above the line in annex J shall be avoided.

The protective earthing terminal shall be resistant to significant corrosion. Corrosion resistance can be achieved by a suitable plating or coating process.

Compliance is checked by inspection and by reference to the table of electrochemical potentials (annex J).

2.5.11 Resistance of protective earthing conductors

The resistance of the connection between the protective earthing terminal or earthing contact, and parts required to be earthed, shall not exceed 0,1 Ω .

Compliance is checked by the following test:

The test current is 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 does not exceed 12 V and the test current can be either a.c. or d.c. but not more than 25 A.

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

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 is not included in the resistance measurement. However, the cable is protected by a suitably rated protective device which takes into account the impedance of the cable.

If the protection of an SELV CIRCUIT is achieved by earthing in accordance with 2.3.6, the 0,1 Ω 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.

Care is 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 Disconnect devices

2.6.1 General

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

Compliance is checked by inspection.

2.6.2 Methods

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.

Functional switches are permitted to 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.

The following types of disconnect devices are permitted:

- the plug on the power supply cord,
- an appliance coupler,

- isolating switches,
- circuit breakers
- any equivalent device offering a degree of safety equal to the above.

NOTE

Some disconnect devices complying with IEC 1058-1 are examples of those considered to comply with the requirements of this standard.

Compliance is checked by inspection.

2.6.3 Permanently connected equipment

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 an appropriate disconnect device shall be provided as part of the building installation.

NOTE

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

Compliance is checked by inspection.

2.6.4 Parts which remain energised

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

Compliance is checked by inspection.

2.6.5 Switches in flexible cords

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

Compliance is checked by inspection.

2.6.6 Single phase equipment

For single-phase equipment, the disconnect device shall disconnect both poles simultaneously, except that a single-pole disconnect device can be 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 disconnect device in the building installation when the equipment is used where identification of the neutral in the mains supply is not possible.

NOTE

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

- on equipment supplied from an IT POWER SYSTEM;
- on PLUGGABLE EQUIPMENT supplied through a reversible appliance coupler or a reversible plug (unless the appliance coupler or plug itself is used as the disconnect device);
- on equipment supplied from a socket-outlet with indeterminate polarity.

Compliance is checked by inspection.

2.6.7 Three-phase equipment

For three-phase equipment, the disconnect device shall disconnect simultaneously all phase conductors of the supply. For equipment requiring a neutral connection to an IT POWER SYSTEM, the disconnect device shall be a four-pole device and shall disconnect all phase conductors and the neutral conductor; if this four-pole device is not provided in the equipment, the installation instructions shall specify the need for its provision as part of the building installation.

If a disconnect device interrupts the neutral conductor, it shall simultaneously interrupt all phase conductors.

Compliance is checked by inspection.

2.6.8 Switches as disconnect devices

Where the disconnect device is a switch incorporated in the equipment, its on and off positions shall be marked in accordance with 1.7.8.

Compliance is checked by inspection.

2.6.9 Plugs as disconnect devices

Where a plug on the power supply cord is used as the disconnect device, the installation instructions shall comply with 1.7.2.

Compliance is checked by inspection.

2.6.10 Devices for pluggable equipment

For CLASS I EQUIPMENT, the supply plug or appliance coupler, if used as the disconnect device, shall make the protective earthing connection earlier than the supply connections and shall break it later than the supply connections.

Compliance is checked by inspection.

2.6.11 Interconnected equipment

Where a group of units having individual supply connections is interconnected in such a way that it is possible for HAZARDOUS VOLTAGE or HAZARDOUS 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.

Compliance is checked by inspection.

2.6.12 Multiple power sources

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.

If more than one such disconnect device is provided on a unit, all these devices shall be grouped together. It is not necessary that the devices be mechanically linked.

Compliance is checked by inspection.

2.7 Overcurrent and earth fault protection in primary circuits

All the requirements of 2.7 (see part IV) apply.

2.8 Safety interlocks

2.8.1 General principle

SAFETY INTERLOCKS shall be provided where OPERATOR ACCESS involves areas normally presenting hazards in the meaning of this standard.

2.8.2 Protection requirements

SAFETY INTERLOCKS shall be so designed that the hazard will be removed before the cover, door, etc. is in any position that will permit contact of the test finger, figure 19 with hazardous parts.

For protection against electric shock and energy hazards, (see 2.1.5), removal, opening or withdrawal of the cover, door, etc., shall:

- necessitate previous de-energization of such parts, or
- automatically initiate disconnection of the supply to such parts, and reduce within 2 s the voltage to 42,4 V peak, or 60 V d.c., or less, and the energy level to less than 20 J.

For a moving part which will continue to move through momentum and will continue to present a hazard (e.g. a spinning print drum), removal, opening or withdrawal of the cover, door, etc., shall:

- necessitate previous reduction of movement to an acceptably safe level, or
- automatically initiate reduction of the movement to an acceptably safe level.

Compliance is checked by inspection, measurement and use of the test finger, figure 19.

2.8.3 Inadvertent reactivation

SAFETY INTERLOCKS shall be designed so that inadvertent reactivation of the hazard cannot occur when covers, guards, doors, etc. are not in the closed position.

Any accessible interlock which can be operated by means of the test finger, figure 19, is considered to be likely to cause inadvertent reactivation of the hazard.

SAFETY INTERLOCK switches shall be selected taking into account the mechanical shock and vibration experienced in normal operation, so that this does not cause inadvertent switching to an unsafe condition.

Compliance is checked by inspection and where necessary by a test with the test finger, figure 19.

2.8.4 Failsafe operation

A SAFETY INTERLOCK system shall comply with either item a) or item b), as follows:

- a) the probable failure mode(s) of the interlock system will not create a hazard for which protection is required;
- b) an assessment of the interlock means, equipment, circuit diagrams and available data will result in the conclusion that failure is not likely to occur during the normal life of the equipment, and that any possible failure will not allow extreme hazard.

Compliance is checked by inspection and, for interlocks with moving parts, by cycling through 10 000 operations, switching the load imposed in the application of the switch in the equipment, without failure other than in a safe mode.

Reed switches in ELV circuits shall be subjected to 100 000 cycling operations

Assessment of compliance with a) includes not only electro-mechanical components but also, for example, failure of a single semi-conductor device, together with any consequential failure or malfunction.

It is permitted to use simulated interlock systems for tests.

2.8.5 Override

Where it may be necessary for SERVICE PERSONNEL to override a SAFETY INTERLOCK, the override system shall:

- require an intentional effort to operate;
- reset automatically to normal operation when servicing is complete, or shall prevent normal operation unless the SERVICE PERSONNEL have carried out restoration;
- require a TOOL for operation when in OPERATOR ACCESS AREAS and shall not be operable with the test finger;
- not bypass a SAFETY INTERLOCK for an extreme hazard unless another reliable means of safety protection becomes effective when the interlock is thus bypassed. The equipment shall be designed such that the interlock cannot be bypassed until the other means of protection is fully in place and operational.

Compliance is checked by inspection.

2.8.6 Mechanically operated interlock switches

A mechanical interlock switch shall either comply with 2.8.6.1 or pass the tests of 2.8.6.2 and 2.8.6.3

2.8.6.1 Contact gaps

The contact gap shall not be less than that for the primary power disconnect device (see 2.6.2) if located in the PRIMARY CIRCUIT. For other circuits, the contact gap shall not be less than the CLEARANCE values in table 5 of 2.9.

Clearance is checked by inspection and measurement.

2.8.6.2 Reliability

The switch shall successfully perform 50 cycles at the rate of 6-10 cycles per minute, making and breaking 150 percent of the current imposed in the application except that for a switch that switches a motor load, the test is conducted with the rotor of the motor in a locked condition.

Except for reed switches in ELV CIRCUITS, an electric strength test, as specified in 5.3 for REINFORCED INSULATION, is applied between the contacts after the tests of 2.8.4 and 2.8.6.2.

Reed switches in ELV CIRCUITS shall be subjected to 100 000 cycling operations during the test of 2.8.4.

2.8.6.3 Actuating parts

Where the actuating part in a mechanical interlock system is relied upon for safety, precautions shall be taken to ensure that it is not overstressed. If this requirement is not covered by the design of the component, the over-travel beyond the operating position of the actuator shall be limited to 50% of the maximum, for example by its mounting or location, or by adjustment.

Compliance is checked by inspection and measurement.

2.9 Clearances, creepage distances and distances through insulation

2.9.1 General

CLEARANCES shall be dimensioned in accordance with 2.9.2.

CREEPAGE DISTANCES shall be dimensioned in accordance with 2.9.3.

Distances through insulation shall be dimensioned in accordance with 2.9.4.

NOTE 1

CLEARANCE and electric strength requirements are based on the expected overvoltage transients which may enter the equipment from the mains supply. According to IEC 664, the magnitude of these transients is determined by the normal supply voltage and the supply arrangements. The latter are categorised into four groups as Installation Categories I to IV. (Also known as Overvoltage Categories I to IV). This standard assumes Installation Category II at the equipment supply terminals.

NOTE 2

The design of solid insulation and CLEARANCES should be co-ordinated in such a way that if an incident overvoltage transient exceeds the limits of Installation Category II the solid insulation can withstand a higher voltage than the CLEARANCES.

The requirements given in 2.9 are for insulation operating at frequencies up to 30 kHz. It is permitted to use the same requirements for insulation operating at frequencies over 30 kHz until additional data is available.

Interpolation is not permitted for CREEPAGE DISTANCES or CLEARANCES, except where explicitly stated.

For OPERATIONAL INSULATION, CREEPAGE DISTANCES and CLEARANCES smaller than those specified in 2.9 are permitted subject to the requirements of items b) or c) of 5.4.4.

If the CREEPAGE DISTANCE derived from table 6 is less than the applicable CLEARANCE, then the dimension for CLEARANCE shall be used as the minimum CREEPAGE DISTANCE.

The values for Pollution Degree 1 are applicable to components and assemblies which are sealed so as to exclude dust and moisture (see 2.9.6).

The values for Pollution Degree 2 are generally applicable to equipment covered by the scope of this standard.

The values for Pollution Degree 3 are applicable where a local internal environment within the equipment is subject to conductive pollution or to dry non-conductive pollution which could become conductive due to expected condensation.

For all power systems, the mains supply voltage in tables 3, 4 and 5 is the phase-to-neutral voltage.

NOTE 3

In Norway, due to the IT POWER SYSTEM used, the mains supply voltage is considered equal to phase-to-phase voltage.

EN 60950:1992 - European differences

Delete the note.

Norway

Due to the IT POWER SYSTEM used, the mains supply voltage is considered equal to phase-to-phase voltage.

The following conditions are applicable during the assessment for compliance in accordance with 2.9.2 and 2.9.3.

- *Movable parts are placed in the most unfavourable position.*
- *For equipment incorporating ordinary NON-DETACHABLE POWER SUPPLY CORDS, CREEPAGE DISTANCE measurements are made with supply conductors of the largest cross-sectional area specified in 3.3.5, and also without conductors.*
- *When measuring CLEARANCES and CREEPAGE DISTANCES from an enclosure of insulating material through a slot or openings in the enclosure,, the accessible surface shall be considered to be conductive as if it were covered by metal foil wherever it can be touched by the test finger (figure 19), applied without appreciable force. (See figure F.14, point B).*

2.9.2 Clearances

CLEARANCES in PRIMARY CIRCUITS shall be dimensioned in accordance with table 3 and table 4. CLEARANCES in SECONDARY CIRCUITS shall be dimensioned in accordance with table 5. The relevant conditions under the tables shall be taken into account.

NOTE 1

For clearances which are provided for compliance with 6.2.1.2, table 5 applies. A transient rating of 1,5 kV peak should be assumed except where it is known that incoming transients will be suppressed, in which case the appropriate transient rating should be used.

The values in the tables are the minimum values which shall be applied after taking account of manufacturing tolerances and deformation which can occur due to handling, shock and vibration likely to be encountered during manufacture, transport and normal use.

The specified CLEARANCES are not applicable to the air gap between the contacts of THERMOSTATS, thermal cutouts, overload protection devices, switches of microgap construction and similar components where the CLEARANCE varies with the contacts. For air gaps between the contacts of interlock switches the requirements of 2.8.6 are applicable.

For PRIMARY CIRCUITS operating on nominal mains voltages up to 300 V, where the repetitive peak voltage in the circuit exceeds the peak value of the mains supply voltage, the minimum CLEARANCE is the sum of the following two values:

- the minimum CLEARANCE value from table 3 for an insulation WORKING VOLTAGE equal to the mains supply voltage, and the appropriate additional CLEARANCE value from table 4.
- The values in parentheses in table 4 shall be used:
 - when the values in parentheses in table 3 are used in accordance with condition 3 of table 3, and
 - for OPERATIONAL INSULATION.

NOTE 2

The total CLEARANCES obtained by the use of table 4 lie between the values required for homogeneous and inhomogeneous fields. As a result they may not assure conformance with the appropriate electric strength test in case of fields which are substantially inhomogeneous.

Table 3 - Minimum clearances for insulation in primary circuits and between primary and secondary circuits in mm

Insulation working voltage (see 2.2.7) up to an including		Circuits subject to installation Category II														
		Nominal mains supply voltage ≤ 150 V (Transient rating 1 500V)						Nominal mains supply voltage > 150 V ≤ 300 V (Transient rating 2 500 V)						Nominal mains supply voltage > 300 V ≤ 00 V (Transient rating 4 000 V)		
		Pollution degrees 1 and 2		Pollution degree 3			Pollution degrees 1 and 2			Pollution degree 3			Pollution degrees 1, 2 and 3			
V peak or d.c.	V r.m.s. (sinusoidal)	Op	B/S	R	Op	B/S	R	Op	B/S	R	Op	B/S	R	Op	B/S	R
71	50	0,4	1,0 (0,7)	2,0 (1,4)	1,0	1,3 (1,0)	2,6 (2,0)	1,0	2,0 (1,7)	4,0 (3,4)	1,3	2,0 (1,7)	4,0 (3,4)	2,0	3,2 (3,0)	6,4 (6,0)
210	150	0,7	1,0 (0,7)	2,0 (1,4)	1,0	1,3 (1,0)	2,6 (2,0)	1,4	2,0 (1,7)	4,0 (3,4)	1,7	2,0 (1,7)	4,0 (3,4)	2,0	3,2 (3,0)	6,4 (6,0)
420	300	Op 1,7 B/S 2,0(1,7) R 4,0(3,4)												2,5	3,2 (3,0)	6,4 (6,0)
840	600	Op 3,0 B/S/3,2(3,0) R 6,4(6,0)														
1 400	1 000	Op/B/S/ 4,2 R 6,4														
2 800	2 000	Op/B/S/R 8,4														
7 000	5 000	Op/B/S/R 17,5														
9 800	7 000	Op/B/S/R 25														
14 000	10 000	Op/B/S/R 37														
28 000	20 000	Op/B/S/R 80														
42 000	30 000	Op/B/S/R 130														

Conditions applicable to Table 3

- 1 This table is applicable to equipment that will not be subject to transients exceeding Installation Category II according to IEC 664. The appropriate transient voltage ratings are given in parentheses at the top of each nominal mains supply voltage column. Where higher transients are possible, additional protection might be necessary in the mains supply to the equipment or to the installation.
- 2 The values in the table are applicable to OPERATIONAL (Op), BASIC (B), SUPPLEMENTARY (S) and REINFORCED (R) INSULATION.
- 3 The values in parentheses are applicable to BASIC, SUPPLEMENTARY or REINFORCED INSULATION only if manufacturing is subject to a quality control programme, an example of which is given in annex R. In particular, DOUBLE and REINFORCED INSULATION shall be subject to 100% electric strength testing.
- 4 For BASIC, SUPPLEMENTARY and REINFORCED INSULATION, all parts of the PRIMARY CIRCUIT are assumed to be at not less than the normal supply voltage with respect to earth.
- 5 For WORKING VOLTAGES between 2 800 V and 42 000 V peak or d.c., linear interpolation is permitted between the nearest two points, the calculated spacing being rounded up to the next higher 0,1 mm increment.
- 6 For an air gap serving as REINFORCED INSULATION between a part at a HAZARDOUS VOLTAGE and an accessible conductive part of the ENCLOSURE of floor standing equipment or of the non-vertical top surface of desk top equipment the CLEARANCE shall be not less than 10 mm.

Table 4 - Additional clearances for insulation in primary circuits with repetitive peak voltages exceeding the peak value of the mains supply voltage

Nominal mains supply voltage ≤ 150 v		Nominal mains supply voltage > 150 V ≤ 300 V		Additional clearance mm	
Pollution degrees 1 and 2	Pollution degree 3	Pollution degrees 1, 2 and 3	Operational, basic or supplementary insulation	Reinforced insulation	
Maximum repetitive peak voltage V	Maximum repetitive peak voltage V	Maximum repetitive peak voltage V			
210 (210)	210 (210)	420 (420)	0	0	
298 (290)	294 (300)	493 (497)	0,1	0,2	
388 (370)	379 (390)	567 (574)	0,2	0,4	
474 (450)	463 (480)	640 (651)	0,3	0,6	
562 (530)	547 (570)	713 (728)	0,4	0,8	
650 (610)	632 (660)	787 (805)	0,5	1,0	
738 (690)	716 (750)	860 (881)	0,6	1,2	
826 (770)	800 (840)	933 (958)	0,7	1,4	
914 (850)	- -	1006 (1035)	0,8	1,6	
1002 (930)	- -	1080 (1112)	0,9	1,8	
1090 (1010)	- -	1153 (1189)	1,0	2,0	
- -	- -	1226 (1266)	1,1	2,2	
- -	- -	1300 (1343)	1,2	2,4	
- -	- -	- (1420)	1,3	2,6	

Table 5 - Minimum clearances in secondary circuits (mm)

Insulation working voltage up to and including		Circuits subject to installation Category I (see condition 5)																	
		Nominal mains supply voltage ≥ 150 V (Transient rating of secondary circuit 800 V)						Nominal mains supply voltage > 150 V ≤ 300 V (Transient rating of secondary circuit 1500 V)						Nominal mains supply voltage > 300 V ≤ 600 V (Transient rating of secondary circuit 2 500 V)			Circuits not subjected to transient overvoltage (see condition 4)		
V peak or d.c.	V r.m.s. (sinusoidal)	Pollution degrees 1 and 2			Pollution degree 3			Pollution degrees 1 and 2			Pollution degree 3			Pollution degrees 1, 2 and 3			Pollution degrees 1 and 2 only		
		Op	B/S	R	Op	B/S	R	Op	B/S	R	Op	B/S	R	Op	B/S	R	Op	B/S	R
71	50	0,4	0,7 (0,4)	1,4 (0,8)	1,0	1,3 (1,0)	2,6 (2,0)	0,7	1,0 (0,7)	2,0 (1,4)	1,0	1,3 (1,0)	2,6 (2,0)	1,7	2,0 (1,7)	4,0 (3,4)	0,4	0,4	0,8
140	100	0,6	0,7 (0,6)	1,4 (1,2)	1,0	1,3 (1,0)	2,6 (2,0)	0,7	1,0 (0,7)	2,0 (1,4)	1,0	1,3 (1,0)	2,6 (2,0)	1,7	2,0 (1,7)	4,0 (3,4)	0,6	0,7 (0,6)	1,4 (1,2)
210	150	0,6	0,9 (0,6)	1,8 (1,2)	1,0	1,3 (1,0)	2,6 (2,0)	0,7	1,0 (0,7)	2,0 (1,4)	1,0	1,3 (1,0)	2,6 (2,0)	1,7	2,0 (1,7)	4,0 (3,4)	0,6	0,7 (0,6)	1,4 (1,2)
280	200	Op 1,1 B/S 1,4(1,1) R 2,8(2,2)												1,7	2,0 (1,7)	4,0 (3,4)	1,1	1,1	2,2
420	300	Op 1,6 B/S 1,9(1,6) R 3,8(3,2)												1,7	2,0 (1,7)	4,0 (3,4)	1,4	1,4	2,8
700	500													Op/B/S 2,5 R 5,0					
840	600													Op/B/S 3,2 R 5,0					
1 400	1 000													Op/B/S 4,2 R 5,0					
2 800	2 000													Op/B/S/R 8,4					
7 000	5 000													Op/B/S/R 17,5					
9 800	7 000													Op/B/S/R 25					
14 000	10 000													Op/B/S/R 37					
28 000	20 000													Op/B/S/R 80					
42 000	30 000													Op/B/S/R 130					

Conditions applicable to Table 5

- The values in the table are applicable to OPERATIONAL (Op), BASIC (B), SUPPLEMENTARY (S) and REINFORCED (R) INSULATION.
- The values in parentheses are applicable to BASIC, SUPPLEMENTARY or REINFORCED INSULATION only if manufacturing is subject to a quality control programme, an example of which is given in annex R. In particular, DOUBLE and REINFORCED INSULATION shall be subject to 100% electric strength testing.
- For WORKING VOLTAGES between 2 800 V peak or d.c. and 42 000 V peak or d.c., linear interpolation is permitted between the nearest two points, the calculated spacing being rounded up to the next higher 0,1 mm increment.
- The values are applicable to d.c. SECONDARY CIRCUITS which are reliably connected to earth and have capacitive filtering which limits the peak-to-peak ripple to 10% of the d.c. VOLTAGE.
- SECONDARY CIRCUITS will normally be Installation Category I if the PRIMARY is Installation Category II. However, a floating SECONDARY CIRCUIT shall be subject to the requirements for PRIMARY CIRCUITS in Table 3 unless separated from PRIMARY CIRCUITS by an earthed metal screen.
- External signal cables should be prevented from introducing into SECONDARY CIRCUITS transients that exceed the applicable transient overvoltage limit, where they might result in a hazard.
- For an air gap serving as REINFORCED INSULATION between a part at a HAZARDOUS VOLTAGE and an accessible conductive part of the ENCLOSURE of floor standing equipment or of the non-vertical top surface of desk top equipment the CLEARANCE shall be not less than 10 mm.

Compliance is checked by measurement, taking into account the figures in annex F, subject to conditions detailed in 2.9.1.

If necessary, a force is applied to any point on internal parts and to the outside of conductive ENCLOSURES, in an endeavour to reduce the CLEARANCE while taking measurements. The force shall have a value of:

- 10 N for internal parts;
- 30 N for ENCLOSURES.

The force is applied to ENCLOSURES by means of a rigid test finger having outline dimensions as in figure 19.

Circuits shall not be subjected to internally generated transient overvoltages exceeding the appropriate value for the mains supply voltage and installation category.

If the transient overvoltages exceed the test voltages in 5.3.2, the determination of transient limits shall be made using IEC 664.

NOTE
The above paragraph is under consideration.

2.9.3 Creepage distances

CREEPAGE DISTANCES shall be not less than the appropriate minimum values specified in table 6 taking into account the relevant conditions specified under the table.

Compliance is checked by measurement, taking account of the figures in annex F and subject to the conditions in 2.9.1.

Table 6 - Minimum creepage distances (mm)

Working voltage up to and including V r.m.s. or d.c	OPERATIONAL, BASIC and SUPPLEMENTARY INSULATION						
	Pollution degree 1		Pollution degree 2			Pollution degree 3	
	Material group		Material group			Material group	
	I, II, IIIa + IIIb		I	II	IIIa + IIIb	I	II
50	Use the appropriate CLEARANCE from table 3 or table 5	0,6	0,9	1,2	1,5	1,7	1,9
100		0,7	1,0	1,4	1,8	2,0	2,2
125		0,8	1,1	1,5	1,9	2,1	2,4
150		0,8	1,1	1,6	2,0	2,2	2,5
200		1,0	1,4	2,0	2,5	2,8	3,2
250		1,3	1,8	2,5	3,2	3,6	4,0
300		1,6	2,2	3,2	4,0	4,5	5,0
400		2,0	2,8	4,0	5,0	5,6	6,3
600		3,2	4,5	6,3	8,0	9,6	10,0
1000		5,0	7,1	10,0	12,5	14,0	16,0

Conditions applicable to table 6

- 1 For REINFORCED INSULATION, the values for CREEPAGE DISTANCES are twice the values in the table for BASIC INSULATION.
- 2 If the CREEPAGE DISTANCE derived from table 6 is less than the applicable CLEARANCE from tables 3 and 4 or from table 5, as appropriate, then the value for that CLEARANCE shall be applied as the value for the minimum CREEPAGE DISTANCE.
- 3 Material group I 600 ≤ CTI (comparative tracking index)
 Material group II 400 ≤ CTI < 600
 Material group IIIa 175 ≤ CTI < 400

Material group IIIb 100 \leq CTI < 175

The CTI rating refers to the value obtained in accordance with method A of IEC 112.

- 4 Where the material group is not known, material group IIIb shall be assumed.
- 5 For WORKING VOLTAGES of 127 V, 208 V and 415 V, it is permitted to use CREEPAGE DISTANCES corresponding to 125 V, 200 V and 400 V.
- 6 It is permitted to use minimum CREEPAGE DISTANCES equal to the applicable CLEARANCES for glass, mica, ceramic or similar materials.
- 7 Linear interpolation is permitted between the nearest two points, the calculated spacing being rounded to the next higher 0,1 mm increment.

2.9.4 **Solid insulation**

NOTE

See also 3.1.5.

2.9.4.1 **Minimum distances through insulation**

Unless otherwise specified (see 2.1.3, 2.9.5 and 3.1.5), distance through insulation shall be dimensioned according to WORKING VOLTAGE and to application of the insulation (see 2.2.7 and 2.2.6) and as follows:

- for WORKING VOLTAGES not exceeding 50 V (71 V peak or d.c.), there is no thickness requirement;
- SUPPLEMENTARY INSULATION shall have a minimum thickness of 0,4 mm;
- REINFORCED INSULATION shall have a minimum thickness of 0,4 mm when not subject to any mechanical stress which, at nominal operating temperature, would be likely to lead to deformation or deterioration of the insulating material.

NOTE

Under mechanical stress conditions, the thickness may have to be increased to comply with the requirements of clauses 4 and 5.

Compliance is checked by measurement.

2.9.4.2 **Thin sheet materials**

The above requirements are not applicable to insulation in thin sheet material irrespective of its thickness, provided that it is used within the equipment protective ENCLOSURE and is not subject to handling or abrasion during OPERATOR servicing, and one of the following applies:

- SUPPLEMENTARY INSULATION comprises at least two layers of material, each of which will pass the electric strength test for SUPPLEMENTARY INSULATION; or
- SUPPLEMENTARY INSULATION comprises three layers of material for which all combinations of two layers together pass the electric strength test for SUPPLEMENTARY INSULATION; or
- REINFORCED INSULATION comprises at least two layers of material, each of which will pass the electric strength test for REINFORCED INSULATION; or
- REINFORCED INSULATION comprises three layers of insulation material for which all combinations of two layers together pass the electric strength test for REINFORCED INSULATION.

The enamel or other insulating coating on winding wire such as is normally used in transformer construction is not considered to be insulation in thin sheet material.

There is no requirement for all layers of insulation to be of the same insulating material.

Compliance is checked by inspection and measurement.

2.9.4.3 **Printed circuit boards**

SUPPLEMENTARY or REINFORCED INSULATION between conductor layers in single-layer and multi-layer printed boards shall meet one of the following requirements. Either:

- the insulation shall have a minimum thickness of 0,4 mm, or

- the insulation shall comprise two or more layers of prepreg or other thin sheet insulating material. There is no thickness requirement for the layers or for the overall insulation. The overall insulation in the finished printed board shall pass the appropriate electric strength test of 5.3.2.

Printed boards having SUPPLEMENTARY or REINFORCED INSULATION comprising fewer than three layers of prepreg or other thin sheet insulating material shall be subjected to 100% electric strength testing during manufacture.

Printed boards employing thin sheet insulating material other than prepreg shall pass the thermal ageing and thermal cycling tests of 2.9.5.

NOTE 1

Prepreg is the term used for a layer of glass cloth impregnated with a partially cured resin.

NOTE 2

An example of a thin sheet insulating material in this application is polyamide.

Compliance is checked by measurement and, where specified, by electric strength tests.

2.9.5 Coated printed boards

For printed boards whose conductors are coated with a suitable coating material, the minimum separation distances of table 7 are applicable to conductors before they are coated, subject to the following requirements.

Either one or both conductive parts and at least 80% of the distances over the surface between the conductive parts shall be coated. Between any two uncoated conductive parts and over the outside of the coating, the minimum distances in tables 3, 4 or 5 apply.

The values in table 7 shall be used only if manufacturing is subject to a quality control programme, an example of which is given in annex R. In particular, DOUBLE and REINFORCED INSULATION shall be subject to 100% electric strength testing.

In default of the above conditions, the requirements of 2.9.2 and 2.9.3 shall apply.

Table 7 - Minimum separation distances for coated printed boards (mm)

Maximum working voltage V r.m.s or d.c	Operational, basic or supplementary insulation	Reinforced insulation
63	0,1	0,2
125	0,2	0,4
160	0,3	0,6
200	0,4	0,8
250	0,6	1,2
320	0,8	1,6
400	1,0	2,0
500	1,3	2,6
630	1,8	3,6
800	2,4	3,8
1 000	2,8	4,0
1 250	3,4	4,2
1 600	4,1	4,6
2 000	5,0	5,0
2 500	6,3	6,3
3 200	8,2	8,2
4 000	10,0	10,0
5 000	13,0	13,0
6 300	16,0	16,0
8 000	20,0	20,0
10 000	26,0	26,0
12 500	33,0	33,0
16 000	43,0	43,0
20 000	55,0	55,0
25 000	70,0	70,0
30 000	86,0	86,0

Condition applicable to table 7

For voltages between 2 000 V and 30 000 V it is permitted to use linear interpolation between the nearest two points, the calculated spacing being rounded up to the next higher 0,1 mm increment.

The coating process, the coating material and the base material shall be such that uniform quality is assured and the separation distances under consideration are effectively protected.

The coating material shall also be tested to the requirements of IEC 112 for material group III a or III b, as defined in table 6, condition 3 of this standard.

Compliance is checked by measurement taking into account figures F.12 and F.13 and by the following series of tests.

– **Preliminary tests**

Three sample boards (or, for 2.9.8, two components and one board) identified as samples 1, 2 and 3 are required. The use of either actual boards, or specially produced samples with representative minimum separations, is permitted. Each sample board is to be representative of the minimum separations used, and coated. Each sample board is subjected to the full sequence of manufacturing processes, including soldering and cleaning, to which it is normally subjected during equipment assembly.

When visually inspected, they shall show no evidence of pinholes or bubbles in the coating or breakthrough of conductive tracks at corners.

– **Thermal cycling test**

Sample 1 is subjected ten times to the following sequence of temperature cycles:

68 h at $100^{\circ}\text{C} \pm 2^{\circ}\text{C}$

1 h at $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$

2 h at $0^{\circ}\text{C} \pm 2^{\circ}\text{C}$

1 h at $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$

– **Thermal ageing test**

Sample 2 is subjected to a temperature of $130^{\circ}\text{C} \pm 2^{\circ}\text{C}$ for 1 000 h.

– **Electric strength test**

Samples 1 and 2 are then subjected to the humidity treatment of 2.2.3 (48 h treatment) and shall withstand the relevant electric strength test of 5.3.2 between conductors.

– **Abrasion resistance test**

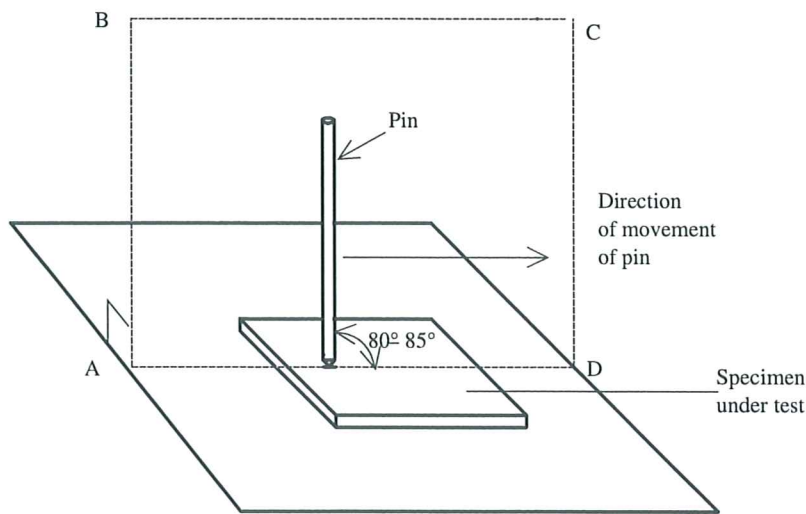
Sample board 3 is subjected to the following test.

Scratches are made across five pairs of conducting parts and the intervening separations at points where the separations will be subject to the maximum potential gradient during the tests.

The scratches are made by means of a hardened steel pin, the end of which has the form of a cone having a top angle of 40° its tip being rounded and polished with a radius of $0,25 \text{ mm} \pm 0,02 \text{ mm}$.

Scratches are made by drawing the pin along the surface in a plane perpendicular to the conductor edges at a speed of $20 \text{ mm/s} \pm 5 \text{ mm/s}$ as shown in figure 6. The pin is so loaded that the force exerted along its axis is $10 \text{ N} \pm 0,5 \text{ N}$. The scratches shall be at least 5 mm apart and at least 5 mm from the edge of the specimen.

After this test, the coating layer shall neither have loosened nor have been pierced, and it shall withstand an electric strength test as specified in 5.3.2 between conductors.



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NOTE

The pin is in the plane A B C D which is perpendicular to the specimen under test.

Figure 6 - Abrasion resistance test for coating layers

2.9.6 Enclosed and sealed parts

For components or sub-assemblies which are enclosed or hermetically sealed against ingress of dirt and moisture, and which satisfy the following compliance requirements, the minimum internal CREEPAGE DISTANCES and CLEARANCES can be the values for Pollution Degree 1. Internal connections shall be fixed or insulated to inhibit degradation of insulation by mechanical shock or vibration.

Compliance is checked by inspection, measurement and by subjecting the component or sub-assembly to the following tests:

Thermal cycling test

The sample is subjected ten times to the following sequence of temperature cycles:

- 68 h at $ST^{\circ}C \pm 2^{\circ}C$*
- 1 h at $25^{\circ}C \pm 2^{\circ}C$*
- 2 h at $0^{\circ}C \pm 2^{\circ}C$*
- 1 h at $25^{\circ}C \pm 2^{\circ}C$*

Where ST is

- for all components or subassemblies, except transformers: the highest temperature measured under normal conditions on the component or sub-assembly under consideration with a minimum of 85°C.*
- for transformers: the highest winding temperature measured under normal conditions, plus 10 K, with a minimum of 85°C.*

For transformers, magnetic couplers and similar devices, where the insulation is relied upon for safety, a voltage of 500 V r.m.s. at 50 Hz to 60 Hz is applied between windings during the thermal cycling test. No evidence of insulation breakdown shall occur during this test.

The component or sub-assembly is then subjected to the following humidity treatment:

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

Before the humidity treatment the sample is brought to a temperature between $t^{\circ}C$ and $(t + 4)^{\circ}C$.

After the humidity treatment the sample is subjected to the electric strength test of 5.3.2.

2.9.7 Encapsulated parts

The distances between conducting parts internal to components or assemblies which are treated with an insulating compound filling all internal CLEARANCES, excluding air and preventing the ingress of dirt and moisture, shall be subject only to the requirements of 2.9.4.

Such treatment might include potting, encapsulation or impregnation.

Distances between conductive parts along uncemented joints shall be considered as CLEARANCES and CREEPAGE DISTANCES for which the values in tables 3, 4, 5 and 6 for Pollution Degree 1 shall apply.

Compliance is checked by inspection, measurement and by subjecting the component or sub-assembly to the test of 2.9.4

Additionally, a visual inspection shall show that there are no cracks in the encapsulating, impregnating or other material and that coatings have not loosened or shrunk, and (after sectioning the sample) that there are no significant voids in the material.

2.9.8 Component external terminations

The requirements of 2.9.2 and 2.9.3 are applicable to the spacings between external terminations of components conforming to 2.9.7 except when they have a coating of material satisfying the requirements of 2.9.5 including the quality control requirements, an example of which is given in annex R. In such a case the insulation distance of table 7 shall be applicable to the component before coating. Between any two uncoated conductive parts and over the outside of the coating, the minimum distances of tables 3, 4, 5 and 6 shall be applied.

Where coatings are employed over terminations to increase effective CREEPAGE DISTANCES and CLEARANCES, the mechanical arrangement and rigidity of the terminations shall be adequate to ensure that, during normal handling and assembly into equipment and subsequent use, the terminations will not be subject to deformation which would crack the coating or reduce the spacing between conducting parts below the values in table 7.

Compliance is checked by inspection taking into account figures F.12 and F.13 and by applying the first sequence covered by the preliminary tests, thermal cycling test, thermal ageing test and electric strength test of 2.9.5. These tests are carried out on a completed assembly including the component(s).

The abrasion resistance test is carried out using a specially prepared sample printed board as described for sample 3 in 2.9.5 except that the separation between the conductive parts shall be representative of the minimum separations and maximum potential gradients used in the assembly.

2.10 Interconnection of equipment

2.10.1 General requirements

Where equipment is intended to be electrically connected to other equipment, interconnection circuits shall be selected to provide continued conformance with the requirements of 2.3 for SELV CIRCUITS, and with the requirements of clause 6 for TNV CIRCUITS, after making connections between equipments.

NOTE 1

This is normally achieved by connecting SELV CIRCUITS to SELV CIRCUITS, and TNV CIRCUITS to TNV CIRCUITS.

NOTE 2

It is permitted for an interconnecting cable to carry more than one type of CIRCUIT (SELV, LIMITED CURRENT, TNV, ELV, HAZARDOUS VOLTAGE) provided that they are separated as required by this standard.

2.10.2 Types of interconnection circuits

Except as permitted in 2.10.3, interconnection circuits shall not be ELV CIRCUITS. Each interconnection circuit shall be one of the following types:

- an SELV CIRCUIT or a LIMITED CURRENT CIRCUIT;
- a TNV CIRCUIT;
- a HAZARDOUS VOLTAGE circuit.

2.10.3 ELV interconnection circuits

Where additional equipment is specifically complementary to the host (first) equipment, e.g. a collator for a copying machine, ELV interconnection circuits are permitted between the equipments, provided that the equipments continue to meet the requirements of this standard when connected together.

3 Wiring connection and supply

3.1 General

3.1.2 Wire protection against mechanical damage

Wireways shall be smooth and free from sharp edges. Wires shall be protected so that they do not come into contact with burrs, cooling fins, moving parts etc., which may cause damage to the insulation of conductors. Holes in metal, through which insulated wires pass, shall have smooth well-rounded surfaces or shall be provided with bushings.

In electronic assemblies, it is permitted for wires to be in close contact with wire wrapping posts and the like if any breakdown of insulation will not result in a hazard, or if adequate mechanical protection is provided by the insulation system employed.

Compliance is checked by inspection.

3.1.3 Securing of internal wiring

Internal wiring shall be routed, supported, clamped or secured in a manner that prevents:

- excessive strain on wire and on terminal connections,
- loosening of terminal connections,
- damage of conductor insulation.

Compliance is checked by inspection.

3.1.4 Uninsulated conductors

For uninsulated conductors it shall not be possible to reduce, in normal use, CREEPAGE DISTANCES and CLEARANCES below the relevant values specified in 2.9.

Compliance is checked by inspection.

3.1.5 Insulation of conductors

Insulation of individual conductors shall be suitable for the application and WORKING VOLTAGE involved.

The insulation under consideration shall be capable of withstanding the appropriate electric strength test specified in 5.3.2.

NOTE

If the suitability of conductor insulation is assessed by reference to a relevant component standard, that standard may contain requirements for distance through insulation.

Where a power supply cord, whose insulating properties comply with those of the cord types of 3.2.4, is used inside the equipment, either as an extension of the external power supply cord or as an independent cable, its sheath is considered to be adequate SUPPLEMENTARY INSULATION for the purposes of this sub-clause.

If applicable test results are not already available, compliance is checked by applying the electric strength test using a sample of approximately 1 m length and by applying the relevant test voltage as follows:

- *for insulation of a conductor: by the voltage test method given in clause 3 of IEC 885-1 : 1987, using the relevant test voltage in 5.3.2 for the grade of insulation under consideration;*
- *for SUPPLEMENTARY INSULATION, for example sleeving around a group of conductors: between a conductor inserted into the sleeve and metal foil wrapped tightly round the sleeve for a length of at least 100 mm.*

3.1.6 Green/yellow insulation

The colour combination green/yellow shall be used only to identify protective earth connections (see 2.5.5).

Compliance is checked by inspection.

3.1.7 Beads and ceramic insulators

Beads and similar ceramic insulators on conductors shall be so fixed or supported that they cannot change their position. Moreover, they shall not rest on sharp edges or sharp corners. If beads are inside flexible metal conduits, they shall be contained within an insulating sleeve, unless the conduit is prevented from movement in normal use.

Compliance is checked by inspection and by manual test.

3.1.8 Screwed electrical contacts

Where electrical contact pressure is required, a screw shall engage at least two complete threads into a metal plate or a metal nut or a metal insert. Screws of insulating material shall not be used where electrical connections including protective earthing are involved, nor where their replacement by metal screws could impair SUPPLEMENTARY or REINFORCED INSULATION. Where screws of insulating material contribute to other safety aspects, they shall be engaged by at least two complete threads.

Compliance is checked by inspection.

3.1.9 Screws in insulating material

Electrical connections shall be so designed that contact pressure is not transmitted through insulating material unless there is sufficient resilience in the metallic parts to compensate for any possible shrinkage or distortion of the insulating material.

Compliance is checked by inspection.

3.1.10 Stranded conductors

The end of a stranded conductor shall not be consolidated by soft soldering at places where the conductor is subject to contact pressure unless the method of clamping is designed so as to obviate the risk of a bad contact due to cold flow of the solder.

Spring terminals that compensate for the cold flow are deemed to satisfy this requirement.

Preventing the clamping screws from rotating is not considered to be adequate.

Compliance is checked by inspection.

3.1.11 Thread cutting screws

Spaced thread (sheet metal) screws shall not be used for the connection of current-carrying parts, unless they clamp these parts directly in contact with each other and are provided with a suitable means of locking.

Thread-cutting (self-tapping) screws shall not be used for the electrical connection of current-carrying parts, unless they generate a full form standard machine screw thread. Moreover, such screws shall not be used if they are operated by the user or installer unless the thread is formed by a swageing action.

Thread-cutting and spaced thread screws are permitted to provide earthing continuity but in such cases it shall not be necessary to disturb the connection in normal use and at least two screws shall be used for each connection.

Compliance is checked by inspection.

3.2 Connection to primary power

3.2.1 Means of connection

For safe and reliable connection to a primary power supply, equipment shall be provided with one of the following:

- terminals for permanent connection to the supply;
- a NON-DETACHABLE POWER SUPPLY CORD for permanent connection to the supply, or for connection to the supply by means of a plug;
- an appliance inlet for connection of a DETACHABLE POWER SUPPLY CORD;
- a mains plug that is integral with the equipment or part of the equipment, for example, a transformer or power supply unit enclosed in the plug BODY.

Where equipment is provided with more than one supply connection (e.g. with different voltages or frequencies or as redundant power), the design shall be such that all of the following conditions are met:

- separate means of connection are provided for different circuits;
- supply plug connections, if any, are not interchangeable if a hazard could result from incorrect plugging;
- the OPERATOR is prevented from touching bare parts of an ELV CIRCUIT or parts at HAZARDOUS VOLTAGES, such as plug contacts, when one or more connectors are disconnected.

Compliance is checked by inspection.

EN 60950 - European differences

Denmark

Supply cords of single-phase appliances having a rated current not exceeding 10 A shall be provided with a plug according to the following table:

Class		Plug
		Section 107-2-D1 Standard Sheet
I	Protection against indirect contact required *) .	DK 2-1a or DK 2-5a
	Earthing connection not required	DK 2-1a, DK 2-5a DKA 2-1a, DKA 2-1b, C 1b, C 2b, C 3b, C 4
II		DK 2-5a**), DKA 2-1a, DKA 2-1b, C 1b, C5, C6
*) Appliances fitted with a socket-outlet for providing power to other appliances. Appliances covered by the general requirement for protection against indirect contact in Section 10, clause 18.1 Appliances which are mainly used in locations where protection against indirect contact is required, cf. Section 10, clause 17. **) The earthing contact not connected.		

If poly-phase appliances and single-phase appliances having a rated current exceeding 10 A are provided with a supply cord with a plug, this plug shall be in accordance with the following table:

Class of equipment	Plug	
	The Heavy Current Regulations Section 107-1-D1, Standard Sheet	The Heavy Current Regulations Section 117 Standard Sheet
I	DK 6-1a	II
II	DK 6-1a *)	II*)
III	-	IX
*) The earthing contact not connected.		

Switzerland

Plugs for connection of the power supply cord to primary power have to comply with SEV/ASE 1011.

3.2.2 Permanently connected equipment

PERMANENTLY CONNECTED EQUIPMENT shall be provided with either:

- a set of terminals as specified in 3.3, or
- a NON-DETACHABLE POWER SUPPLY CORD.

Fixed PERMANENTLY CONNECTED EQUIPMENT, unless it has a NON-DETACHABLE POWER SUPPLY CORD, shall:

- permit the connection of the supply wires after the equipment has been fixed to its support;
- be provided with cable entries, conduit entries, knock-outs or glands, which allow connection of the appropriate types of cables or conduits.

For equipment having a RATED CURRENT not exceeding 16 A the cable entries shall be suitable for cables and conduits having an overall diameter as shown in table 10.

NOTE

In some countries the sizes of conduit in parentheses are required.

Table 10 - Sizes of cables and conduits, rated current up to 16 A

Number of conductors including protective earthing conductor where provided	Overall diameter mm	
	Cable	Conduit
2	13,0	16,0 (23,0)
3	14,0	16,0 (23,0)
4	14,5	20,0 (29,0)
5	15,5	20,0 (29,0)

EN 60950 - European differences

Delete the note and in table 10, delete the values in parentheses.

Conduit and cable entries and knock-outs for supply connections shall be so designed or located that the introduction of the conduit and cable does not affect the protection against electric shock, or reduce CREEPAGE DISTANCES and CLEARANCES below the values specified in 2.9.

Compliance is checked by inspection, by a practical installation test and by measurement.

3.2.3 Appliance inlets

Appliance inlets shall be all of the following:

- so located or enclosed that parts at HAZARDOUS VOLTAGE are not accessible during insertion or removal of the connector (appliance inlets complying with IEC 320 are considered to comply with this requirement);
- so placed that the connector can be inserted without difficulty;
- so placed that, after insertion of the connector, the equipment is not supported by the connector for any position of normal use on a flat surface.

Appliance inlets for CLASS I EQUIPMENT shall have an earthing terminal connected to the protective earthing terminal within the equipment.

Compliance is checked by inspection and, for accessibility, by means of the test finger, figure 19.

3.2.4 Power supply cords

Power supply cords shall:

- if rubber insulated, be of synthetic rubber and not lighter than ordinary tough rubber-sheathed flexible cords according to IEC 245 (designation 245 IEC 53);
- if polyvinyl chloride insulated:

- for equipment having a mass not exceeding 3 kg, be not lighter than ordinary polyvinyl chloride sheathed flexible cord according to IEC 227 (designation 227 IEC 52);
- for equipment having a mass exceeding 3 kg, be not lighter than ordinary polyvinyl chloride sheathed flexible cord according to IEC 227 (designation 227 IEC 53);
- include, in case of CLASS I EQUIPMENT, a green/yellow protective earthing conductor electrically connected to the protective earthing terminal within the equipment and connected to the protective earthing contact of the plug, if any;
- have conductors with cross-sectional areas not less than those specified in table 11.

Table 11 - Sizes of conductors in power supply cords

Rated current of equipment A	Nominal cross-sectional area mm ²
Up to and including 6	0,75 ¹⁾
Over 6 up to and including 10	1,00 (0,75) ²⁾
Over 10 up to and including 13	1,25 (1,0) ³⁾
Over 13 up to and including 16	1,5 (1,0) ³⁾
Over 16 up to and including 25	2,5
Over 25 up to and including 32	4
Over 32 up to and including 40	6
Over 40 up to and including 63	10
Over 63 up to and including 80	16
Over 80 up to and including 100	25
Over 100 up to and including 125	35
Over 125 up to and including 160	50

Conditions applicable to table 11

- 1 For RATED CURRENT up to 3 A, a nominal cross-sectional area of 0,5 mm² is permitted in some countries provided that the length of the cord does not exceed 2 m.
- 2 The value in parentheses applies to DETACHABLE POWER SUPPLY CORDS fitted with the connectors rated 10 A in accordance with IEC 320 (types C13, C15, C15A and C17), provided that the length of the cord does not exceed 2 m.
- 3 The value in parentheses applies to DETACHABLE POWER SUPPLY CORDS fitted with the connectors rated 16 A in accordance with IEC 320 (types C19, C21 and C23), provided that the length of the cord does not exceed 2 m.

NOTE

IEC 320 specifies acceptable combinations of appliance couplers and flexible cords, including those covered by conditions 1), 2) and 3). However, a number of countries have indicated that they do not accept all of the values listed in Table 11, particularly those covered by conditions 1), 2) and 3).

EN 60950 - European differences

Replace

"245 IEC 53" by "H05 RR-F",

"227 IEC 52" by "H03 VV-F or H03 VVH2-F" and

"227 IEC 53" by "H05 VV-F or H05 VVH2-F2".

In Table 11, replace the first four lines by the following:

	Up to including 6	0,75 ¹⁾
Over 6	up to and including 10	1,0
Over 10	up to and including 16	1,6

In the conditions applicable to table 11, delete the words "in some countries" in condition 1 and delete conditions 2 and 3.

Delete the note

United Kingdom

A power supply cord with conductor of 1,25 mm² is allowed for equipment with a rated current over 10 A and up to and including 13 A.

Compliance is checked by inspection and by measurement. In addition, for screened cords, compliance is checked by tests similar to those of IEC 227. However, flexing tests need be applied only to power supply cords for MOVABLE EQUIPMENT which is intended to be moved while in normal use.

Damage to the screen is permitted provided that:

- *during the flexing test the screen does not make contact with any conductor, and*
- *after the flexing test, the sample withstands the electric strength test between the screen and all other conductors.*

3.2.5 Power supply cord anchorages and strain relief

For equipment with a NON-DETACHABLE POWER SUPPLY CORD, a cord anchorage shall be supplied such that:

- the connecting points of the cord conductors are relieved from strain;
- the outer covering of the cord is protected from abrasion.

It shall not be possible to push the cord back into the equipment if this could create a hazard within the meaning of this standard.

For CLASS I EQUIPMENT, the construction shall be such that if the power supply cord should slip in its anchorage, placing a strain on conductors, the protective earthing conductor will be the last to take the strain.

The cord anchorage shall either be made of insulating material or have a lining of insulating material complying with the requirements for SUPPLEMENTARY INSULATION. However, where the cord anchorage is a bushing that includes the electrical connection to the screen of a screened power cord, this requirement shall not apply.

The construction of the cord anchorage shall be such that:

- cord replacement does not impair the safety of the equipment;
- for ordinary replacement cords, it is clear how the relief from strain is to be obtained;
- the cord is not clamped by a screw which bears directly on the cord;
- methods such as tying the cord into a knot or tying the cord with a string, are not used;
- the cord cannot rotate in relation to the BODY of the equipment to such an extent that mechanical strain is imposed on the electrical connections.

Compliance is checked by inspection and by applying the following tests which are made with the type of power supply cord supplied with the equipment.

It shall not be possible to push the cord back into the equipment to such an extent that the cord or its conductors, or both, could be damaged or internal parts of the equipment could be displaced.

The cord is be subjected 25 times to a steady pull of the value shown in table 12, applied in the most unfavourable direction, each time for 1 s.

Table 12 - Physical tests on power supply cords

<i>Mass (M) of the equipment kg</i>	<i>Pull N</i>
<i>M ≤ 1</i>	<i>30</i>
<i>1 < M ≤ 4</i>	<i>60</i>
<i>4 < M</i>	<i>100</i>

During the tests, the power supply cord shall not be damaged. This is checked by visual inspection and by an electric strength test between the power cord conductors and accessible conductive parts, at the test voltage appropriate for REINFORCED INSULATION.

After the tests, the power supply cord shall not have been longitudinally displaced by more than 2 mm nor shall there be appreciable strain at the connections.

CREEPAGE DISTANCES *and* CLEARANCES shall not be reduced below the values specified in 2.9.

3.2.6 Protection against mechanical damage

Power supply cords shall not be exposed to sharp points or cutting edges within or on the surface of the equipment, or at the inlet opening or inlet bushing.

The overall sheath of a NON-DETACHABLE POWER SUPPLY CORD shall continue into the equipment through any inlet bushing or cord guard and shall extend by at least half the cord diameter beyond the clamp of the cord anchorage.

Inlet bushings, where used, shall:

- be reliably fixed
- not be removable without the use of a TOOL.

An inlet bushing in a non-metallic ENCLOSURE shall be of insulating material.

An inlet bushing or cord guard on metal-encased CLASS II EQUIPMENT shall meet the requirements for SUPPLEMENTARY INSULATION.

Compliance is checked by inspection and measurement.

3.2.7 Cord guards

A cord guard shall be provided at the power supply cord inlet opening of equipment which has a NON-DETACHABLE POWER SUPPLY CORD, and which is hand-held or intended to be moved while in operation. Alternatively, the inlet or bushing shall be provided with a smoothly rounded bell-mouthed opening having a radius of curvature equal to at least 1,5 times the overall diameter of the cord with the largest cross-sectional area to be connected.

Cord guards shall:

- be so designed as to protect the cord against excessive bending where it enters the equipment;
- be of insulating material;
- be fixed in a reliable manner;
- project outside the equipment beyond the inlet opening for a distance of at least five times the overall diameter or, for flat cords, at least five times the major overall cross-sectional dimension, of the cord.

Compliance is checked by inspection, by measurement and, where necessary, by the following test:

The equipment is tested with the cord as delivered by the manufacturer.

The equipment is so placed that the axis of the cord guard, where the cord leaves it, projects at an angle of 45° when the cord is free from stress. A mass equal to 10 D²g is then attached to the free end of the cord, D being, in millimetres, the overall diameter of, or for flat cords, the minor overall dimension of, the cord delivered with the equipment.

If the cord guard is of temperature-sensitive material, the test is made at 23°C ± 2°C.

Flat cords are bent in the plane of least resistance.

Immediately after the mass has been attached, the radius of curvature of the cord shall nowhere be less than 1,5 D.

3.2.8 Supply wiring space

The supply wiring space provided inside, or as part of, the equipment for permanent connection or for connection of ordinary NON-DETACHABLE POWER SUPPLY CORDS shall be designed:

- to allow the conductors to be introduced and connected easily;
- so that, for hand-held or CLASS II EQUIPMENT, the uninsulated end of a conductor is unlikely to become free from its terminal, or, should it do so, cannot come into contact with accessible conductive parts;
- to permit checking before fitting the cover, if any, that the conductors are correctly connected and positioned;
- so that covers, if any, can be fitted without risk of damage to the supply conductors or their insulation;

- so that covers, if any, giving access to the terminals can be removed with a commonly available TOOL.

Compliance is checked by inspection and by an installation test with cords of the largest cross-sectional area of the appropriate range specified in 3.3.5.

3.3 Wiring terminals for external primary power supply conductors

3.3.1 Connection terminals

PERMANENTLY CONNECTED EQUIPMENT and equipment with ordinary NON-DETACHABLE POWER SUPPLY CORDS shall be provided with terminals in which connection is made by means of screws, nuts or equally effective devices.

Compliance is checked by inspection.

3.3.4 Security of terminations

For the purpose of applying the requirements for power supply cords:

- it is assumed that two independent fixings will not become loose at the same time;
- conductors connected by soldering are not considered to be adequately fixed unless they are held in place near to the termination, independently of the solder, but "hooking in" before the soldering is, in general, considered to be a suitable means for maintaining the conductors of a power supply cord in position, provided that the hole through which the conductor is passed is not unduly large;
- conductors connected to terminals or terminations by other means are not considered to be adequately fixed unless an additional fixing is provided near to the terminal or termination; this additional fixing, in the case of insulated stranded conductors, clamps both the insulation and the conductor.

3.3.8 Grouping of wiring terminals

For ordinary NON-DETACHABLE POWER SUPPLY CORDS, each terminal shall be located in proximity to its corresponding terminal or terminals of different potential and to the protective earthing terminal, if any.

Compliance is checked by inspection.

3.3.9 Stranded wire

Terminals shall be so located, guarded or insulated that, should a strand of a flexible conductor escape when the conductor is fitted, there is no risk of accidental contact between such a strand and:

- accessible conductive parts, or
- unearthed conductive parts separated from accessible conductive parts by SUPPLEMENTARY INSULATION only.

Compliance is checked by inspection and, unless a special cord is prepared in such a way as to prevent the escape of strands, by the following test.

Insulation approximately 8 mm in length is removed from the end of a flexible conductor having the appropriate nominal cross-sectional area. One wire of the stranded conductor is left free and the other wires are fully inserted into, and clamped in, the terminal.

Without tearing the insulation back, the free wire is bent in every possible direction, but without making sharp bends round the guard.

If the conductor is at HAZARDOUS VOLTAGE, the free wire shall not touch any metal part which is accessible or is connected to an accessible metal part or, in the case of DOUBLE INSULATED equipment, any metal part which is separated from accessible metal parts by SUPPLEMENTARY INSULATION only.

If the conductor is connected to an earthing terminal, the free wire shall not touch any live part.

4.2 Mechanical strength and stress relief

All the requirements of 4.2 (see part V) apply.

4.3 Construction details

4.3.1 Supply voltage selection

Equipment which can be adjusted to suit different primary power supply voltages shall be so constructed that changing of the setting requires the use of a TOOL if incorrect setting causes a hazard.

Compliance is checked by manual test.

4.3.2 Accessible control devices

Equipment shall be so constructed that manual adjustment of accessible control devices requires the use of a TOOL if inadvertent adjustment might create a hazard.

Compliance is checked by manual test.

4.3.4 Dust, powders, liquids and gases

Equipment producing dust (e.g. paper dust) or employing powders, liquids or gases shall be so constructed that no dangerous concentration of these materials can exist and that no hazard within the meaning of this standard is created by condensation, vaporisation, leakage, spillage or corrosion during normal operation, storage, filling or emptying. In particular, CREEPAGE DISTANCES and CLEARANCES shall not be reduced below the requirements of 2.9.

Compliance is checked by inspection and, where spillage of liquid could affect electrical insulation during replenishment, by the following test and, for flammable liquids, by the tests of 4.4.8.

The equipment shall be ready to use according to its installation instructions, but not energised.

The liquid container of the equipment is completely filled with the liquid specified by the manufacturer, and a further quantity, equal to 15% of the capacity of the container, is poured in steadily over a period of 1 min. For liquid containers having a capacity not exceeding 250 ml, and for containers without drainage and for which the filling cannot be observed from outside, a further quantity of liquid, equal to the capacity of the container, is poured in steadily over a period of 1 min.

Immediately after this treatment, the equipment shall withstand an electric strength test as specified in 5.3.2 on any insulation on which spillage could have occurred and inspection shall show that the liquid has not created a hazard within the meaning of this standard.

The equipment is permitted to stand in normal test-room atmosphere for 24 h before being subjected to any further electrical test.

4.3.5 Manual controls

Handles, knobs, grips, levers and the like shall be reliably fixed so that they will not work loose in normal use if this might result in a hazard. Sealing compounds and the like, other than self-hardening resins, shall not be used to prevent loosening.

If manual controls are used to indicate the position of switches or similar components, it shall not be possible to fix them in a wrong position if this might result in a hazard.

Compliance is checked by inspection, by manual test and by trying to remove the handle, knob, grip or lever by applying for 1 min an axial force as follows.

If the shape of these parts is such that an axial pull is unlikely to be applied in normal use, the force is:

*15 N for the operating means of electrical components,
20 N in other cases.*

If the shape is such that an axial pull is likely to be applied, the force is:

*30 N for the operating means of electrical components,
50 N in other cases.*

4.3.6 Driving belts and couplings

Driving belts and couplings shall not be relied upon to ensure electrical insulation, unless the belt or coupling is of a special design which removes the risk of inappropriate replacement.

Compliance is checked by inspection.

4.3.7 Sleeving on wiring

Where sleeving is used as SUPPLEMENTARY INSULATION on internal wiring, it shall be retained in position by positive means.

A sleeve is considered to be retained by positive means if it can be removed only by breaking or cutting or if it is clamped at both ends.

Compliance is checked by inspection and by manual test.

4.3.8 Gaps in insulation

Any gap with a width greater than 0,3 mm in SUPPLEMENTARY INSULATION shall not coincide with any such gap in BASIC INSULATION, nor shall any such gap in REINFORCED INSULATION give straight access to parts at HAZARDOUS VOLTAGE.

Compliance is checked by inspection and by measurement.

4.3.9 Fixing of internal parts

Equipment shall be so constructed that should any wire, screw, nut, washer, spring or similar part become loose or fall out of position, it cannot in normal use become so disposed that CREEPAGE DISTANCES or CLEARANCES over SUPPLEMENTARY INSULATION or REINFORCED INSULATION are reduced to less than the values specified in 2.9.

Compliance is checked by inspection, by measurement and by manual test.

For the purpose of assessing compliance:

- *it is assumed that two independent fixings will not become loose at the same time;*
- *it is assumed that parts fixed by means of screws or nuts provided with self-locking washers or other means of locking are not liable to become loose, provided these screws or nuts are not required to be removed during the replacement of the power supply cord;*
- *wires connected by soldering are not considered to be adequately fixed unless they are held in place near to the termination, independently of the soldered connection;*
- *wires connected to terminals are not considered to be adequately secured unless either an additional fixing is provided near to the terminal, this additional fixing, in the case of stranded conductors clamping the insulation and not only the conductors; or the wires are provided with terminators (e.g. ring lugs crimped onto the conductors, or the like) which are unlikely to become free;*
- *short rigid wires are not regarded as likely to come away from a terminal if they remain in position when the terminal screw is loosened.*

4.3.10 Insulation degradation by contamination and ageing

SUPPLEMENTARY INSULATION and REINFORCED INSULATION shall be so designed or protected that they are not likely to be impaired by deposition of dirt, or by dust resulting from wear of parts within the equipment, to such an extent that CREEPAGE DISTANCES and CLEARANCES are reduced below the values specified in 2.9.

Parts of synthetic rubber used as SUPPLEMENTARY or REINFORCED INSULATION shall be resistant to ageing and be so arranged and dimensioned that CREEPAGE DISTANCES are not reduced below the values specified in 2.9 if any cracks occur.

Compliance is checked by inspection and by measurement.

4.3.11 Resistance to oil

Where internal wiring, windings, commutators, slip-rings and the like, and insulation in general, are exposed to oil, grease or similar substances, the insulation shall have adequate properties to resist deterioration under these conditions.

Compliance is checked by inspection.

4.3.13 Security of screwed connections

Screwed connections, electrical or otherwise, shall withstand the mechanical stresses occurring in normal use, if their loosening or failure could affect safety.

Compliance is checked by inspection.

NOTE

Spring washers and the like can provide satisfactory locking.

4.3.14 Openings in enclosures

Openings in the top and sides of FIRE ENCLOSURES and of ELECTRICAL ENCLOSURES, excluding openings in OPERATOR ACCESS AREAS within an ENCLOSURE, shall comply with 4.3.15 and 4.3.16 as appropriate.

NOTE 1

The examples of figures 8, 9 and 10 are not intended to be used as engineering drawings but are only shown to illustrate the intent of these requirements.

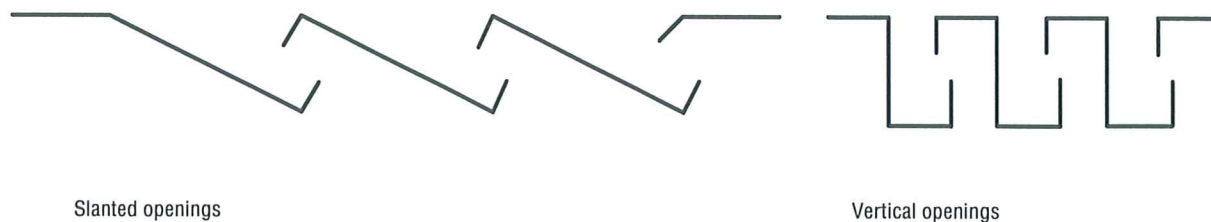
NOTE 2

Requirements for equipment to be installed in RESTRICTED ACCESS LOCATIONS are under consideration.

4.3.15 Openings on top of enclosures

In the top of FIRE ENCLOSURES and of ELECTRICAL ENCLOSURES, openings directly over bare parts at HAZARDOUS VOLTAGE shall comply with one of the following:

- not exceed 5 mm in any dimension, or
- not exceed 1 mm in width regardless of length, or
- be so constructed that direct, vertical entry of a falling object is prevented from reaching such bare parts by means of a trap or restrictions. (See figure 8 for examples of top cover designs that prevent such direct entry.)



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Figure 8 - Examples of cross-sections of designs of openings preventing vertical access

Compliance is checked by inspection and measurement, all doors, panels, covers etc. provided with the equipment being closed.

4.3.16 Openings on sides of enclosures

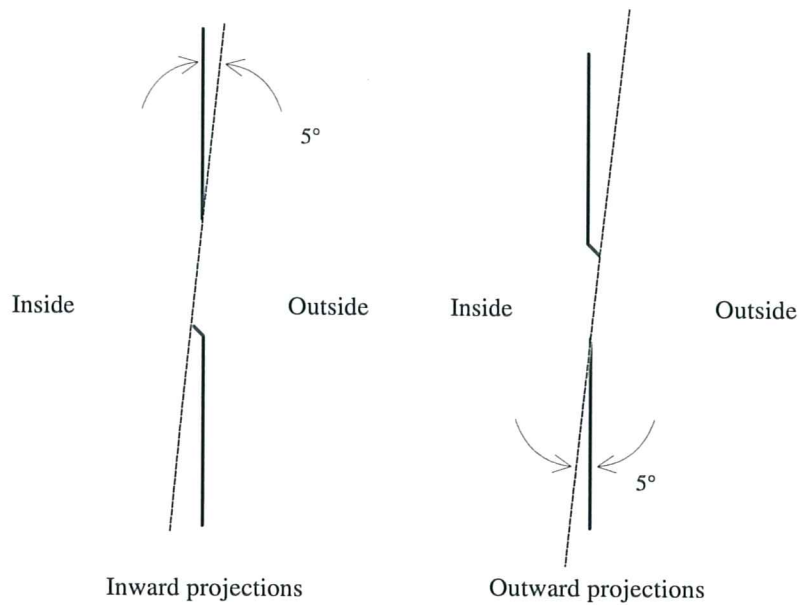
Openings in the sides of FIRE ENCLOSURES and of ELECTRICAL ENCLOSURES shall comply with one of the following:

- not exceed 5 mm in any dimension, or
- not exceed 1 mm in width regardless of length, or

- be provided with louvres that are shaped to deflect outwards an external vertically falling object (see figure 9 for examples), or
- be so located that an object, upon entering the ENCLOSURE, is unlikely to fall on bare parts at HAZARDOUS VOLTAGES (see figure 10 for an example).

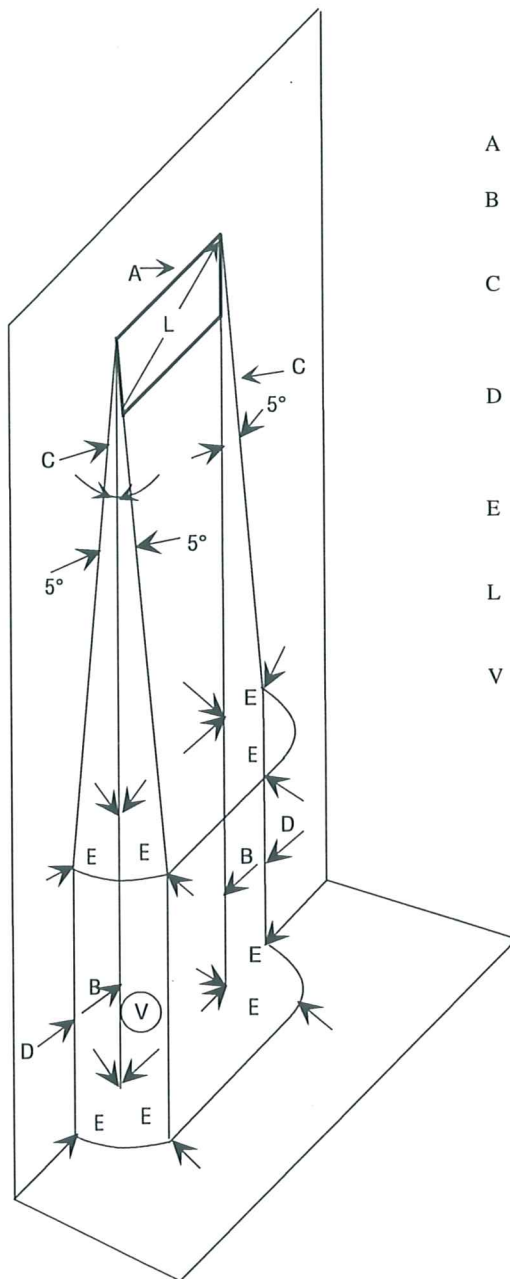
Where a portion of the side of the FIRE ENCLOSURE falls within the area as traced out by the 5° angle in figure 10, the limitations in 4.4.6 on sizes of openings in bottoms of FIRE ENCLOSURES also apply to this portion of the side.

Compliance is checked by inspection and measurement, all doors, panels, covers etc. provided with the equipment being closed.



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Figure 9 - Examples of louvre design



- A ENCLOSURE side opening.
- B Vertical projection of the outer edges of the side opening.
- C Inclined lines that project at a 5° angle from the edges of the side opening to points located E distance from B.
- D Line which is projected straight downward in the same plane as the ENCLOSURE side wall.
- E Projection of the opening (not to be greater than L).
- L Maximum dimension of the ENCLOSURE side opening.
- V Volume in which bare parts at HAZARDOUS VOLTAGE are not located.

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Figure 10 - Example of enclosure side opening

4.3.17 Plug and socket mismatching

Within a manufacturer's unit or system, plugs and sockets likely to be used by the OPERATOR or by SERVICE PERSONNEL shall not be employed in a manner likely to create a hazard due to mismatching. Keying, location, or in the case of connectors accessible only to SERVICE PERSONNEL, clear marking, is permitted to meet the requirement.

Compliance is checked by inspection.

4.3.18 Direct plug in equipment

Equipment which is intended to plug directly into a wall socket-outlet, and where the weight of the equipment is to be taken by the pins, shall not impose undue strain on the socket-outlet.

Compliance is checked by inspection and, in cases of doubt, by the following test.

The equipment is inserted, as in normal use, into a fixed socket-outlet without earthing contact, which can be pivoted about a horizontal axis intersecting the centre lines of the contact tubes at a distance of 8 mm behind the engagement face of the socket-outlet. The additional torque which has to be applied to the socket-outlet to maintain the engagement face in the vertical plane shall not exceed 0,25 Nm.

5.2 Earth leakage current

5.2.1 General

Equipment intended to be connected to TT or TN POWER SYSTEMS shall comply with the requirements in 5.2.2 to 5.2.5. Equipment intended to be connected to IT POWER SYSTEMS shall comply with the requirements in annex G.

5.2.2 Limits

Equipment shall not have earth leakage current in excess of the values in table 17 when measured as defined in 5.2.3 or 5.2.4.

Table 17 - Maximum earth leakage current

Class	Type of equipment	Maximum leakage current mA
II	ALL	0,25
I	HAND-HELD	0,75
I	MOVABLE (other than HAND-HELD)	3,5
I	STATIONARY, PLUGGABLE TYPE A	3,5
I	STATIONARY, PERMANENTLY CONNECTED, or PLUGGABLE TYPE B:	
	— not subject to the conditions in 5.2.5	3,5
	— subject to the conditions in 5.2.5	5% of input current

Systems of interconnected equipment with individual connections to primary power shall have each piece of equipment tested separately. Systems of interconnected equipment with one common connection to primary power shall be treated as a single piece of equipment.

Equipment designed for multiple (redundant) supplies shall be tested with only one supply connected.

If it is clear from a study of the circuit diagrams of CLASS I PERMANENTLY CONNECTED EQUIPMENT or PLUGGABLE EQUIPMENT TYPE B that the earth leakage current will exceed 3,5 mA, but will not exceed 5% of input current, the tests need not be made.

Compliance is checked by the following tests which are carried out using the measuring instrument described in annex D, or any other circuit giving the same results, and preferably using an isolating supply transformer as shown. If the use of an isolating transformer is not practicable, the equipment is mounted on an insulating stand, not earthed, and due safety precautions are taken in view of the possibility of the BODY of the equipment being at a HAZARDOUS VOLTAGE.

For CLASS II EQUIPMENT, the test is made to accessible conductive parts, and to metal foil having dimensions of 10 cm x 20 cm in contact with accessible non-conductive parts. If the area of the foil is smaller than the surface under test, the foil is moved so as to test all parts of the surface. Where adhesive metal foil is used, the adhesive shall be conductive. Precautions are taken to avoid the metal foil affecting the heat dissipation of the equipment.

Note

This test simulates hand contact

If it is inconvenient to test equipment at the most unfavourable supply voltage (see 1.4.5), it is permitted to test at any available voltage within the RATED VOLTAGE RANGE or within the tolerance of RATED VOLTAGE and then calculate the results.

5.2.3 Testing of single-phase equipment

Single-phase equipment intended for operation between one phase conductor and neutral is tested using the circuit of figure 13 with the selector switch in each of the positions 1 and 2.

For each position of the selector switch, any switches within the equipment controlling primary power and likely to be operated in normal use are opened and closed in all possible combinations.

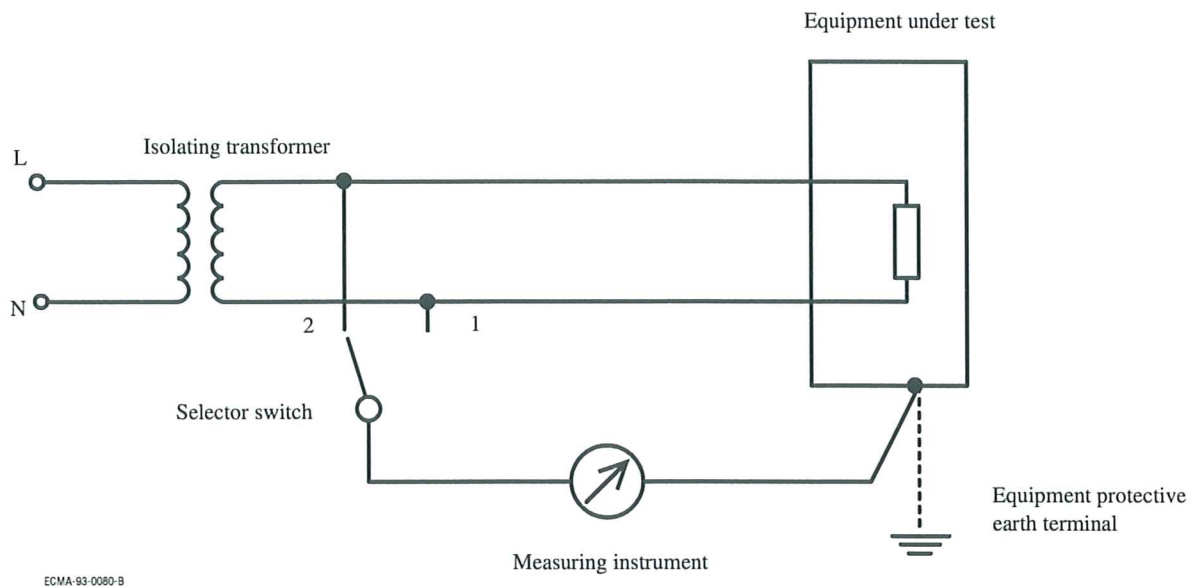


Figure 13 - Test circuit for earth leakage current on single-phase equipment

None of the current values shall exceed the relevant limit specified in table 17.

5.2.4 Testing of three-phase equipment

Three-phase equipment and equipment intended for operation between two phase conductors is tested using the circuit of figure 14. During the test, any switches within the equipment controlling primary power and likely to be operated in normal use are opened and closed in all possible combinations.

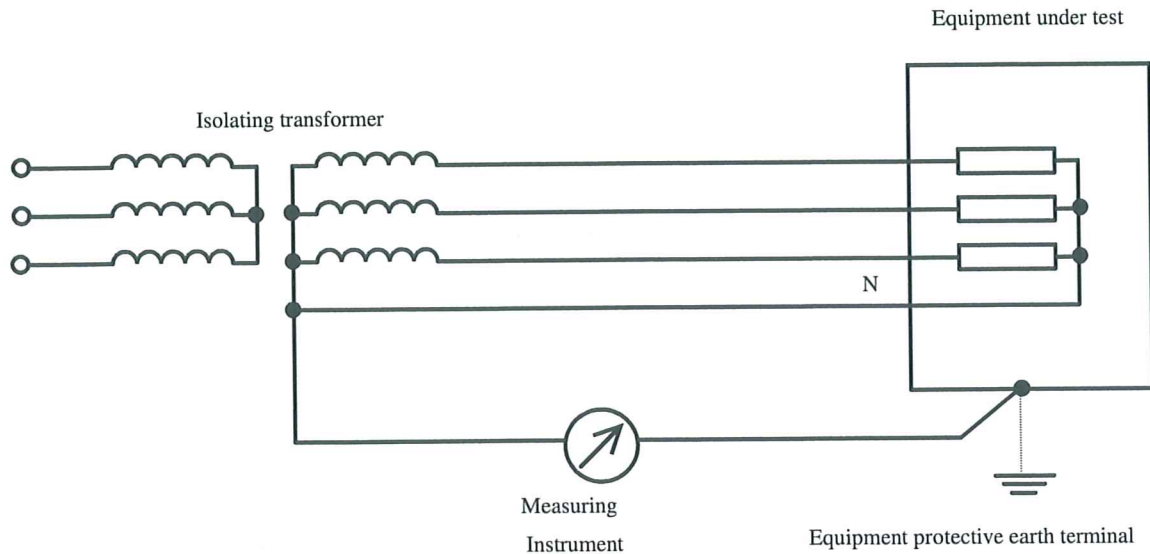
Any components used for EMI suppression and connected between phase and earth are disconnected one at a time; for this purpose groups of components in parallel connected through a single connection are treated as single components.

NOTE

Where filters are normally encapsulated, it may be necessary to provide an unencapsulated unit for this test or to simulate the filter network.

Each time a line to earth component is disconnected, the sequence of switch operations is repeated.

None of the current values shall exceed the relevant limit specified in table 17.



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Figure 14 - Test circuit for earth leakage current on three-phase equipment

5.2.5 Equipment with earth leakage current exceeding 3,5 mA

CLASS I STATIONARY EQUIPMENT that is PERMANENTLY CONNECTED EQUIPMENT, or that is PLUGGABLE EQUIPMENT TYPE B, with an earth leakage current exceeding 3,5 mA shall be subject to the following conditions:

- leakage current shall not exceed 5% of the input current per phase. Where the load is unbalanced the largest of the three-phase currents shall be used for this calculation. Where necessary, the tests in 5.2.3 and 5.2.4 shall be used but with a measuring instrument of negligible impedance;
- the cross-sectional area of the internal protective earthing conductor shall be not less than that the conductors in table 11, with a minimum of 1,0 mm² in the path of high leakage current;
- a label bearing the following warning, or similar wording, shall be affixed adjacent to the equipment primary power connection:

HIGH LEAKAGE CURRENT

Earth connection essential before connecting supply

5.3 Electric strength

5.3.1 General

The electric strength of the insulating materials used within the equipment shall be adequate.

Compliance is checked by testing the equipment in accordance with 5.3.2, or, for SAFETY ISOLATING TRANSFORMERS, in accordance with clause C.3, while the equipment is still in a well-heated condition immediately following the heating test as specified in 5.1.

In order to facilitate electric strength testing, it is permitted to test components and sub-assemblies separately. In such a case, the components and sub-assemblies are tested in a well-heated condition achieved by simulating the heating test prior to the electric strength test.

5.3.2 Test procedure

The insulation is subjected for 1 min either to a voltage of substantially sine-wave form having a frequency of 50 Hz or 60 Hz or to a d.c. voltage equal to the peak voltage of the prescribed a.c. test voltage. Test voltages are as specified in table 18 for the appropriate grade of INSULATION (OPERATIONAL, BASIC, SUPPLEMENTARY or REINFORCED) and the WORKING VOLTAGE (U), as specified in 2.2.7, across the insulation.

For d.c. WORKING VOLTAGES which are derived inside the equipment from an a.c. mains supply or from

batteries, the *WORKING VOLTAGE* (r.m.s.) used in table 18 is the d.c. component of the voltage plus the peak value of any ripple, all divided by $\sqrt{2}$.

The voltage applied to the insulation on test is gradually raised from zero to the prescribed voltage, and held at that value for 60 s.

NOTE 1

For production test purposes, it is permitted to reduce the duration of the electric strength test to 1 s. Alternative methods of production test are under consideration.

There shall be no insulation breakdown during the test.

Insulation breakdown is considered to have occurred when the current which flows as a result of the application of the test voltage rapidly increases in an uncontrolled manner, i.e. the insulation does not restrict the flow of the current. Corona discharge or a single momentary flashover is not regarded as insulation breakdown.

Insulation coatings are tested with metal foil in contact with the insulating surface. This procedure is limited to places where the insulation is likely to be weak, for example where there are sharp metal edges under the insulation. If practicable, insulation linings are tested separately. Care is taken that the metal foil is so placed that no flashover occurs at the edges of the insulation. Where adhesive metal foil is used, the adhesive shall be conductive.

For equipment incorporating both *REINFORCED INSULATION* and lower grades of insulation, care is taken that the voltage applied to the *REINFORCED INSULATION* does not overstress *BASIC* or *SUPPLEMENTARY INSULATION*.

To avoid damage to components or insulation which are not involved in the test, disconnection of integrated circuits or the like in *SECONDARY CIRCUITS*, and the use of equipotential bonding, are permitted.

NOTE 2

Where there are capacitors across the insulation under test (e.g. radio-frequency filter capacitors), it is recommended that d.c. test voltages are used.

NOTE 3

Components providing a d.c. path in parallel with the insulation to be tested, such as discharge resistors for filter capacitors, and voltage limiting devices, should be disconnected.

Table 18 - Test voltages for electric strength tests - Part 1

	Test voltage ²⁾ volts r.m.s.							
	Points of application (as appropriate)							
	Primary to BODY Primary to secondary Between parts in PRIMARY CIRCUITS					Secondary to BODY Between independent secondaries ³⁾		
Working voltage ⇒ Grade of insulation ↓	U ≤ 130 V r.m.s	130 V < U ≤ 250 V r.m.s	250 V < U ≤ 1000 V r.m.s	1 kV < U ≤ 7 kV r.m.s	7 kV < U ≤ 35 kV r.m.s	U ≤ 42,4 V peak, or 60 V d.c	42,4 V peak, or 60 V d.c. > U ≤ 7 kV r.m.s	
OPERATIONAL 1)	1000	1500	see V _a in table 18 Part 2	see V _a in table 18 Part 2	1,5U	500	see V _a in table 18 Part 2	
BASIC SUPPLEMENTARY	1000	1500	see V _a in table 18 Part 2	see V _a in table 18 Part 2	1,5U	No test	see V _a in table 18 Part 2	
REINFORCED	2000	3000	3000	see V _b in table 18 Part 2	1,5U	No test	see V _b in table 18 Part 2	

Conditions applicable to table 18, parts 1 and 2

- 1) No test is applied to OPERATIONAL INSULATION, unless option (b) of 5.4.4 has been selected.
- 2) The test voltages are for application to solid insulation at any altitude. For CLEARANCES, it is permitted to reduce the voltages for altitude by the following multipliers:

Altitude (m)	Sea level (0)	500	1 000	2 000
Multiplier	1	0,94	0,89	0,79
- 3) For WORKING VOLTAGES exceeding 7 kV in SECONDARY CIRCUITS, the same values as for PRIMARY CIRCUITS apply.
- 4) At these voltages, the values of V_b are determined by the general curve $V_b = 183,2 U^{0,4638}$ and are not 1,6 V_a.
- 5) Interpolation is permitted between adjacent points in the table.

Table 18 - Test voltages for electric strength tests - Part 2
volts r.m.s

U	V _a	V _b	U	V _a	V _b	U	V _a	V _b
24	500	800	218	1 391	2 226	1 652	3 959	3 959
25	510	815	227	1 418	2 268	1 701	4 037	4 037
26	519	830	237	1 446	2 314	1 751	4 117	4 117
27	528	845	247	1 474	2 359	1 803	4 199	4 199
28	537	859	257	1 502	2403	1 856	4 283	4 283
29	546	873	268	1 531	2 450	1 912	4 369	4 369
30	558	887	280	1 563	2 500	1 968	4 455	4 455
31	563	901	292	1 593	2 549	2 026	4 544	4 544
32	571	914	305	1 626	2 601	2 087	4 636	4 636
33	580	927	319	1 660	2 656	2 149	4 728	4 728
35	596	953	333	1 693	2 709	2 213	4 823	4 823
37	611	978	347	1 726	2 762	2 279	4 920	4 920
39	626	1 002	362	1 760	2 816	2 347	5 018	5 018
41	641	1 026	378	1 796	2 873	2 416	5 118	5 118
43	655	1 048	395	1 833	2 933	2 488	5 220	5 220
45	669	1 071	415	1 875	3 000	2 562	5 325	5 325
47	683	1 093	433	1 913	3 000	2 639	5 432	5 432
49	696	1 114	452	1 951	3 000	2 718	5 541	5 541
51	709	1 135	472	1 991	3 000	2 799	5 652	5 652
53	722	1 155	493	2 031	3 000	2 882	5 765	5 765
55	735	1 175	515	2 073	3 000	2 967	5 880	5 880
58	753	1 205	537	2 114	3 000	3 056	5 998	5 998
61	771	1 233	561	2 157	3 000	3 147	6 118	6 118
64	788	1 261	585	2 199	3 000	3 240	6 240	6 240
67	805	1 288	610	2 242	3 000	3 337	6 365	6 365
70	821	1 314	637	2 288	3 000	3 436	6 492	6 492
73	838	1 340	665	2 334	3 000	3 538	6 622	6 622
76	853	1 365	694	2 381	3 000	3 643	6 754	6 754
79	869	1 390	725	2 429	3 000	3 751	6 889	6 889
82	884	1 414	757	2 478	3 000	3 863	7 027	7 027
86	904	1 446	790	2 528	3 000	3 978	7 168	7 168
90	923	1 477	825	2 579	3 000	4 056	7 311	7 311
94	942	1 507	861	2 631	3 000	4 218	7 457	7 457
98	960	1 536	899	2 684	3 000	4 343	7 606	7 606
102	978	1 565	938	2 738	3 000	4 472	7 758	7 758
107	1 000	1 600	979	2 792	3 000	4 605	7 913	7 913
112	1 000	1 634 ⁴⁾	1 000	2 820	3 000	4 742	8 071	8 071
117	1 000	1 668 ⁴⁾	1 030	2 877	3 000	4 883	8 232	8 232
122	1 000	1 701 ⁴⁾	1 061	2 935	3 000	5 028	8 397	8 397
127	1 000	1 733 ⁴⁾	1 096	3 000	3 000	5 178	8 565	8 565
130	1 000	1 751	1 129	3 061	3 061	5 332	8 736	8 736
131	1 099	1 758	1 163	3 123	3 123	5 491	8 911	8 911
137	1 122	1 795	1 197	3 184	3 184	5 654	9 089	9 089
143	1 144	1 831	1 233	3 249	3 249	5 822	9 271	9 271
149	1 166	1 866	1 270	3 314	3 314	5 995	9 456	9 456
155	1 188	1 900	1 308	3 381	3 381	6 173	9 645	9 645
162	1 212	1 940	1 347	3 449	3 449	6 357	9 838	9 838
169	1 236	1 978	1 387	3 518	3 518	6 546	10 035	10 035
176	1 260	2 016	1 428	3 587	3 587	6 741	10 236	10 236
184	1 286	2 058	1 470	3 658	3 659	6 942	10 441	10 441
192	1 312	2 099	1 513	3 730	3 730	7 000	10 500	10 500
200	1 337	2 139	1 558	3 805	3 805			
209	1 364	2 183	1 604	3 880	3 880			

5.4 Abnormal operation and fault conditions

All the requirements of 5.4 (see part VIII) apply.

6 Connection to telecommunication networks

6.1 Requirements

Equipment intended to be directly connected to TELECOMMUNICATION NETWORKS shall be provided with adequate protection:

- to ensure compliance with the requirements for TNV CIRCUITS and protection against electric shock, as detailed in 6.2;
- for the SERVICE PERSONNEL and other users of the TELECOMMUNICATION NETWORK from hazards in the equipment, as detailed in 6.3;
- for the equipment user from voltages on the TELECOMMUNICATION NETWORK, as detailed in 6.4.

NOTE 1

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

NOTE 2

The requirements of 6.2.1.2, 6.3.3 and 6.4 can apply to the same physical insulation or CLEARANCE.

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Protective means in the equipment shall not prevent transient surge protection in the telecommunication network from operating properly (d.c. spark-over voltage of the surge suppressor installed in the telecommunication network: approx. 245 V).

6.2 TNV circuits and protection against electric shock

6.2.1 TNV circuit characteristics and requirements

6.2.1.1 Limits

Under normal operating conditions, TNV CIRCUITS shall not exceed the following limits:

- a) For continuous voltages, the combination of a.c. and d.c. values is such that

$$\frac{U_{ac}}{70,7} + \frac{U_{dc}}{120} \leq 1$$

where:

U_{ac} is the peak value of the a.c. voltage (V) at any frequency,

U_{dc} is the value of the d.c. voltage (V).

NOTE 1

When U_{dc} is zero, U_{ac} can be up to 70,7 V peak.

NOTE 2

When U_{ac} is zero, U_{dc} can be up to 120 V.

- b) For telephone ringing signals, the signal complies with the criteria of either clause M.2 or clause M.3.
- c) For telegraph or teletypewriter signals of any frequency, the signal has a value not exceeding 135 V peak with respect to earth.

EN 60950 - European differences

In the event of a single insulation fault or component failure TNV circuits shall not exceed the limits of figure 15.

6.2.1.2 Separation from unearthed accessible parts

There shall be BASIC INSULATION or better between:

- TNV CIRCUITS and unearthed OPERATOR-accessible conductive parts, and between
- TNV CIRCUITS and unearthed SELV CIRCUITS. In the event of a single insulation fault or component failure, the limits of 6.2.1.1 a) or b) shall not be exceeded on accessible parts.

NOTE

Requirements for TNV CIRCUITS complying with 6.2.1.1 c) are under consideration.

EN 60950 - European differences

This subclause only applies to TNV circuits normally operating in excess of the limits of SELV circuits.

6.2.1.3 Separation from earthed SELV circuits

If a TNV CIRCUIT complying with 6.2.1.1 a) or b) is connected to an SELV CIRCUIT that has one pole connected to earth, 2.3.9 applies except that the limits of 2.3.3 are replaced by the limits of 6.2.1.1 a) or b).

NOTE

Requirements for TNV CIRCUITS complying with 6.2.1.1 c) are under consideration.

EN 60950 - European differences

This subclause only applies to TNV circuits normally operating in excess of the limits of SELV circuits.

6.2.1.4 Separation from hazardous voltages

TNV CIRCUITS shall be separated from circuits at HAZARDOUS VOLTAGES by one or more of the following methods:

- (a) by DOUBLE or as detailed in 2.3.4;
- (b) by BASIC INSULATION, together with protective screening connected to the protective earth terminal, as detailed in 2.3.5;

NOTE 1

In Finland method (b) is permitted only for permanently connected equipment or for pluggable equipment type B.

NOTE 2

In Norway method (b) is not permitted

EN 60950 - European differences

Delete the notes

Finland

Method (b) is only permitted for permanently connected equipment or for pluggable equipment type B

Norway

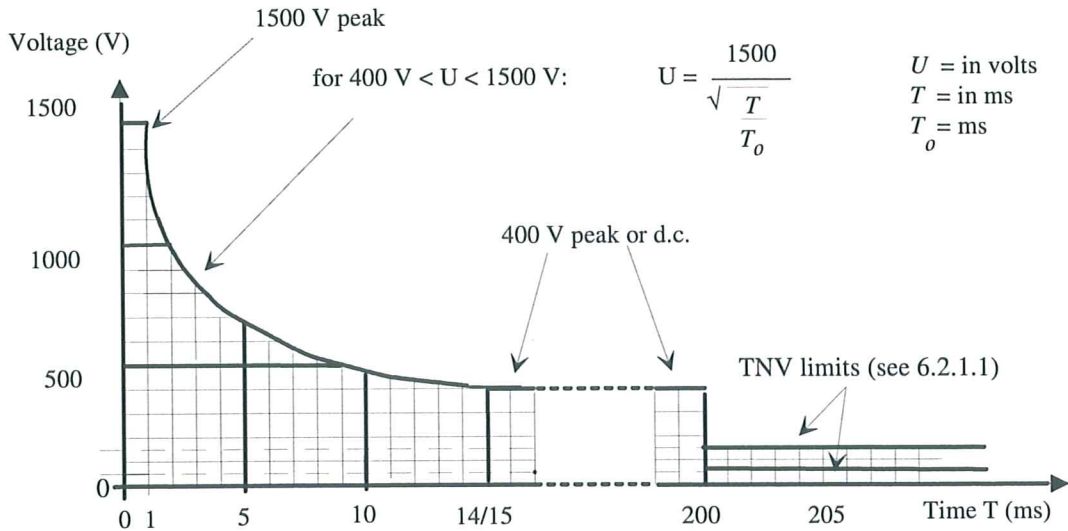
Insulation between parts conductively connected to the supply mains and parts connected to a public telecommunication network shall comply with the requirements for DOUBLE or REINFORCED INSULATION.

- (c) by a design complying with 6.2.1.5.

6.2.1.5 Connection of TNV circuits to other circuits

It is permitted to supply a TNV CIRCUIT by a d.c. voltage not exceeding 120 V, produced by rectification of an a.c. voltage greater than 50 V, provided that:

- the a.c. voltage is separated from other circuits at HAZARDOUS VOLTAGE by either method (a) or method (b) of 6.2.1.4, and
- the limits of figure 15 are not exceeded at the d.c. output in the event of a single insulation fault or component failure.



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Figure 15 - Maximum voltage after a single fault

Compliance is checked by inspection and by simulation of breakdown of BASIC INSULATION and component failures such as are likely to occur. These fault conditions are applied in turn and one at a time. Observation is continued until stable conditions have existed for at least five seconds.

The voltage across a 500Ω resistor, connected between any two conductors or between one conductor and earth, at the connections to the TELECOMMUNICATION NETWORK, shall fall within the shaded area of figure 15. Where a 500Ω resistor causes overload to the circuit, the nominal output load is used.

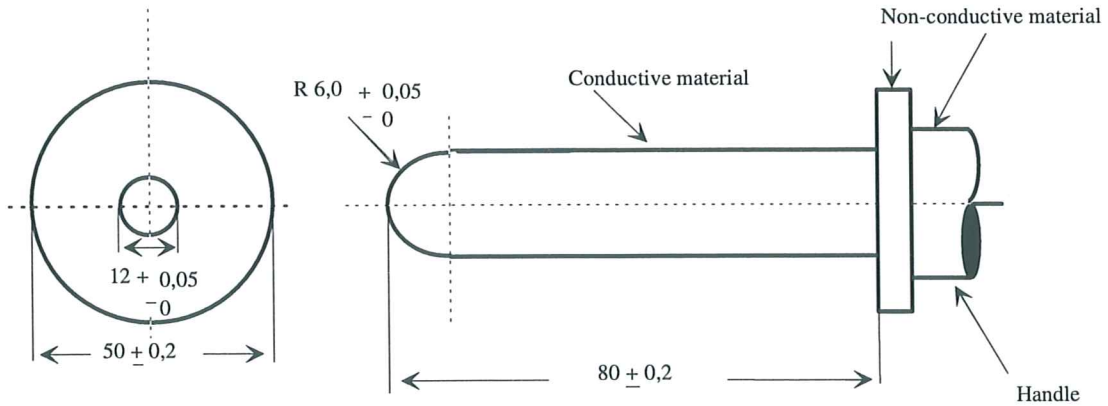
NOTE
 The 500Ω resistor approximates the impedance of the telecommunication line and the human body in parallel.

6.2.2 Protection against contact with TNV circuits

Equipment shall be provided with adequate protection against contact with bare conductive TNV CIRCUIT parts that carry voltages which exceed 42,4 V peak, or 60 V d.c., under normal operating conditions.

Exempt from this requirement are:

- contacts of connectors which cannot be touched by the test probe (figure 16);
- equipment intended for installation in a RESTRICTED ACCESS LOCATION.



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Figure 16 - Test probe

Compliance is checked by inspection, by measurement, and by means of the test finger, figure 19, applied as specified in the compliance section of 2.1.2. During the test, consideration is given to TELECOMMUNICATION SIGNALS generated internally in the equipment and to those passed through the equipment.

6.3 Protection of telecommunication network service personnel, and other users of the telecommunication network, from hazards in the equipment

6.3.1 Protection from hazardous voltages

Circuitry intended to be connected to a TELECOMMUNICATION NETWORK shall comply with the requirements for TNV CIRCUITS. This applies whether or not such circuitry is OPERATOR-accessible prior to the connection to the TELECOMMUNICATION NETWORK.

NOTE

Examples of circuitry which could be connected to a TELECOMMUNICATION NETWORK include ports of a PABX intended for connection to

- extension telephones, where such extensions could be in remote locations,
- another PABX.

6.3.2 Use of protective earthing

Protective earthing of CLASS I EQUIPMENT shall not rely on the TELECOMMUNICATION NETWORK.

Where protection of the TELECOMMUNICATION NETWORK relies on the protective earthing of the equipment, the equipment installation

instructions and other relevant literature shall state that integrity of protective earthing must be ensured. (See also 1.7.2.)

6.3.3 Particular requirements for pluggable equipment type A

The requirements of 6.3.3 do not apply to equipment intended to be installed by SERVICE PERSONNEL.

The requirements of 6.3.3 do not apply to equipment that needs a connection to earth for functional reasons, provided the equipment has a marking stating that safety requirements are not fulfilled unless the equipment is connected to a wall socket-outlet with protective earth contact.

EN 60950 - European differences

In the second paragraph, **replace** "for functional reasons" by "to enable the equipment to function".

In PLUGGABLE EQUIPMENT TYPE A there shall be insulation between circuitry intended to be connected to a TELECOMMUNICATION NETWORK and any parts or circuitry that may be earthed, either within the equipment under test or via other equipment.

The insulation shall comply with the requirements of SUPPLEMENTARY INSULATION for a PRIMARY CIRCUIT. The following additional requirements apply to any components bridging the insulation:

- capacitors are left in place during electric strength testing of the insulation, and shall not be damaged.
- surge suppressors shall have a minimum d.c. sparkover voltage of 1,6 times the RATED VOLTAGE of the equipment. If left in place during electric strength testing of the insulation, they shall not be damaged.

It is permitted to remove components other than capacitors during electric strength testing of the insulation.

If this option has been chosen, an additional test with a test circuit according to figure 17 is performed with all components in place. The test is performed with a voltage equal to the RATED VOLTAGE of the equipment.

The current flowing in the test circuit shall not exceed 10 mA.

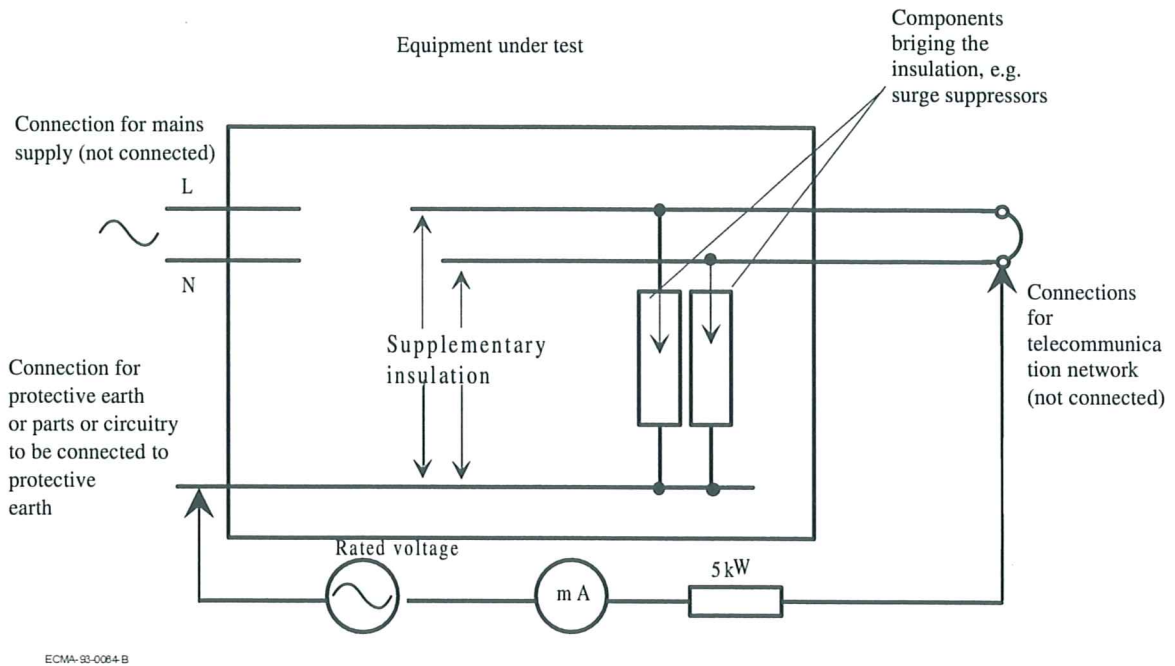


Figure 17 - Test for separation between a telecommunication network and earth

6.4 Protection of the equipment user from voltages on the telecommunication network

6.4.1 Separation from telecommunication network conductors

Equipment shall provide electrical separation complying with the test requirements of 6.4.2, between the port provided for connection of the TELECOMMUNICATION NETWORK conductors, including any conductor required by the TELECOMMUNICATION NETWORK authority to be connected to earth, and each of the following:

- a) unearthed conductive parts and non-conductive parts of the equipment expected to be held or touched during normal use, e.g. a telephone handset or a keyboard;
- b) parts and circuitry that can be touched by the test finger, figure 19, except contacts of connectors that cannot be touched by the test probe, figure 16;
- c) circuitry which is provided for connection of other equipment. This applies whether or not this circuitry is accessible. It does not apply to circuitry carrying TELECOMMUNICATION SIGNALS.

NOTE 1

The purpose of this requirement is to ensure that parts and circuitry which are permitted to be accessible to touch by the user, including SELV CIRCUITS and LIMITED CURRENT CIRCUITS, are adequately isolated from the TELECOMMUNICATION NETWORK.

NOTE 2

In Finland for pluggable equipment it is forbidden to use surge suppressors between the telecommunication network and conductive metallic parts which are permitted to be accessible.

EN 60950 - European differences

Delete note 2.

Finland

For pluggable equipment it is forbidden to use surge suppressors between the telecommunication network and conductive metallic parts which are permitted to be accessible.

6.4.2 Test procedure

Compliance with 6.4.1 is checked by the test of either 6.4.2.1 or 6.4.2.2.

Where circuit analysis and equipment investigation indicate that the results of the tests would be invalidated, for example, where there is a common connection to an earth connection, an exemption from this requirement is permitted.

As an alternative to testing the complete equipment, it is permitted to apply the test to a component (for example a signal transformer) which is clearly intended to provide the separation required. In such a case, the component shall not be bypassed by other components, mounting devices or wiring unless these components or wiring also meet the separation requirements of 6.4.

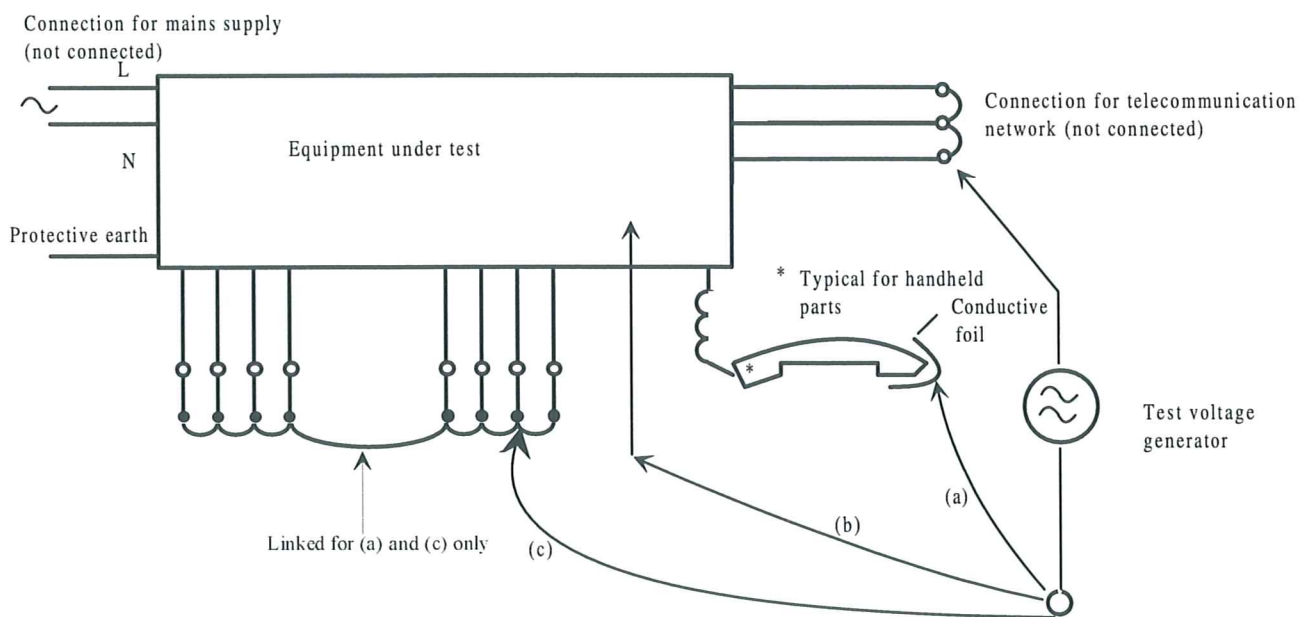
The choice of the tests:

- between those of 6.4.2.1 and 6.4.2.2, and
- between testing the complete equipment or a component

is specified by the manufacturer.

For the tests, all leads connected to the TELECOMMUNICATION NETWORK are connected together (see figure 18). Similarly, all leads intended to be connected to other equipment of a subscriber's installation are connected together.

In the case of non-conductive parts, metal foil is pressed against these parts with a pressure of approx. 0,5 N/cm².



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Figure 18 - Application points of test voltage

6.4.2.1 Impulse test

The electrical separation is subjected to ten impulses of alternating polarity, using the impulse test generator of annex N. The interval between successive impulses is 60 s and the initial voltage, U_c , is:

- in case (a) of 6.4.1: 2,5 kV;
- in cases (b) and (c): 1,5 kV.

NOTE 1

The value of 2,5 kV for case (a) has been chosen primarily to ensure the adequacy of the insulation concerned and it does not necessarily simulate likely overvoltages.

NOTE 2

In Austria, a value of $U_c = 2,0$ kV is used in cases (b) and (c).

EN 60950 - European differences

Delete note 2

Austria (Femmeldebauvorschrift Teil 11)

Equipment shall comply with $U_c = 2,0$ kV in cases b) and c).

6.4.2.2 Electric strength test

The electrical separation is subjected for 60 s to a substantially sinusoidal voltage having a frequency of 50 Hz or 60 Hz, or to a d.c. voltage equal to the peak value of the prescribed a.c. voltage.

The a.c. test voltage is:

- in case (a) of 6.4.1: 1,5 kV;
- in cases b) and c): 1,0 kV.

The voltage is gradually raised from zero to the prescribed voltage and then held at that value for 60 s.

NOTE

Where there are capacitors across the insulation under test, it is recommended that d.c. test voltages are used.

6.4.2.3 Compliance criteria for 6.4.2.1 and 6.4.2.2

During the tests of 6.4.2.1 and 6.4.2.2 there shall be no breakdown of insulation.

Insulation breakdown is considered to have occurred when the current which flows as a result of the application of the test voltage rapidly increases in an uncontrolled manner, i.e. the insulation does not restrict the flow of current.

If a surge suppressor operates (or sparkover occurs within a gas discharge tube) during the test:

- in case a) of 6.4.1 such operation represents a failure;
- in cases b) and c) such operation is permitted during the impulse test. Otherwise, it represents a failure.

For impulse tests, damage to insulation may be checked by an insulation resistance test. The test voltage is 500 V d.c. or, where surge suppressors are present, a d.c. voltage that is 10% less than the surge suppressor operating or striking voltage. The insulation resistance shall not be less than 2 M Ω . Disconnection of surge suppressors is permitted while insulation resistance is being measured.

Alternatively, surge suppressor operation or breakdown through insulation may be judged from the shape of an oscillogram.

NOTE 1

A description of procedures to judge whether surge suppressor operation or breakdown through insulation has occurred, using oscillograms, is given in annex S.

NOTE 2

In installations where overvoltages presented to the equipment may exceed 1,5 kV peak, additional measures such as surge suppression may be necessary.

Part III - Protection from energy hazards

Foreword

This part contains all the requirements related to protection against energy hazards. These requirements shall be applied in conjunction of the requirements of clause 1, and making reference to the definitions of clause 1. Referenced annexes to be found in volume 2 of this Standard.

2.1 Methods of protection against energy hazards

2.1.4 Protection in service access areas

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.

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

NOTE

Precautions against unintentional contact by SERVICE PERSONNEL are not required for any SECONDARY CIRCUITS, including ELV CIRCUITS that operate at less than 42,4 V peak, or 60 V d.c. (see 1.2.14.2).

Bare parts that involve an energy hazard (see 2.1.5) 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.

Any guards required for compliance with this sub-clause shall be easily removable and replaceable if removal is necessary for servicing.

Compliance is checked by inspection.

2.1.5 Energy hazards in operator access areas

There shall be no energy hazard in OPERATOR ACCESS AREAS.

Compliance is checked by means of the test finger, figure 19 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 conductive enclosures

CLEARANCES behind earthed or unearthed conductive ENCLOSURES shall not be reduced to a level that would result in an energy hazard arising during the relevant tests of 4.2 involving a force of 250 N, in equipment to which this test is applicable.

Compliance is checked by inspection.

2.4 Limited current circuits

2.4.1 General requirements

LIMITED CURRENT CIRCUITS shall be so designed that the limits specified in 2.4.2 are not exceeded under normal operating conditions and 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.

Except as permitted in 2.4.3, segregation of parts of LIMITED CURRENT CIRCUITS from other circuits shall be as described in 2.3 for SELV CIRCUITS.

Compliance is checked by inspection and measurement.

2.4.2 Limiting values

- For accessible parts not exceeding 450 V peak or d.c., the circuit capacitance shall not exceed 0,1 μ F.
- For accessible parts exceeding 450 V peak or d.c., but not exceeding 15 000 V peak or d.c., the available stored charge shall not exceed 45 μ C.
- For accessible parts exceeding 15 000 V peak or d.c., the available energy shall not exceed 350 mJ.

2.4.3 Connection of limited current circuits to other circuits

LIMITED CURRENT CIRCUITS are permitted to be supplied from or connected to other circuits, provided that the following conditions are met:

- the LIMITED CURRENT CIRCUIT meets the limits of 2.4.2 under normal operating conditions;
- the LIMITED CURRENT CIRCUIT continues to meet the limits of 2.4.2 in the event of a single failure of any component or insulation in the LIMITED CURRENT CIRCUIT, or of any component or insulation in the other circuit to which it is connected.

If a LIMITED CURRENT CIRCUIT is connected to one or more other circuits, the LIMITED CURRENT CIRCUIT is that part which complies with the requirements of 2.4.1.

2.6 Disconnect devices

All the requirements of 2.6 (see part II) apply.

2.7 Overcurrent and earth fault protection in primary circuits

All the requirements of 2.7 (see part IV) apply.

2.8 Safety interlocks

All the requirements of 2.8 (see part II) apply.

2.10 Connection to other equipment

All the requirements of 2.10 (see part II) apply.

4.2 Mechanical strength and stress relief

All the requirements of 4.2 (see part V) apply.

5.4 Abnormal operation and fault conditions

All the requirements of 5.4 (see part VIII) apply.

Part IV - Prevention of fire hazards

Foreword

This part contains all the requirements related to prevention of fire hazards. These requirements shall be applied in conjunction of the requirements of clause 1, and making reference to the definitions of clause 1. Referenced annexes to be found in volume 2 of this Standard.

2.6 Primary power insulation

All the requirements of 2.6 (see part II) apply.

2.7 Overcurrent and earth fault protection in primary circuits

2.7.1 Basic requirement

Protection against excess currents, short-circuits and earth faults in PRIMARY CIRCUITS shall be provided, either as an integral part of the equipment or as part of the building installation.

NOTE

In countries detailed in the following list, the protective devices necessary to comply with the requirements of 5.4 must be included as part of the equipment: Denmark, Finland, France, Norway, Sweden, United Kingdom.

EN 60950 - European differences

Replace 2.7.1 with the following text:

To protect against excess current, short circuits and earth faults in primary circuits, protective devices shall be included either as an integral part of the equipment or as part of the installation, subject to all of the following a), b) and c):

- a) Except as detailed in b), protective devices necessary to comply with the requirements of 5.4 shall be included as integral part of the equipment.
- b) For components in series with the mains input to the equipment such as the supply cord, appliance coupler, RFI filters and switch, short circuit and earth fault protection may be provided by protective devices in the installation.
- c) If reliance is placed on protection in the building installation, the installation instructions shall comply with 1.7.11 except that for PLUGGABLE EQUIPMENT TYPE A the building installation shall be regarded as providing protection in accordance with the rating of the wall socket outlet and 1.7.11 does not apply.

2.7.2 Faults not covered in 5.4

Protection against faults not covered in 5.4, e.g. short-circuits to protective earth in primary wiring, need not be fitted as an integral part of the equipment. (See also 1.7.11.)

Compliance is checked by inspection.

EN 60950 - European differences

Delete 2.7.2.

2.7.3 Short-circuit protection

Unless appropriate short-circuit backup protection is provided, protective devices shall have adequate breaking (rupturing) capacity to interrupt the maximum fault current (including short-circuit current) which can flow.

For PERMANENTLY CONNECTED EQUIPMENT or PLUGGABLE EQUIPMENT TYPE B, it is permitted for short-circuit backup protection to be in the building installation. (See also 1.7.11.)

For PLUGGABLE EQUIPMENT TYPE A, the building installation is considered as providing short-circuit protection.

NOTE

Appropriate conditions for short-circuit testing are under consideration.

Compliance is checked by inspection and by the tests of 5.4.

2.7.4 Number and location of protective devices

Protective 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 earthing conductor).

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

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

NOTE

For protective devices that are an integral part of the equipment, examples of the minimum number and location of fuses or circuit breaker poles are given in table 1 for single-phase equipment or sub-assemblies and in table 2 for three-phase equipment. The examples are not necessarily valid for protective devices in the building installation.

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

	Protection against	Minimum number of fuses or circuit-breaker poles	Location
Equipment to be connected to POWER SYSTEMS with earthed neutral reliably identified	Earth faults	1	Phase conductors
	Overcurrent	1	Either of the two conductors
Equipment to be connected to any supply, including IT POWER SYSTEMS and supplies with reversible plugs	Earth faults	2	Both conductors
	Overcurrent	1	Either of the two conductors

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 three conductors
		Overcurrent	2	Any two conductors
With earthed neutral (TN or TT)	4	Earth faults	3	Each phase conductor
		Overcurrent	3	Each phase conductor
With unearthed neutral	4	Earth faults	4	All four conductors
		Overcurrent	3	Each phase conductor

2.7.5 Protection by several devices

Where protective devices are used in more than one pole of a supply to a given load, those devices shall be located together. It is permitted to combine two or more protective devices in one component.

Compliance is checked by inspection.

2.7.6 Warning to service personnel

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 single phase CLASS I EQUIPMENT connected to a polarised supply; and
- 2) where, after operation of the protective device, parts of the equipment that remain under voltage might represent a hazard during servicing.

NOTE

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

2.10 Interconnection of equipment

All the requirements of 2.10 (see part II) apply.

2.11 Limited power source

A limited power source shall incorporate an isolating transformer and shall comply with one of the following:

- the output of the isolating transformer is inherently limited in compliance with table 8;
- a fixed impedance limits the output in compliance with table 8;
- an overcurrent protective device is used and the output is limited in compliance with table 9;
- a regulating network limits the output in compliance with table 8, both under normal operating conditions and after any single fault in the regulating network (open-circuit or short-circuit);
- a regulating network limits the output in compliance with table 8 under normal operating conditions,
- and an overcurrent protective device limits the output in compliance with table 9 after any single fault in the regulating network (open-circuit or short-circuit).

Where an overcurrent protective device is used, it shall be a fuse or a non-adjustable non-autoreset electromechanical device.

NOTE 1

In Denmark and Finland a limited power source shall incorporate an isolating transformer and shall comply with the following:

- the open circuit voltage shall not exceed 42,4 V peak or d.c. and shall not generate voltages above that value;
- the current which may be drawn for more than 2 min. at any load, including short circuits, shall not exceed 0,2 A.

Table 8 - Limits for inherently limited power sources

Output voltage ¹⁾ (U_{oc})		Output current ²⁾ (I_{sc})	VA ³⁾ (V x A)
V a.c.	V d.c	A	
< 20	≤ 20	≤ 8,0	≤ 5 x U_{oc}
20 < U_{oc} < 30	20 < U_{oc} ≤ 30	≤ 8,0	≤ 100
-	30 < U_{oc} ≤ 60	≤ 150 / U_{oc}	≤ 100

Conditions applicable to table 8

- 1 U_{oc} : Output voltage measured in accordance with 1.4.5 with all load circuits disconnected. Voltages are for sinusoidal a.c. and ripple-free d.c. For non-sinusoidal a.c., and for d.c. with ripple greater than 10% peak, the peak voltage shall not exceed 42,4 V.
- 2 I_{sc} : Maximum output current after 60 s of operation with any non-capacitive load, including short-circuit.
- 3 VA: Maximum output VA with any load. Initial transients lasting less than 100 ms are ignored.

NOTE 2

In Norway the maximum value of VA for values of U_{oc} exceeding 10 V is 50.

**Table 9 - Limits for power sources not inherently limited
(overcurrent protective device required)**

Output voltage ¹⁾ (U_{oc})		Output current ²⁾ (I_{sc})	VA ³⁾	Rated current value of overcurrent protective device ⁴⁾
V a.c.	V d.c.	A	(V x A)	A
≤ 20	≤ 20	≤ 1000 U_{oc}	≤ 250	≤ 5,0
20 < U_{oc} ≤ 30	20 < U_{oc} ≤ 30			≤ 100 / U_{oc}
-	30 < U_{oc} ≤ 60			≤ 100 / U_{oc}

Conditions applicable to Table 9

- 1 U_{OC} : Output voltage measured in accordance with 1.4.5 with all load circuits disconnected. Voltages are for sinusoidal a.c. and ripple-free d.c. For non- sinusoidal a.c., and for d.c. with ripple greater than 10% peak, the peak voltage shall not exceed 42,4 V.
- 2 I_{SC} : Maximum output current after 60 s of operation with any non-capacitive load, including short-circuit, and with any overcurrent protective devices bypassed.
- 3 VA : Maximum output VA with any load and with overcurrent protective devices bypassed. Initial transients lasting less than 100 ms are ignored.
- 4 The rated current values of overcurrent protective devices are based on fuses and circuit-breakers that break the circuit within 120 s with a current equal to 210% of the rated current value specified in the table.

NOTE 3

In Norway the maximum value of VA is 50.

EN 60950 - European differences

Delete notes 1, 2 and 3.

Denmark (Heavy Current Regulations)

Finland (Decree N° 205/74)

A limited power source shall incorporate an isolating transformer and shall comply with the following:

- the open circuit voltage shall not exceed 42,4 V peak d.c. and shall not generate voltages above that value;
- the current which may be drawn for more than two minutes at any load, including short circuits, shall not exceed 0,2 A.

Norway (National Building Installation Specifications - February 1991)

- Table 8 - Limits for inherently limited power sources
In Norway, the maximum value of VA for values of U_{OC} exceeding 10 V is 50.
- Table 9 - Limits for power sources not inherently limited (overcurrent protective device required)
In Norway, the maximum value of VA is 50.

4.2 Mechanical strength and stress relief

All the requirements of 4.2 (see part V) apply.

4.3 Construction details

4.3.1 Supply voltage selection

Equipment which can be adjusted to suit different primary power supply voltages shall be so constructed that changing of the setting requires the use of a TOOL if incorrect setting causes a hazard.

Compliance is checked by manual test.

4.3.2 Accessible control devices

Equipment shall be so constructed that manual adjustment of accessible control devices requires the use of a TOOL if inadvertent adjustment might create a hazard.

Compliance is checked by manual test.

4.3.12 Radiation

Equipment that can generate ionising radiation or ultraviolet light or that uses a laser, or in which flammable liquids, flammable gases or similar hazards are present, shall be so designed that harmful effect to persons and damage to materials affecting safety are prevented.

*Except for equipment using lasers or generating ionising radiation, compliance is checked by inspection.
For ionising radiation compliance is checked by the test in annex H.
For equipment using lasers, compliance is checked according to IEC 825.*

4.3.14 Openings in enclosures

Openings in the top and sides of FIRE ENCLOSURES and of ELECTRICAL ENCLOSURES, excluding openings in OPERATOR ACCESS AREAS within an ENCLOSURE, shall comply with 4.3.15 and 4.3.16 as appropriate.

NOTE 1

The examples of figures 8, 9 and 10 are not intended to be used as engineering drawings but are only shown to illustrate the intent of these requirements.

NOTE 2

Requirements for equipment to be installed in RESTRICTED ACCESS LOCATIONS are under consideration.

4.3.15 Openings on top of enclosures

In the top of FIRE ENCLOSURES and of ELECTRICAL ENCLOSURES, openings directly over bare parts at HAZARDOUS VOLTAGE shall comply with one of the following:

- not exceed 5 mm in any dimension, or
- not exceed 1 mm in width regardless of length, or
- be so constructed that direct, vertical entry of a falling object is prevented from reaching such bare parts by means of a trap or restrictions. (See figure 8 for examples of top cover designs that prevent such direct entry.)



Slanted openings

Vertical openings

ECMA-93-0075-B

Figure 8 - Examples of cross-sections of designs of openings preventing vertical access

Compliance is checked by inspection and measurement, all doors, panels, covers etc. provided with the equipment being closed.

4.3.16 Openings on sides of enclosures

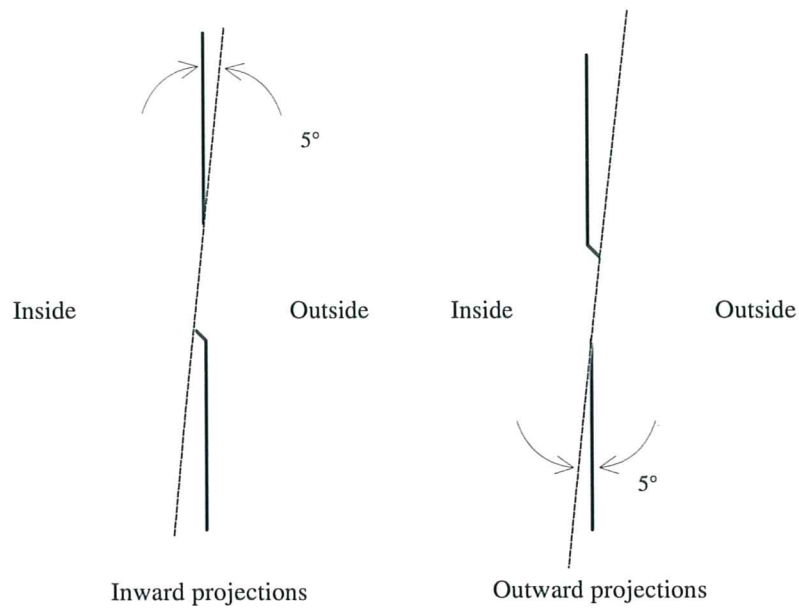
Openings in the sides of FIRE ENCLOSURES and of ELECTRICAL ENCLOSURES shall comply with one of the following:

- not exceed 5 mm in any dimension, or
- not exceed 1 mm in width regardless of length, or

- be provided with louvres that are shaped to deflect outwards an external vertically falling object (see figure 9 for examples), or
- be so located that an object, upon entering the ENCLOSURE, is unlikely to fall on bare parts at HAZARDOUS VOLTAGES (see figure 10 for an example).

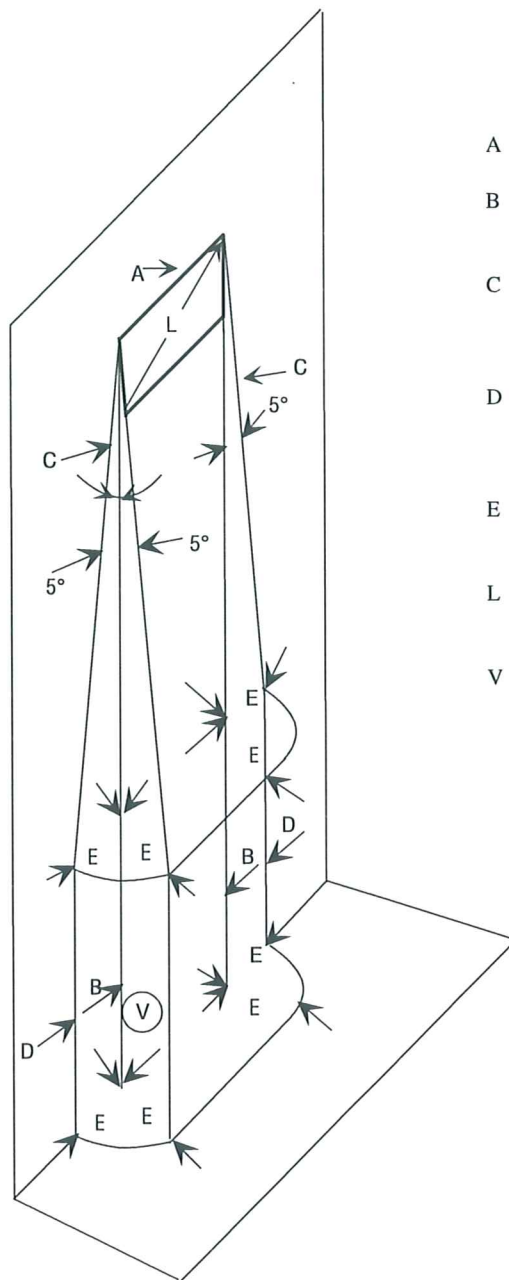
Where a portion of the side of the FIRE ENCLOSURE falls within the area as traced out by the 5° angle in figure 11, the limitations in 4.4.6 on sizes of openings in bottoms of FIRE ENCLOSURES also apply to this portion of the side.

Compliance is checked by inspection and measurement, all doors, panels, covers etc. provided with the equipment being closed.



ECMA-93-0076-B

Figure 9 - Examples of louvre design



- A ENCLOSURE side opening.
- B Vertical projection of the outer edges of the side opening.
- C Inclined lines that project at a 5° angle from the edges of the side opening to points located E distance from B.
- D Line which is projected straight downward in the same plane as the ECLOSURE side wall.
- E Projection of the opening (not to be greater than L).
- L Maximum dimension of the ENCLOSURE side opening.
- V Volume in which bare parts at HAZARDOUS VOLTAGE are not located.

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Figure 10 - Example of enclosure side opening

4.3.17 Plug and socket mismatching

Within a manufacturer's unit or system, plugs and sockets likely to be used by the OPERATOR or by SERVICE PERSONNEL shall not be employed in a manner likely to create a hazard due to mismatching. Keying, location, or in the case of connectors accessible only to SERVICE PERSONNEL, clear marking, is permitted to meet the requirement.

Compliance is checked by inspection.

4.3.19 Liquids under pressure

Equipment that, in normal use, contains liquid shall incorporate adequate safeguards against the risk of build-up of excessive pressure.

Compliance is checked by inspection and, if necessary, by an appropriate test.

4.3.20 Earth faults in heating elements, fire prevention

Heating elements in CLASS I EQUIPMENT shall be protected so that, under earth fault conditions, a fire hazard due to overheating is prevented. In such equipment, temperature sensing devices, if any, shall disconnect all phase conductors supplying the heating elements.

The temperature sensing devices shall also disconnect the neutral conductor:

- a) on equipment supplied from an IT POWER SYSTEM;
- b) on PLUGGABLE EQUIPMENT supplied through a reversible appliance coupler or a reversible plug;
- c) on equipment supplied from a socket-outlet with indeterminate polarity.

In cases b) and c), it is permitted to meet this requirement by connecting a THERMOSTAT in one conductor and a THERMAL CUT-OUT in the other conductor.

Compliance is checked by inspection.

4.3.21 Batteries

Equipment employing lithium cells or similar batteries shall be designed to prevent reverse polarity installation of the battery and to prevent forced charge or forced discharge if this would result in a hazard. The short- or open-circuiting of any protective component, one at a time, shall not result in a fire or explosion hazard through the resultant forced discharge or forced charge over an extended period of time.

Compliance is checked by inspection and test.

4.4 Resistance to fire

4.4.1 Methods of achieving resistance to fire

NOTE 1

When applying the requirements in this standard, foamed materials of CLASS HF-1 are regarded as better than those of CLASS HF-2, and HF-2 better than HBF. Similarly, other materials, including rigid (engineering structural) foam, of CLASSES 5V or V-0 are regarded as better than those of CLASS V-1, V-1 better than V-2, and V-2 better than HB.

Sub-clause 4.4 specifies requirements intended to minimise the risk of ignition and the spread of flame, both within the equipment and to the outside.

There are two methods of providing protection against ignition and spread of flame that could affect electronic components such as integrated circuits, transistors, thyristors, diodes, resistors and capacitors:

1. Selection and application of components and materials which minimise the possibility of ignition and spread of flame. The appropriate requirements are detailed in 4.4.2 and 4.4.3.
2. Application of the simulated fault tests in 5.4.6, third dashed paragraph.

NOTE 2

Method 1 may be preferred for equipment with a large number of electronic components. Method 2 may be preferred for equipment with a small number of electronic components.

4.4.2 Minimising the risk of ignition

The risk of ignition due to high temperature shall be minimised by the appropriate use of components and by suitable construction.

Electrical components shall be used in such a way that their maximum working temperature under NORMAL LOAD conditions is less than that necessary to cause ignition of their surroundings or of lubricating materials with which they are likely to come into contact. The limits in 5.1 shall not be exceeded for the surrounding material.

Components working at high temperatures shall be effectively shielded or separated to prevent overheating of their surrounding materials and components.

Where it is not practical to protect components against overheating under fault conditions, the components shall be mounted on materials of FLAMMABILITY CLASS V-1, or better, and shall be separated from less fire-resistant material by at least 13 mm of air.

NOTE
See also 1.5.4.

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

4.4.3 Flammability classification of materials and components

4.4.3.1 Propagation of fire

Components and parts inside a FIRE ENCLOSURE, and air filter assemblies (see 4.4.3.6), shall be so constructed, or shall make use of such materials, that the propagation of fire is minimised.

In considering how to minimise propagation of fire, and what are "small parts", account shall be taken of the cumulative effect of small parts when they are adjacent to each other, and also of the possible effect of propagating fire from one part to another.

Compliance with 4.4.3.2 to 4.4.3.6 is checked by inspection and, where necessary, by the appropriate tests of annex A.

4.4.3.2 Material and components

Except as specified in 1.5.4 and elsewhere in 4.4.3, all materials and components shall comply with one of the following:

- they shall have a FLAMMABILITY CLASS of V-2 or better;
- they shall have a FLAMMABILITY CLASS of HF-2 or better;
- they shall pass the flammability test described in clause A.2.

4.4.3.3 Exemptions

The requirements of 4.4.3.2 do not apply to:

- materials and components within an ENCLOSURE of 0,06 m³ or less consisting totally of metal and having no ventilation openings, or within a sealed unit containing an inert gas;
- one or more layers of thin insulating material, such as adhesive tape, used directly on any surface within a FIRE ENCLOSURE, including the surface of current-carrying parts, provided that the combination of the thin insulating material and the surface of application complies with the requirements of flammability CLASS V-2, or better, or HF-2, or better.

NOTE

Where the thin insulating material referred to in the above exclusion is on the inner surface of the FIRE ENCLOSURE itself, the requirements in 4.4.4 continue to apply to the FIRE ENCLOSURE.

- components meeting the flammability requirements of a relevant IEC component standard which includes such requirements;
- meter cases (if otherwise determined to be suitable for mounting of parts at HAZARDOUS VOLTAGE), meter faces and indicator lamps or jewels;
- the following parts, provided that they are separated from electrical parts (other than insulated wires and cables) which under fault conditions are likely to produce a temperature that could cause ignition, by at least 13 mm of air or by a solid barrier of material of FLAMMABILITY CLASS V-1, or better:
 - gears, cams, belts, bearings and other small parts which would contribute negligible fuel to a fire;
 - tubing for air or any fluid systems, containers for powders or liquids, and foamed plastic parts, provided that they are of FLAMMABILITY CLASS HB or better, or FLAMMABILITY CLASS HBF or better;
 - parts which are required to have particular properties in order to perform intended functions, such as rubber rollers for paper pick-up and delivery, and ink tubes;
- integrated circuit packages, transistor packages, optocoupler packages, capacitors and other small parts mounted on material of FLAMMABILITY CLASS V-1 or better.

4.4.3.4 **Wiring harnesses**

A wiring harness shall comprise individual materials which are of FLAMMABILITY CLASS V-2, or better, or which comply with the flammability requirements of relevant IEC standards. Exempt from this requirement are:

- PVC, TFE, PTFE, FEP, and neoprene insulation on wiring;
- individual clamps (not including helical wraps or other continuous forms), lacing tape, twine and cable ties.

4.4.3.5 **Cord anchorage bushings**

Cord anchorage bushings applied over PVC jacketed power supply cords shall be of FLAMMABILITY CLASS HB or better.

4.4.3.6 **Air filter assemblies**

Air filter assemblies shall be constructed of materials of FLAMMABILITY CLASS V-2, or better, or of HF-2, or better, except that the following constructions need not comply with this requirement:

- air filter assemblies in air circulating systems, whether or not airtight, that are not intended to be vented outside the FIRE ENCLOSURE
- air filter frames constructed of materials of FLAMMABILITY CLASS HB, provided that they are separated from electrical parts (other than insulated wires and cables) which under fault conditions are likely to produce a temperature that could cause ignition, by at least 13 mm of air or by a solid barrier of material of FLAMMABILITY CLASS V-1, or better;
- air filter assemblies located inside or outside a FIRE ENCLOSURE, provided that the filter materials are separated by a metal screen from parts that could cause ignition. This screen may be perforated and shall meet the requirements of 4.4.6 for the bottoms of FIRE ENCLOSURES.
- air filter assemblies located external to the FIRE ENCLOSURE, constructed of materials of FLAMMABILITY CLASS HB or better, or FLAMMABILITY CLASS HBF or better.

4.4.4 **Materials for enclosures and for decorative parts**

Materials used for ENCLOSURES of equipment shall be such that the risk of ignition and the spread of fire or flames are minimised.

Metals, ceramic materials, and glass which is heat-resistant tempered or wired or laminated, are considered to comply without test.

MECHANICAL ENCLOSURES, ELECTRICAL ENCLOSURES and parts of such ENCLOSURES, if located externally to FIRE ENCLOSURES, and DECORATIVE PARTS, shall be of flammability CLASS HB or better, except that small external DECORATIVE PARTS that would contribute negligible fuel to a fire, such as nameplates, mounting feet, key caps, knobs and the like, shall be exempt from this requirement.

NOTE 1

Where MECHANICAL or ELECTRICAL ENCLOSURES also serve as FIRE ENCLOSURES, the more stringent requirements for FIRE ENCLOSURES apply. For ENCLOSURES or parts of ENCLOSURES, inside FIRE ENCLOSURES, 4.4.3 has more stringent requirements.

For MOVABLE EQUIPMENT having a total mass not exceeding 18 kg, FIRE ENCLOSURES are considered to comply without test if in the smallest thickness used the material is of FLAMMABILITY CLASS V-1 or better. Alternatively, such FIRE ENCLOSURES are permitted if they pass the test of clause A.2.

For MOVABLE EQUIPMENT having a total mass exceeding 18 kg and for all STATIONARY EQUIPMENT, FIRE ENCLOSURES are considered to comply without test if in the smallest thickness used the material is of FLAMMABILITY CLASS 5V. Alternatively, such FIRE ENCLOSURES are permitted if they pass the test of clause A.1.

ENCLOSURES or parts of ENCLOSURES that are located within 13 mm of arcing parts, such as unenclosed commutators and unenclosed switch contacts, shall also pass the test of clause A.3.

ENCLOSURES or parts of ENCLOSURES that are located within 13 mm of parts which, under any condition of normal or abnormal operation, could attain a temperature sufficient to ignite the ENCLOSURE shall also pass the test of clause A.4.

Components which fill an aperture in a FIRE ENCLOSURE and which are intended to be mounted in this way, need not be evaluated for compliance with the flammability requirements for FIRE ENCLOSURES, provided that the components comply with the safety aspects of the relevant IEC component standard.

NOTE 2

Examples of these components are fuseholders, switches, pilot lights, connectors, and appliance inlets.

Compliance is checked by examination and, where necessary, by test.

NOTE 3

In the United States of America, additional requirements apply to ENCLOSURES and DECORATIVE PARTS of equipment used in special computer rooms.

EN 60950 - European differences

Delete note 3

4.4.5 Conditions for fire enclosures

4.4.5.1 Components requiring a fire enclosure

Except as noted in 4.4.5.2, the following components require a FIRE ENCLOSURE:

- components having unenclosed arcing parts, such as open switch and relay contacts and commutators;
- components having windings, such as transformers, solenoids and relays;
- wiring;
- semiconductor devices, such as transistors, diodes, and integrated circuits;
 - resistors, capacitors, and inductors;
 - components within a limited power source (see 2.11) including over-current protective devices, limiting impedances, regulating networks and wiring up to the point where the limited power source output criteria are met.

4.4.5.2 Components not requiring a fire enclosure

The following components do not require a FIRE ENCLOSURE:

- wiring and cables insulated with PVC, TFE, PTFE, FEP or neoprene, and their connectors;
- motors that comply with annex B;
- components in a SECONDARY CIRCUIT supplied by a limited power source complying with 2.11, provided that:
 - the components are mounted on materials of FLAMMABILITY CLASS V-1 or better, and
 - the wiring used in such circuits is insulated with PVC, TFE, PTFE, FEP or neoprene.

4.4.6 Fire enclosure construction

NOTE

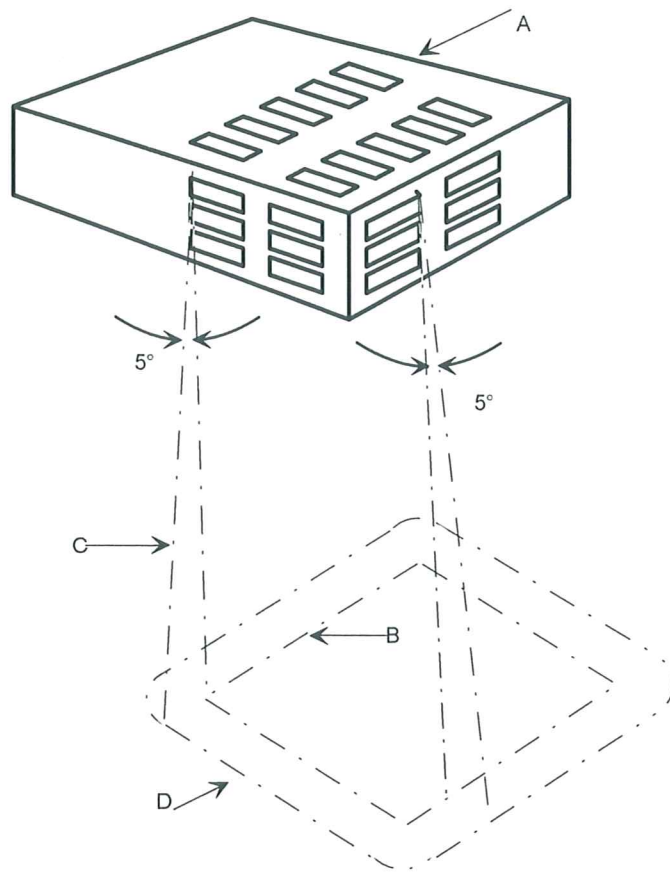
See also 4.3.14, 4.3.15 and 4.3.16.

In order to minimise the possibility of emission of flame, molten metal, flaming or glowing particles or flaming drops, a FIRE ENCLOSURE shall comply with the following requirements.

Equipment that can be energised only if an OPERATOR is in attendance is exempt from these requirements if it is clear that failure would be evident to the OPERATOR.

Except as specified elsewhere in 4.4.6, the bottom of a FIRE ENCLOSURE, or individual barriers, shall provide protection under all internal parts, including partially enclosed components or assemblies, which, under fault conditions, could emit material likely to ignite the supporting surface. The bottom or barrier shall be located as, and no smaller in area than, indicated in figure 11, and be horizontal, lipped or otherwise shaped to provide equivalent protection.

An opening for drainage, ventilation etc. shall be protected by a baffle, screen or the like so that molten metal, burning material and the like cannot fall outside the FIRE ENCLOSURE.



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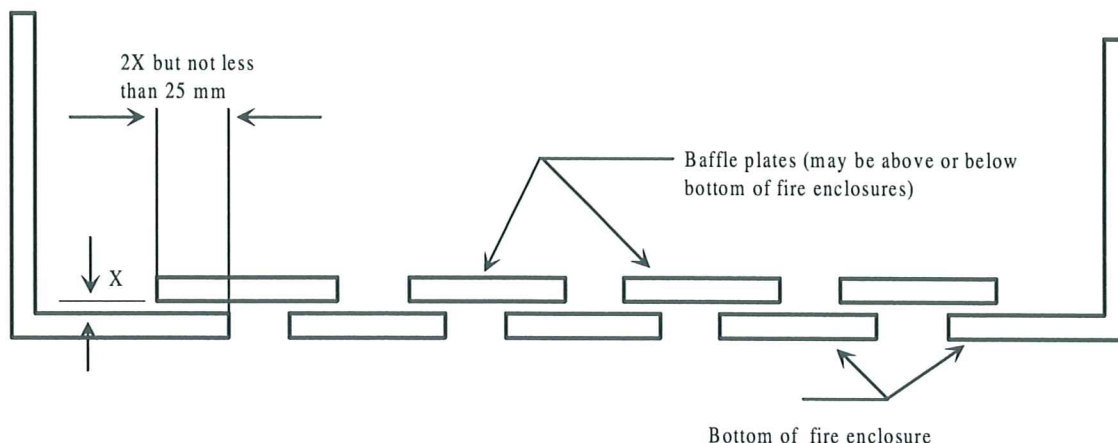
- A** The portion of a component under which a FIRE ENCLOSURE is required, for example, under those openings in a component or assembly through which flaming particles might be emitted. If the component or assembly does not have its own FIRE ENCLOSURE, the area to be protected is the entire area occupied by the component or assembly.
- B** The outline of the area of A projected vertically downward onto the horizontal plane of the lowest point of the FIRE ENCLOSURE.
- C** Inclined line that traces an outline D on the same plane as B. Moving around the perimeter of the outline B, this line projects at a 5° angle from the vertical at every point around the perimeter of the openings in A and is oriented to trace out the largest area.
- D** Minimum outline of the bottom of the FIRE ENCLOSURE. A portion of the side of a FIRE ENCLOSURE which is within the area traced out by the 5° angle is also considered to be part of the bottom of the FIRE ENCLOSURE.

Figure 11 - Typical bottom of a fire enclosure for partially enclosed component or assembly

Compliance is checked by inspection and, where necessary, by the test of clause A.5.

The following constructions are considered to satisfy the requirement without test:

- *no opening in the bottom of a FIRE ENCLOSURE;*
- *openings in the bottom of any size under:*
 - PVC, TFE, PTFE, FEP and neoprene insulated conductors and their connectors;*
 - impedance or thermally protected motors;*
 - an internal barrier, screen or the like which itself complies with the requirements for a FIRE ENCLOSURE (see also 4.2.1);*
- *openings in the bottom, each not larger than 40 mm² under*
 - components of FLAMMABILITY CLASS V-1 or better, or FLAMMABILITY CLASS HF-1 or better;*
 - parts made of material of FLAMMABILITY CLASS V-1 or better, or FLAMMABILITY CLASS HF-1 or better;*
- *baffle plate construction as illustrated in figure 12;*
- *metal bottoms of FIRE ENCLOSURES conforming with the dimensional limits of any line in table 15;*
- *metal bottom screens having a mesh not greater than 2 mm X 2 mm and a wire diameter of not less than 0,45 mm.*



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Figure 12 - Baffle plate construction

Table 15 - Size and spacing of holes in metal bottoms of FIRE ENCLOSURES

Minimum thickness mm	Maximum diameter of holes mm	Minimum spacing of holes centre to centre mm
0,66	1,14	1,70 (233 holes/645 mm ²)
0,66	1,19	2,36
0,76	1,15	1,70
0,76	1,19	2,36
0,81	1,91	3,18 (72 holes/645 mm ²)
0,89	1,90	3,18
0,91	1,60	2,77
0,91	1,98	3,18
1,00	1,60	2,77
1,00	2,00	3,00

4.4.7 Doors or covers in fire enclosures

If part of a FIRE ENCLOSURE consists of a door or cover leading to an OPERATOR ACCESS AREA, one of the following requirements shall apply:

- the door or cover shall be interlocked to comply with the requirements in 2.8;
- a door or cover, intended to be routinely opened by the OPERATOR, shall comply with both of the following conditions:
 - It shall not be removable from the FIRE ENCLOSURE by the OPERATOR;
 - It shall be provided with a means to keep it closed during normal operation;
- a door or cover intended only for occasional use by the OPERATOR, such as for the installation of accessories, shall be permitted to be removable provided the equipment instructions include directions for correct removal and replacement of the door or cover.

Compliance is checked by inspection.

4.4.8 Flammable liquids

If flammable liquid is used in equipment, the liquid shall be kept in a closed reservoir, except for the amount needed for the functioning of the equipment. The maximum quantity of flammable liquid stored in an equipment shall in general be not more than 5 litres. If, however, the usage of liquid is such that more than 5 litres is consumed in 8 h, the quantity stored is permitted to be increased to that required for 8 h operation.

Oil or equivalent fluids used for lubrication or in a hydraulic system shall have a flash point of 149°C, or higher, and the reservoir shall be of sealed construction. The system shall have provision for expansion of the fluid and shall incorporate means for pressure relief. This requirement is not applicable to lubricating oils which are applied to points of friction in quantities which would contribute negligible fuel to a fire.

Except under conditions given below, replenishable liquids such as printing inks, shall have a flash point of 60°C, or higher, and shall not be under pressure sufficient to cause atomisation.

Replenishable flammable liquids which have a flash point of less than 60°C or which are under sufficient pressure to cause atomisation are permitted provided inspection shows that there is no likelihood of liquid sprays or build-up of flammable vapour-air mixtures which could cause explosion or fire hazard. Under normal operating conditions, equipment using a flammable liquid shall not generate a mixture with a concentration exceeding one quarter of the EXPLOSION LIMIT if the mixture is in proximity to an ignition source, or exceeding half the EXPLOSION LIMIT if the mixture is not in proximity to an ignition source. The investigation shall also take into account the integrity of the liquid handling system. The liquid handling system shall be suitably housed or constructed so as to avoid the risk of fire or explosion, even under the test conditions specified in 4.2.4.

Compliance is checked by inspection and, where necessary, by the following test:

The equipment is operated in accordance with 5.1 until its temperature stabilises. In this condition, the equipment is operated in a normal manner, as directed by the manufacturer's instructions, and samples of the atmosphere in the vicinity of the electrical components and around the equipment are taken to determine the concentration of flammable vapours present.

Samples of the atmosphere are taken at 4 min intervals: four samples to be taken during normal operation, then seven samples after the equipment has stopped.

If, after the equipment has stopped, the concentration of flammable vapours appears to be increasing, samples shall continue to be taken at 4 min intervals until the concentration is shown to be decreasing.

If an abnormal operation of the equipment is possible with any of its fans not running, this condition is simulated during this compliance test.

5.4 Abnormal operation and fault conditions

All the requirements of 5.4 (see part VIII) apply.

Part V - Protection from mechanical hazards

Foreword

This part contains all the requirements related to protection from mechanical hazards. These requirements shall be applied in conjunction of the requirements of clause 1, and making reference to the definitions of clause 1. Referenced annexes to be found in volume 2 of this Standard.

2.6 Disconnect devices

2.6.1 General

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

Compliance is checked by inspection.

2.8 Safety interlocks

All the requirements of 2.8 (see part II) apply.

4.1 Stability and mechanical hazards

4.1.1 Stability tests

Under conditions of normal use, units and equipment shall not become physically unstable to the degree that they could become a hazard to OPERATORS and SERVICE PERSONNEL.

Where a reliable stabilising means is provided to improve stability when drawers, doors, etc. are opened, it shall be automatic in operation when associated with OPERATOR use. Where it is not automatic, suitable and conspicuous markings shall be provided to caution SERVICE PERSONNEL.

Where units are designed to be fixed together on site and not used individually, the stability of individual units shall not be considered.

The requirements of 4.1.1 are not applicable when the installation instructions for a unit specify that the equipment is to be secured to the building structure before operation.

Compliance is checked by the following tests, where relevant. Each test is carried out separately. During the test, containers are to contain the amount of substance within their rated capacity producing the most disadvantageous condition. All castors and jacks, if used in normal operation, are placed in their most unfavourable position, with wheels and the like locked or blocked. However, if the castors are intended only to transport the unit, and if jacks are required to be lowered after installation by the manufacturer's instructions, then the jacks (and not the castors) are used in this test; the jacks are placed in their most unfavourable position, consistent with reasonable levelling of the unit.

- *A unit shall not overbalance when tilted to an angle of 10° from its normal upright positions. Doors, drawers, etc. are closed during this test.*
- *A floor-standing unit having a mass of 25 kg or more shall not tip over when a force equal to 20% of the weight of the unit, but not more than 250 N, is applied in any direction except upwards, at a height not exceeding 2 m from the floor. Doors, drawers, etc. which may be moved for servicing by OPERATOR or SERVICE PERSONNEL are placed in their most unfavourable position, consistent with the manufacturer's instructions.*
- *A floor-standing unit shall not overbalance when a constant downward force of 800 N is applied at the point of maximum moment to any horizontal working surface, or surface offering an obvious foothold, at a height not exceeding 1 m from the floor. Doors, drawers, etc. are closed during this test.*

4.1.2 Guarding of hazardous moving parts

Except as permitted in 4.1.3, hazardous moving parts of equipment shall be so arranged or enclosed or guarded as to provide adequate protection against the risk of personal injury.

Protection for the OPERATOR shall be provided by a suitable construction preventing access to hazardous moving parts.

Permitted methods include:

- locating the moving parts in areas that are not OPERATOR ACCESS AREAS, or
- locating the moving parts in an ENCLOSURE that is provided with mechanical or electrical SAFETY INTERLOCKS that remove the hazard when access is gained.

Protection for SERVICE PERSONNEL shall be provided such that unintentional contact with hazardous moving parts is unlikely during servicing operations involving other parts of the equipment.

A MECHANICAL ENCLOSURE shall be sufficiently complete to contain or deflect parts which, because of failure or for other reasons, might become loose, separated or thrown from a moving part.

AUTOMATIC RESET THERMAL CUT-OUTS or overcurrent protection devices, automatic timer starting, etc. shall not be incorporated if their unexpected resetting might cause danger.

Compliance is checked by inspection and by a test with the test finger, figure 19.

It shall not be possible to touch hazardous moving parts with the test finger, applied without appreciable force in every possible position.

Apertures preventing the entry of the test finger, figure 19, are further tested by means of a straight unjointed version of the test finger applied with a force of 30 N. If the unjointed finger enters, the test with the test finger, figure 19, is repeated, the finger being pushed through the aperture if necessary.

4.1.3 Accessible moving parts

When hazardous moving parts directly involved in the process (e.g. moving or rotating parts of a paper cutter or shredder) cannot be made completely inaccessible during operation, and where the hazard associated with the parts is obvious to the OPERATOR, a warning shall be considered adequate protection.

In such a case where the possibility also exists that fingers, jewellery, clothing etc. can be drawn into the moving parts (e.g. where gears or shredder blades mesh), means shall be provided to stop the moving part.

The warning and, where relevant, the means provided for stopping the moving part, shall be placed in a prominent position readily visible and accessible from the point where the risk of injury is highest.

Compliance is checked by inspection.

4.1.4 Sharp edges

Edges or corners, except those required for proper equipment functioning, shall be rounded and smoothed (no abrupt discontinuity) when they could otherwise be hazardous to OPERATORS because of location or application in the equipment.

Compliance is checked by inspection.

4.1.5 High pressure lamps

The MECHANICAL ENCLOSURE of a high pressure lamp shall have adequate strength to contain an explosion of the lamp so as to prevent a hazard to an OPERATOR or person near the equipment during normal use or OPERATOR servicing.

For the purpose of this standard, a "high pressure lamp" means one in which the pressure exceeds 0,2 MPa when cold or 0,4 MPa when operating.

Compliance is checked by inspection.

4.2 Mechanical strength and stress relief

4.2.1 General

ENCLOSURES shall have adequate mechanical strength and shall be so constructed as to withstand such rough handling as may be expected in normal use.

Mechanical strength tests are not required on an internal barrier, screen or the like, provided to meet the requirements of 4.6.6, if the ENCLOSURE provides mechanical protection.

Compliance is checked for all equipment by the relevant steady force and impact tests of 4.2.2 to 4.2.4. HAND-HELD EQUIPMENT is also subjected to the drop test of 4.2.5.

Alternatively, compliance with this subclause is checked by examination of the construction and available data.

The tests are not applied to handles, levers, knobs, nor to transparent or translucent covers of indicating or measuring devices unless parts at HAZARDOUS VOLTAGE are accessible by means of the test finger (figure 19), if the cover is removed.

For tests to be applied to the face of cathode ray tubes see 4.2.7.

4.2.2 Steady force test, 30 N

Parts of an ENCLOSURE located in an OPERATOR ACCESS AREA, which are protected by a cover or door meeting the requirements of 4.2.3, are subject to a steady force of $30\text{ N} \pm 3\text{ N}$ for a period of 5 s applied by means of a straight, unjointed version of the test finger, figure 19, to the part on or within the complete equipment or on a separate sub-assembly.

After this test the sample shall comply with the requirements of 2.1.2, 2.1.5, 2.5.1, 2.5.2, 2.9, 3.2,5 and 4.1.2, and shall show no signs of interference with the operation of safety features such as THERMAL CUT-OUTS, overcurrent protection devices or interlocks. In case of doubt, SUPPLEMENTARY or REINFORCED INSULATION is subjected to an electric strength test as specified in 5.3.2.

Damage to finish, cracks, dents and chips that do not adversely affect safety or protection against water, and surface cracks in fibre-reinforced mouldings and the like, are ignored.

NOTE

If a separate ENCLOSURE or part of an ENCLOSURE is used for a test, it may be necessary to reassemble such parts on the equipment in order to check compliance.

4.2.3 Steady force test, 250 N

External ENCLOSURES are subjected to a steady force of $250\text{ N} \pm 10\text{ N}$ for a period of 5 s applied to the ENCLOSURE, fitted to the equipment, by means of a suitable test tool providing contact over a circular plane surface 30 mm in diameter.

After this test the sample shall comply with the requirements of 2.1.2, 2.1.5, 2.5.1, 2.5.2, 2.9, 3.2,5 and 4.1.2, and shall show no signs of interference with the operation of safety features such as THERMAL CUT-OUTS, overcurrent protection devices or interlocks. In case of doubt, SUPPLEMENTARY or REINFORCED INSULATION is subjected to an electric strength test as specified in 5.3.2.

Damage to finish, cracks, dents and chips that do not adversely affect safety or protection against water, and surface cracks in fibre-reinforced mouldings and the like, are ignored.

NOTE

If a separate ENCLOSURE or part of an ENCLOSURE is used for a test, it may be necessary to reassemble such parts on the equipment in order to check compliance.

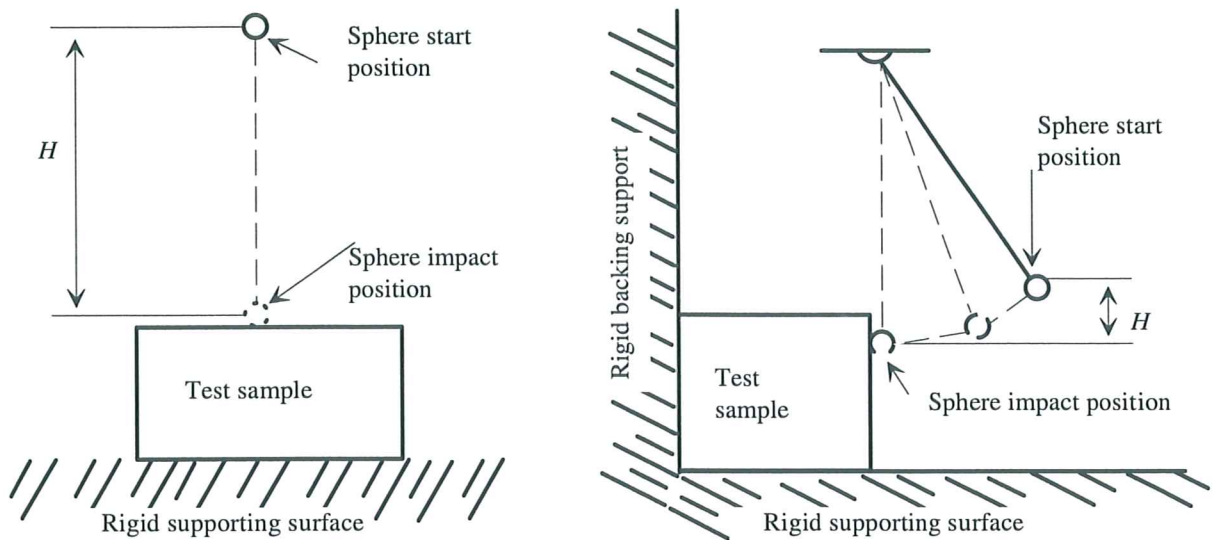
4.2.4 Steel ball test

External surfaces of ENCLOSURES, the failure of which would give access to hazardous voltages, are tested as follows.

HAND-HELD EQUIPMENT and direct plug-in equipment shall not be subject to this test, but to the test of 4.2.5.

This test is not applied to the platen glass of equipment (e.g. copying machines).

- Horizontal surfaces only: a sample consisting of the complete ENCLOSURE or a portion thereof representing the largest un-reinforced area is supported in its normal position. A solid, smooth, steel sphere, approximately 50 mm in diameter and with a mass of $500\text{ g} \pm 25\text{ g}$, is permitted to fall freely from rest through a vertical distance of 1300 mm onto the sample, see figure 7.
- Vertical surfaces only: a sample consisting of the complete ENCLOSURE or a portion thereof representing the largest un-reinforced area is supported in its normal position. A solid, smooth, steel sphere, approximately 50 mm in diameter and with a mass of $500\text{ g} \pm 25\text{ g}$, is suspended by a cord and swung as a pendulum in order to apply a horizontal impact, dropping through a vertical distance of 1300 mm onto the sample, see figure 7.



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Figure 7 - Impact test using sphere

If the pendulum test is inconvenient, it is permitted to simulate horizontal impacts on vertical or sloping surfaces by mounting the sample at 90° to its normal position and applying the vertical impact test instead of the pendulum test.

After this test the sample shall comply with the requirements of 2.1.2, 2.1.5, 2.5.1, 2.5.2, 2.9, 3.2,5 and 4.1.2, and shall show no signs of interference with the operation of safety features such as THERMAL CUT-OUTS, overcurrent protection devices or interlocks. In case of doubt, SUPPLEMENTARY or REINFORCED INSULATION is subjected to an electric strength test as specified in 5.3.2.

Damage to finish, cracks, dents and chips that do not adversely affect safety or protection against water, and surface cracks in fibre-reinforced mouldings and the like, are ignored.

NOTE

If a separate ENCLOSURE or part of an ENCLOSURE is used for a test, it may be necessary to reassemble such parts on the equipment in order to check compliance.

4.2.5 Drop test

HAND-HELD equipment and direct plug-in equipment is subjected to the following drop test.

A sample of the complete equipment is subjected to three impacts that result from being dropped 1 m onto an hardwood surface in positions likely to produce the most adverse results.

The hardwood surface consist of a layer of tongued and grooved oak flooring approximately 13 mm thick by 57 mm wide, mounted on two layers of plywood each 19 mm to 20 mm thick, all supported on a concrete or equivalent non-resilient floor.

Upon conclusion of the test the equipment need not be operational.

After this test the sample shall comply with the requirements of 2.1.2, 2.1.5, 2.5.1, 2.5.2, 2.9, 3.2,5 and 4.1.2, and shall show no signs of interference with the operation of safety features such as THERMAL CUT-OUTS, overcurrent protection devices or interlocks. In case of doubt, SUPPLEMENTARY or REINFORCED INSULATION is subjected to an electric strength test as specified in 5.3.2.

Damage to finish, cracks, dents and chips that do not adversely affect safety or protection against water, and surface cracks in fibre-reinforced mouldings and the like, are ignored.

4.2.6 Stress relief test

ENCLOSURES of moulded or formed thermoplastic materials shall be so constructed that any shrinkage or distortion of the material due to the release of internal stresses caused by the moulding or forming operation does not result in the exposure of hazardous parts.

Compliance is checked by the examination of the construction and available data or by the following test.

A sample consisting of the complete equipment, or of the complete ENCLOSURE together with any supporting framework, is subjected in a circulating air oven to a temperature 10 K higher than the maximum temperature observed on the ENCLOSURE during the test of 5.1, but not less than 70°C, for a period of 7 h, then permitted to cool to room temperature.

NOTE

Relative humidity need not to be maintained at a specific value during this test.

For large equipment where it is impractical to test the complete ENCLOSURE, it is permitted to use a portion of the ENCLOSURE representative of the complete assembly with regard to thickness and shape, and including any mechanical support members.

After this test the sample shall comply with the requirements of 2.1.2, 2.1.5, 2.5.1, 2.5.2, 2.9, 3.2,5 and 4.1.2, and shall show no signs of interference with the operation of safety features such as THERMAL CUT-OUTS, overcurrent protection devices or interlocks. In case of doubt, SUPPLEMENTARY or REINFORCED INSULATION is subjected to an electric strength test as specified in 5.3.2.

Damage to finish, cracks, dents and chips that do not adversely affect safety or protection against water, and surface cracks in fibre-reinforced mouldings and the like, are ignored.

NOTE

If a separate ENCLOSURE or part of an ENCLOSURE is used for a test, it may be necessary to reassemble such parts on the equipment in order to check compliance.

4.2.7 Mechanical strength of cathode ray tubes

If cathode ray tubes having a maximum face dimension exceeding 160 mm are included in the equipment, the cathode ray tubes or the equipment, or both, shall comply with the requirements of IEC 65 for mechanical strength and protection against the effects of implosion.

Compliance is checked by inspection, by measurement and by the relevant test of IEC 65.

4.3 Construction details

4.3.1 Supply voltage selection

Equipment which can be adjusted to suit different primary power supply voltages shall be so constructed that changing of the setting requires the use of a TOOL if incorrect setting causes a hazard.

Compliance is checked by manual test.

4.3.2 Accessible control devices

Equipment shall be so constructed that manual adjustment of accessible control devices requires the use of a TOOL if inadvertent adjustment might create a hazard.

Compliance is checked by manual test.

4.3.14 Openings in enclosures

Openings in the top and sides of FIRE ENCLOSURES and of ELECTRICAL ENCLOSURES, excluding openings in OPERATOR ACCESS AREAS within an ENCLOSURE, shall comply with 4.3.15 and 4.3.16 as appropriate.

NOTE 1

The examples of figures 8, 9 and 10 are not intended to be used as engineering drawings but are only shown to illustrate the intent of these requirements.

NOTE 2

Requirements for equipment to be installed in RESTRICTED ACCESS LOCATIONS are under consideration.

4.4.4 Materials for enclosures and for decorative parts

Materials used for ENCLOSURES of equipment shall be such that the risk of ignition and the spread of fire or flames are minimised.

Metals, ceramic materials, and glass which is heat-resistant tempered or wired or laminated, are considered to comply without test.

MECHANICAL ENCLOSURES, ELECTRICAL ENCLOSURES and parts of such ENCLOSURES, if located externally to FIRE ENCLOSURES, and DECORATIVE PARTS, shall be of flammability CLASS HB or better, except that small external DECORATIVE PARTS that would contribute negligible fuel to a fire, such as nameplates, mounting feet, key caps, knobs and the like, shall be exempt from this requirement.

NOTE 1

Where MECHANICAL or ELECTRICAL ENCLOSURES also serve as FIRE ENCLOSURES, the more stringent requirements for FIRE ENCLOSURES apply. For ENCLOSURES or parts of ENCLOSURES, inside FIRE ENCLOSURES, 4.4.3 has more stringent requirements.

For MOVABLE EQUIPMENT having a total mass not exceeding 18 kg, FIRE ENCLOSURES are considered to comply without test if in the smallest thickness used the material is of FLAMMABILITY CLASS V-1 or better. Alternatively, such FIRE ENCLOSURES are permitted if they pass the test of clause A.2.

For MOVABLE EQUIPMENT having a total mass exceeding 18 kg and for all STATIONARY EQUIPMENT, FIRE ENCLOSURES are considered to comply without test if in the smallest thickness used the material is of FLAMMABILITY CLASS 5V. Alternatively, such FIRE ENCLOSURES are permitted if they pass the test of clause A.1.

ENCLOSURES or parts of ENCLOSURES that are located within 13 mm of arcing parts, such as unenclosed commutators and unenclosed switch contacts, shall also pass the test of clause A.3.

ENCLOSURES or parts of ENCLOSURES that are located within 13 mm of parts which, under any condition of normal or abnormal operation, could attain a temperature sufficient to ignite the ENCLOSURE shall also pass the test of clause A.4.

Components which fill an aperture in a FIRE ENCLOSURE and which are intended to be mounted in this way, need not be evaluated for compliance with the flammability requirements for FIRE ENCLOSURES, provided that the components comply with the safety aspects of the relevant IEC component standard.

NOTE 2

Examples of these components are fuseholders, switches, pilot lights, connectors, and appliance inlets.

Compliance is checked by examination and, where necessary, by test.

NOTE 3

In the United States of America, additional requirements apply to ENCLOSURES and DECORATIVE PARTS of equipment used in special computer rooms.

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Delete note 3

5.4 Abnormal operation and fault conditions

All the requirements of 5.4 (see part VIII) apply.

Part VI - Protection from radiation hazards

Foreword

This part contains all the requirements related to protection from radiation hazards. These requirements shall be applied in conjunction of the requirements of clause 1, and making reference to the definitions of clause 1. Referenced annexes to be found in volume 2 of this Standard.

4.2 Mechanical strength and stress relief

All the requirements of 4.2 (see part V) apply.

4.3 Construction details

4.3.1 Supply voltage selection

Equipment which can be adjusted to suit different primary power supply voltages shall be so constructed that changing of the setting requires the use of a TOOL if incorrect setting causes a hazard.

Compliance is checked by manual test.

4.3.2 Accessible control devices

Equipment shall be so constructed that manual adjustment of accessible control devices requires the use of a TOOL if inadvertent adjustment might create a hazard.

Compliance is checked by manual test.

4.3.12 Radiation

Equipment that can generate ionising radiation or ultraviolet light or that uses a laser, or in which flammable liquids, flammable gases or similar hazards are present, shall be so designed that harmful effect to persons and damage to materials affecting safety are prevented.

*Except for equipment using lasers or generating ionising radiation, compliance is checked by inspection.
For ionising radiation compliance is checked by the test in annex H.
For equipment using lasers, compliance is checked according to IEC 825.*

Part VII - Prevention of chemical hazards

Foreword

This part contains all the requirements related to prevention of chemical hazards. These requirements shall be applied in conjunction of the requirements of clause 1, and making reference to the definitions of clause 1. Referenced annexes to be found in volume 2 of this Standard.

1.3.2 User information

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).

Compliance is checked by evaluation of the documentation provided by the manufacturer.

1.7.2 Safety instructions

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.

NOTE 1

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

NOTE 2

Where appropriate, installation instructions should include reference to national wiring rules.

NOTE 3

Maintenance information is normally made available only to SERVICE PERSONNEL.

NOTE 4

In Norway and Sweden, pluggable CLASS I EQUIPMENT intended for connection to a telephone network or a similar communications system may require a marking stating that the equipment must be connected to an earthed mains socket-outlet.

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:

- for PERMANENTLY CONNECTED EQUIPMENT, that a readily accessible disconnect device shall be incorporated in the fixed wiring;
- for PLUGGABLE EQUIPMENT, that 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.

NOTE 5

The present recommended long term exposure limit for ozone is 0,1 ppm (0,2 mg/m³) calculated as an 8 h time-weighted average concentration. It should be noted that ozone is heavier than air.

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Delete note 4.

Norway

If separation between the mains and a communication system/network other than the public telecommunications networks, relies upon the connection to safety earth, the equipment shall have a marking stating that it must be connected to an earthed mains socket-outlet.

NOTE

For requirements for equipment to be connectED to a public TELECOMMUNICATION NETWORK see 6.2.1.4

Sweden

If the separation between the mains and a SELV terminal relies upon connection to the safety earth, the apparatus shall have a marking stating that it must be connected to an earthed mains socket-outlet when a SELV CIRCUIT is connected to a network passing both unearthed and earthed electrical environment.

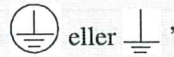
The marking text shall be in Swedish and as follows:

"Apparaten skall anslutas till jordat uttag när den ansluts till ett nätverk."

Denmark (Heavy Current Regulations)

Supply cords of Class I appliances, which are delivered without a plug, must be provided with a visible tag with the following text:

'Vigtigt!
Lederen med grøn/gul isolation
må kun tilsluttes en klemme mærket



If essential for the safety of the appliance, the tag must in addition be provided with a diagram, which shows the connection of the other conductors, or be provided with the following text:

'For tilslutning af de øvrige ledere, se medfølgende installationsvejledning.'

United Kingdom (Statutory Instrument 931:1977)

Power supply cords in CLASS I EQUIPMENT must be provided with a label with the following text in legible characters:

"IMPORTANT
The cores in this mains lead are coloured in accordance with the following code:
green and yellow: earth
blue: neutral
brown: live"

5.4 Abnormal operation and fault conditions

All the requirements of 5.4 (see part VIII) apply.

Part VIII - Protection from heat hazards

Foreword

This part contains all the requirements related to protection from heat hazards and not related to control devices and similar. These requirements shall be applied in conjunction of the requirements of clause 1, and making reference to the definitions of clause 1. Referenced annexes to be found in volume 2 of this Standard.

2.7 Overcurrent and earth fault protection in primary circuits

All the requirements of 2.7 (see part IV) apply.

3.1 General

3.1.1 Wire protection against overheating

For internal wires and for external cables other than power supply cords (see 3.2.4), the cross-sectional area shall be adequate for the current they are intended to carry when the equipment is operating under NORMAL LOAD such that the maximum permitted temperature of conductor insulation is not exceeded.

All internal wiring (including bus-bars) and inter-connecting cables used in the distribution of primary power shall be protected against over-current and short circuit by suitably rated protective devices.

Wiring not directly involved in the distribution path need not require protection where it can be shown that no safety hazard is involved (e.g. indicating circuits).

NOTE 1

Devices for overload protection of components may also provide protection of associated wiring.

NOTE 2

Internal branch circuits may require individual protection depending on reduced wire size and length of conductors.

Compliance is checked by inspection and, as appropriate, by the tests of 5.1.

3.1.2 Wire protection against mechanical damage

Wireways shall be smooth and free from sharp edges. Wires shall be protected so that they do not come into contact with burrs, cooling fins, moving parts etc., which may cause damage to the insulation of conductors. Holes in metal, through which insulated wires pass, shall have smooth well-rounded surfaces or shall be provided with bushings.

In electronic assemblies, it is permitted for wires to be in close contact with wire wrapping posts and the like if any breakdown of insulation will not result in a hazard, or if adequate mechanical protection is provided by the insulation system employed.

Compliance is checked by inspection.

3.1.8 Screwed electrical contacts

Where electrical contact pressure is required, a screw shall engage at least two complete threads into a metal plate or a metal nut or a metal insert. Screws of insulating material shall not be used where electrical connections including protective earthing are involved, nor where their replacement by metal screws could impair SUPPLEMENTARY or REINFORCED INSULATION. Where screws of insulating material contribute to other safety aspects, they shall be engaged by at least two complete threads.

Compliance is checked by inspection.

3.1.9 Screws in insulating material

Electrical connections shall be so designed that contact pressure is not transmitted through insulating material unless there is sufficient resilience in the metallic parts to compensate for any possible shrinkage or distortion of the insulating material.

Compliance is checked by inspection.

3.1.10 Stranded conductors

The end of a stranded conductor shall not be consolidated by soft soldering at places where the conductor is subject to contact pressure unless the method of clamping is designed so as to obviate the risk of a bad contact due to cold flow of the solder.

Spring terminals that compensate for the cold flow are deemed to satisfy this requirement.

Preventing the clamping screws from rotating is not considered to be adequate.

Compliance is checked by inspection.

3.1.11 Thread cutting screws

Spaced thread (sheet metal) screws shall not be used for the connection of current-carrying parts, unless they clamp these parts directly in contact with each other and are provided with a suitable means of locking.

Thread-cutting (self-tapping) screws shall not be used for the electrical connection of current-carrying parts, unless they generate a full form standard machine screw thread. Moreover, such screws shall not be used if they are operated by the user or installer unless the thread is formed by a swaging action.

Thread-cutting and spaced thread screws are permitted to provide earthing continuity but in such cases it shall not be necessary to disturb the connection in normal use and at least two screws shall be used for each connection.

Compliance is checked by inspection.

3.3.2 Special non-detachable power supply cords

For equipment with special NON-DETACHABLE POWER SUPPLY CORDS, the connection of the individual conductors to the internal wiring of the equipment shall be accomplished by any means that will provide a reliable electrical and mechanical connection without exceeding the permitted temperature limits.

It is permitted to use soldered, welded, crimped and similar connections for the connection of external conductors. For soldered or crimped connections, barriers shall be provided such that CREEPAGE DISTANCES and CLEARANCES cannot be reduced to less than the values specified in 2.9 should the conductor break away at a soldered joint or slip out of a crimped connection. Alternatively, for soldered terminations, the conductor shall be positioned or fixed so that reliance is not placed upon the soldering alone to maintain the conductor in position.

Compliance is checked by inspection, by applying a pull of 5 N to the connection, and by measuring the temperature rise of the connection which shall not exceed the values of 5.1.

3.3.3 Screw terminals

Screws and nuts which clamp external power supply conductors shall have a thread conforming with ISO 261 or ISO 262, or a thread comparable in pitch and mechanical strength, (e.g. Unified threads). The screws and nuts shall not serve to fix any other component, except that they are permitted also to clamp internal conductors provided that the internal conductors are so arranged that they are unlikely to be displaced when fitting the supply conductors.

The terminals of a component (e.g. a switch) built into the equipment are permitted for use as terminals for external power supply conductors, provided that they comply with the requirements of 3.3.

Compliance is checked by inspection.

3.3.4 Security of terminations

For the purpose of applying the requirements for power supply cords:

- it is assumed that two independent fixings will not become loose at the same time;
- conductors connected by soldering are not considered to be adequately fixed unless they are held in place near to the termination, independently of the solder, but "hooking in" before the soldering is, in general, considered to be a suitable means for maintaining the conductors of a power supply cord in position, provided that the hole through which the conductor is passed is not unduly large;
- conductors connected to terminals or terminations by other means are not considered to be adequately fixed unless an additional fixing is provided near to the terminal or termination; this additional fixing, in the case of insulated stranded conductors, clamps both the insulation and the conductor.

3.3.5 Conductor size (ampacity)

Terminals shall allow the connection of conductors having nominal cross-sectional areas as shown in table 13.

Where heavier gauge conductors are used, the terminals shall be sized accordingly.

Compliance is checked by inspection, by measurement and by fitting cords of the smallest and largest cross-sectional areas of the appropriate range shown in table 13.

Table 13 - Range of conductor sizes to be accepted by terminals

RATED CURRENT of equipment A	Nominal cross-sectional area mm ²	
	Flexible cords	Other cables
Up to and including 3	0,5 to 0,75	1 to 2,5
Over 3 up to and including 6	0,75 to 1	1 to 2,5
Over 6 up to and including 10	1 to 1,5	1 to 2,5
Over 10 up to and including 13	1,25 to 1,5	1,5 to 4
Over 13 up to and including 16	1,5 to 2,5	1,5 to 4
Over 16 up to and including 25	2,5 to 4	2,5 to 6
Over 25 up to and including 32	4 to 6	4 to 10
Over 32 up to and including 40	6 to 10	6 to 16
Over 40 up to and including 63	10 to 16	10 to 25

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In table 13, replace the fourth and the fifth lines by:

Over 10 up to and including 16 1,5 to 2,5 1,5 to 4.

United Kingdom

The range of conductor sizes of flexible cords to be accepted by terminals for equipment with a rated current of over 10 A up to and including 13 A is 1,24 mm² to 1,5 mm² nominal cross-sectional area.

3.3.6 Wire terminal size

Wire terminals shall have minimum sizes as shown in table 14. Stud terminals shall be provided with washers.

Table 14 - Sizes of terminals for primary power supply conductors

RATED CURRENT of equipment A	Minimum nominal thread diameter mm	
	Pillar type or stud type	Screw type
Up to and including 10	3,0	3,5
Over 10 up to and including 16	3,5	4,0
Over 16 up to and including 25	4,0	5,0
Over 25 up to and including 32	4,0	5,0
Over 32 up to and including 40	5,0	5,0
Over 40 up to and including 63	6,0	6,0

Compliance is checked by inspection and measurement

3.3.7 Wire terminal design

Wire terminals shall be so designed that they clamp the conductor between metal surfaces with sufficient contact pressure and without damage to the conductor.

Wire terminals shall be so designed or located that the conductor cannot slip out when the clamping screws or nuts are tightened.

Wire terminals shall be so fixed that, when the means of clamping the conductor is tightened or loosened:

- the terminal itself does not work loose;
- internal wiring is not subjected to stress;
- CREEPAGE DISTANCES and CLEARANCES are not reduced below the values specified in 2.9.

Compliance is checked by inspection and measurement.

5.1 Heating

In normal use, equipment and its component parts shall not attain excessive temperatures.

Compliance is checked in accordance with 1.4.7 by determining and recording the temperature rise of the various parts under the following conditions.

Taking into account the requirements of 1.4.5, the equipment or parts of the equipment are operated under NORMAL LOAD as follows:

- for CONTINUOUS OPERATION, until steady conditions are established;
- for INTERMITTENT OPERATION, until steady conditions are established, the "on" and "off" periods being the rated "on" and "off" periods;
- for SHORT-TIME OPERATION, for the RATED OPERATING TIME.

It is permitted to test components and other parts independently provided that the test conditions applicable to the equipment are adhered to.

Equipment intended for building-in or rack mounting or for incorporation in larger equipment is tested under the most adverse conditions, actual or simulated, permitted in the manufacturer's installation instructions.

Temperature rises of handles, knobs, grips and the like, is determined for all parts which are gripped in normal use and, if of insulating material, to parts in contact with hot metal.

The temperature rise of electrical insulation (other than that of windings), failure of which could cause a hazard, is measured on the surface of the insulation at a point close to the heat source.

During the test, THERMAL CUT-OUTS shall not operate and sealing compound, if any, shall not flow out.

The temperature rises shall not exceed the values shown in table 16, parts 1 and 2.

NOTE

For temperature rise of windings, see 1.4.8.

Table 16 - Temperature-rise limits ⁷⁾

Part 1

Parts	Maximum temperature rise K
Insulation, including winding insulation :	
-of Class A material	75
-of Class E material	90
-of Class B material	95
-of Class f material	115
-of Class H material	140
	see conditions ¹⁾ , ²⁾ and ⁵⁾
Synthetic rubber or PVC insulation of internal and external wiring including power supply cords	
- without T-marking	50
- with T-marking	T-25
Other thermoplastic insulation	see condition ³⁾
Terminals, including earthing terminals for external earthing conductors of STATIONARY EQUIPMENT, unless provided with a NON-DETACHABLE POWER SUPPLY CORD	60
Parts in contact with flammable liquid	see 4.4.8
Components	see 1.5.1

Table 16 - Temperature-rise limits

Part 2

Parts in OPERATOR ACCESS AREA	Maximum temperature rise K		
	Metal	Glass porcelain, vitreous material	Plastic ⁵⁾ , rubber
Handles, knobs, grips, etc. held or touched for short periods only	35	45	60
Handles, knobs, grips, etc. continuously held in normal use	30	40	50
External surface of equipment which may be touched ⁴⁾	45	55	70
Parts inside the equipment which may be touched ⁶⁾	45	55	70

Conditions applicable to table 16, parts 1 and 2

- 1) If temperature rises of windings are determined by thermocouples, these figures are reduced by 10 K except in the case of motors.
- 2) The classification of insulating materials (classes A, E, B, F and H) is in accordance with IEC 85.
- 3) Due to their wide variety, it is not possible to specify permitted temperature rises for thermoplastic materials; these should pass the tests specified in 5.4.10.
- 4) For areas on the external surface of equipment and having no dimension exceeding 50 mm and which are not likely to be touched in normal use, temperature rises up to 75 K are permitted.
- 5) For each material, account should be taken of data for that material to determine the appropriate maximum temperature rise.
- 6) Temperature rises exceeding the limits are permitted provided that the following conditions are met:
 - unintentional contact with such a part is unlikely;
 - the part has a warning indicating that this part is hot.
- 7) Consideration should be given to the fact that, on a long-term basis, the electrical and mechanical properties of certain insulating materials may be adversely affected, e.g. by softeners evaporating at temperatures below their normal softening temperatures.

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Norway

To prevent fire risk, temperature rise limits for wooden supports shall be taken into account.
The temperature rise limit is 65 °K in general and 60 °K for equipment for continuous operation.

5.4 Abnormal operation and fault conditions

NOTE
See also 4.4.1.

5.4.1 Protection against overload and normal operation

Equipment shall be so designed that the risk of fire or electric shock due to mechanical or electrical overload or failure, or due to abnormal operation or careless use, is limited as far as practicable.

After abnormal operation or a fault, the equipment shall remain safe for an OPERATOR within the meaning of this standard, but it is not required that the equipment should still be in full working order.

It is permitted to use fusible links, THERMAL CUT-OUTS, overcurrent protection devices and the like to provide adequate protection.

Compliance is checked by inspection and by the tests of 5.4. Before the start of each test, it is checked that the equipment is operating normally.

If a component or sub-assembly is so enclosed that short-circuit or disconnection as specified in this clause is not practicable or is difficult to perform without damaging the equipment, it is permitted to make the tests on sample parts provided with special connecting leads. If this is not possible or not practical, the component or sub-assembly as a whole shall pass the tests.

5.4.2 Motors

Under overload, locked rotor, and other abnormal conditions, motors shall not cause hazard because of excessive temperatures.

NOTE

Methods of achieving this include the following:

- the use of motors which do not overheat under locked-rotor conditions (protection by inherent or external impedance);
- the use in SECONDARY CIRCUITS of motors which may exceed the permitted temperature limits but which do not create a hazard;
- the use of a device responsive to motor current;
- the use of an integral THERMAL CUT-OUT;
- the use of a sensing circuit which disconnects power from the motor in a sufficiently short time to prevent overheating if, for example, the motor fails to perform its intended function.

Compliance is checked by the applicable tests of annex B.

5.4.3 Transformer overload

Transformers shall be protected against overload, for example by:

- overcurrent protection;
- internal THERMAL CUT-OUTS
- use of current limiting transformers.

Compliance is checked by the applicable tests of clause C.1.

5.4.4 Operational insulation

For OPERATIONAL INSULATION, CREEPAGE DISTANCES and CLEARANCES shall satisfy one of the following alternative requirements a) or b) or c):

- a) they shall meet the appropriate CREEPAGE DISTANCE and CLEARANCE requirements of 2.9;
- b) they shall withstand the appropriate electric strength tests of 5.3.2;
- c) they shall be short-circuited where short-circuit could cause:
 - overheating of any material, thereby creating a risk of fire, unless the material that could be overheated is FLAMMABILITY CLASS V-1 or better, or
 - thermal damage to BASIC, SUPPLEMENTARY or REINFORCED INSULATION, thereby creating a risk of electric shock.

5.4.5 Electromechanical components

In SECONDARY CIRCUITS, where a hazard is likely to occur, electromechanical components other than motors are checked for compliance with 5.4.1 by applying the following conditions:

- mechanical movement shall be locked in the most disadvantageous position while the component is energised normally;
- in the case of a component which is normally energised intermittently, a fault shall be simulated in the drive circuit to cause continuous energising of the component.

The duration of each test shall be as follows:

- for equipment or components whose failure to operate is not evident to the OPERATOR: as long as necessary to establish steady conditions or up to the interruption of the circuit due to other consequences of the simulated fault condition, whichever is the shorter;*
- for other equipment and components: 5 min or up to interruption of the circuit due to a failure of the component (e.g. burn-out) or to other consequences of the simulated fault condition, whichever is the shorter.*

5.4.6 Simulation of faults

For components and circuits other than those covered by 5.4.2, 5.4.3 and 5.4.5, compliance is checked by simulating fault conditions.

The following faults are simulated:

- faults in any components in PRIMARY CIRCUITS;*
- faults in any components where failure could adversely affect SUPPLEMENTARY or REINFORCED INSULATION;*
- additionally, for equipment that does not comply with the requirements of 4.4.2 and 4.4.3, faults in all components;*
- faults arising from connection of the most unfavourable load impedance to terminals and connectors that deliver power or signal outputs from the equipment, other than mains power outlets.*

Where there are multiple outlets having the same internal circuitry, the test is only made on one sample outlet.

For components in PRIMARY CIRCUITS associated with the mains input, such as the supply cord, appliance couplers, e.m.c. filtering components, switches and their interconnecting wiring, no fault is simulated, provided that the component complies with 5.4.4, option a).

NOTE

Such components are still subject to other requirements of this standard where applicable, including 1.5.1, 2.9, 4.4.3 and 5.3.2.

It is permitted to test circuits within the equipment, or to test simulated circuits, separate components or sub-assemblies outside the equipment.

In addition to the compliance criteria given in 5.4.9, temperatures in the transformer supplying the component under test shall not exceed those specified in clause C.1, and account shall be taken of the exception detailed in clause C.1.

5.4.7 Simulation of conditions of use

Equipment is tested by applying any condition that may be expected in normal use and foreseeable misuse.

In addition, equipment which is provided with a protective covering is tested with the covering in place under normal idling conditions until steady conditions are established.

5.4.8 Unattended equipment

Equipment intended for unattended use and having THERMOSTATS, TEMPERATURE LIMITERS or thermal cutouts, or having a capacitor not protected by a fuse or the like connected in parallel with the contacts, is subjected to the following tests.

THERMOSTATS, TEMPERATURE LIMITERS and THERMAL CUT-OUTS are also assessed for compliance with the requirements in clause K.6.

Equipment is operated under the conditions specified in 5.1 and any control that serves to limit the temperature is short-circuited. If the equipment is provided with more than one THERMOSTAT, TEMPERATURE LIMITER or thermal cut-out, each is short-circuited, one at a time.

If interruption of the current does not occur, the equipment is switched off as soon as steady conditions are established and is permitted to cool down to approximately room temperature.

For equipment rated for only SHORT-TIME OPERATION, the duration of the test is equal to the RATED OPERATING TIME.

For equipment rated for SHORT-TIME or INTERMITTENT OPERATION, the test is repeated until steady state conditions are reached, irrespective of the operating time. For this test the THERMOSTATS, TEMPERATURE LIMITERS and thermal cutouts are not short-circuited.

If in any tests a MANUAL-RESET THERMAL CUT-OUT operates, or if the current is otherwise interrupted before steady conditions are reached, the heating period is taken to have ended; but if the interruption is due to the rupture of an intentionally weak part, the test is repeated on a second sample. Both samples shall comply with the conditions specified in 5.4.9.

5.4.9 Compliance criteria for 5.4.4c, 5.4.5, 5.4.6, 5.4.7 and 5.4.8

During the tests of 5.4.4 c), 5.4.5, 5.4.6, 5.4.7 and 5.4.8:

- *if a fire occurs it shall not propagate beyond the equipment;*
- *the equipment shall not emit molten metal;*
- *ENCLOSURES shall not deform in such a way as to cause non-compliance with 2.1.2, 2.1.5, 2.5.1, 2.9.2 and 4.1.2.*

Moreover, for equipment that does not comply with the requirements of 4.4.2 and 4.4.3 during the tests of 5.4.6, third dashed paragraph, and unless otherwise specified, the temperature rises of insulating materials other than thermoplastic materials shall not exceed 125 K for Class A, 140 K for Class E, 150 K for Class B, 165 K for Class F and 185 K for Class H materials.

If the failure of the insulation would not result in exposure to HAZARDOUS VOLTAGES or HAZARDOUS ENERGY LEVELS, a maximum temperature of 300°C is permitted.

After the tests of 5.4.4, 5.4.5, 5.4.6, 5.4.7, and 5.4.8, an electric strength test is made on any REINFORCED INSULATION, or on BASIC or SUPPLEMENTARY INSULATION forming part of DOUBLE INSULATION if:

- *the CREEPAGE DISTANCE or CLEARANCE has been reduced below the value specified in 2.9, or*
- *the insulation shows visible signs of damage, or*
- *the insulation cannot be inspected.*

This test is made as specified in 5.3.3 after the insulation has cooled to room temperature.

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The Electrical Strength Test after the tests of 5.4.4c, 5.4.5, 5.4.6 and 5.4.7 and 5.4.8 includes testing of basic insulation in Class I equipment

5.4.10 Hazardous voltages on thermoplastic parts

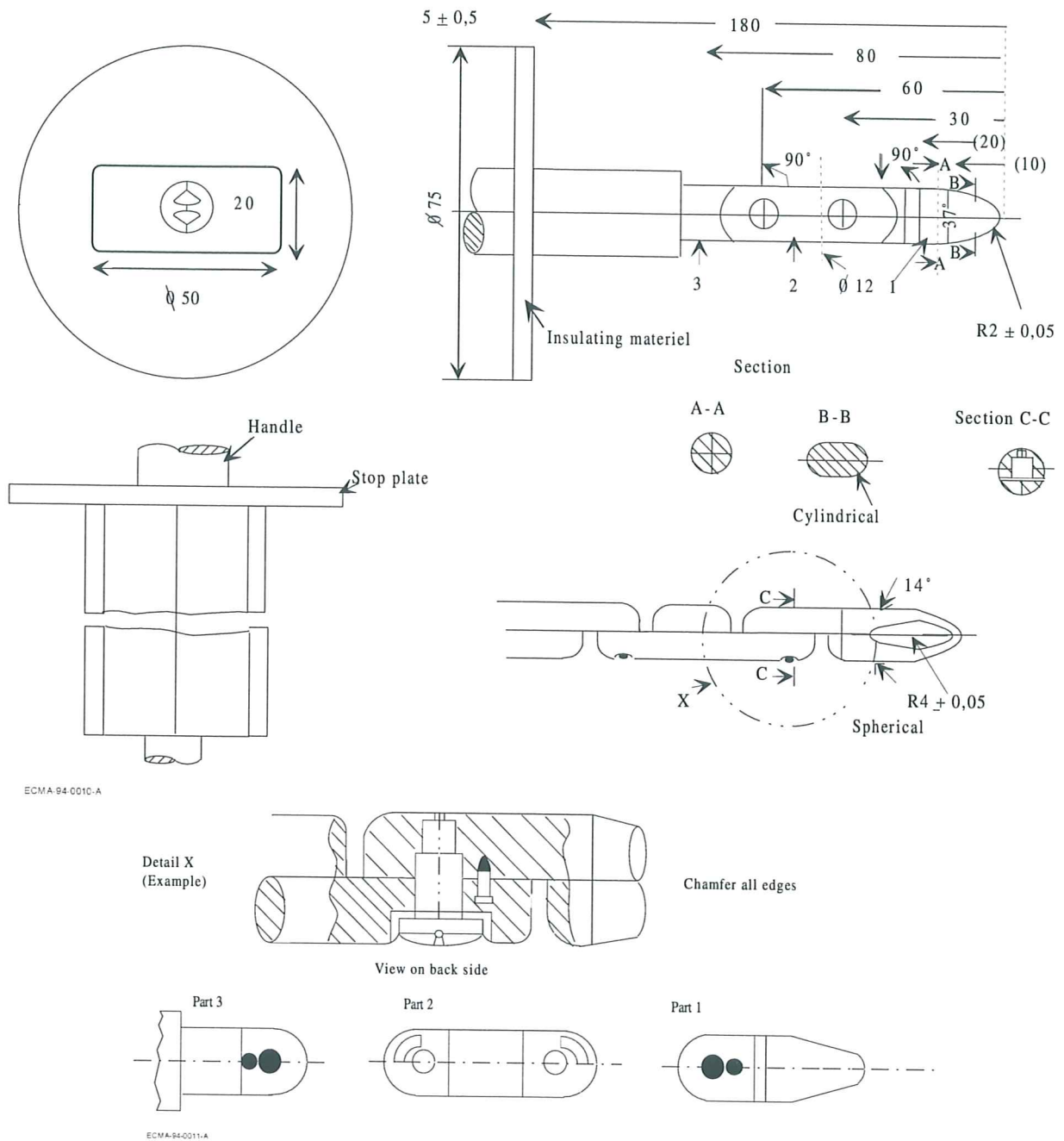
Thermoplastic parts, on which parts at HAZARDOUS VOLTAGE are directly mounted, shall be resistant to abnormal heat.

Compliance is checked by subjecting the part to the following ball-pressure test by means of the test apparatus shown in figure 21.

The surface of the thermoplastic part to be tested is placed in a horizontal position and a steel ball 5 mm in diameter pressed against this surface by a force of 20 N. The test is made in a heating cabinet at a temperature which is 40 K ± 2 K greater than the maximum temperature rise of the part determined during the test of 5.1. However, a thermoplastic part supporting parts at primary voltage is tested at least at 125°C. After 1 h, the ball is removed and the sample is cooled down to approximately room temperature within 10 s by immersion in cold water.

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

The test is not made if it is clear from examination of the physical characteristics of the material that it will meet the requirements of the test.



Linear dimensions in mm.

Material of fingers: for example, heat-treated steel.

Both joints of this finger can be bent through an angle of

90° $\begin{matrix} +10 \\ 0 \end{matrix}$ but in one and the same direction only.

Tolerances on dimensions without specific tolerances:

- on angles: $\begin{matrix} 0 \\ -10' \end{matrix}$
- on linear dimensions: $\begin{matrix} 0 \\ -0,05 \\ \pm 0,2 \text{ mm} \end{matrix}$

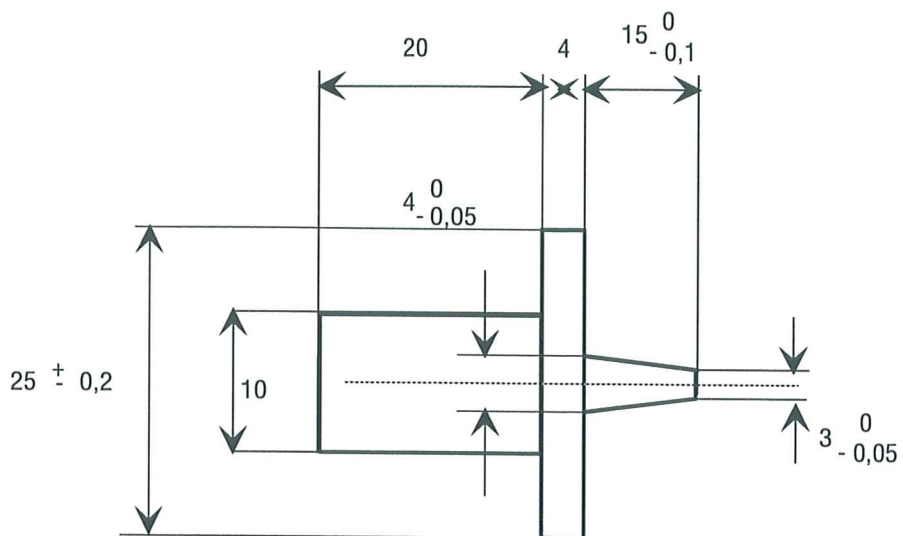
NOTE 1

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

NOTE 2

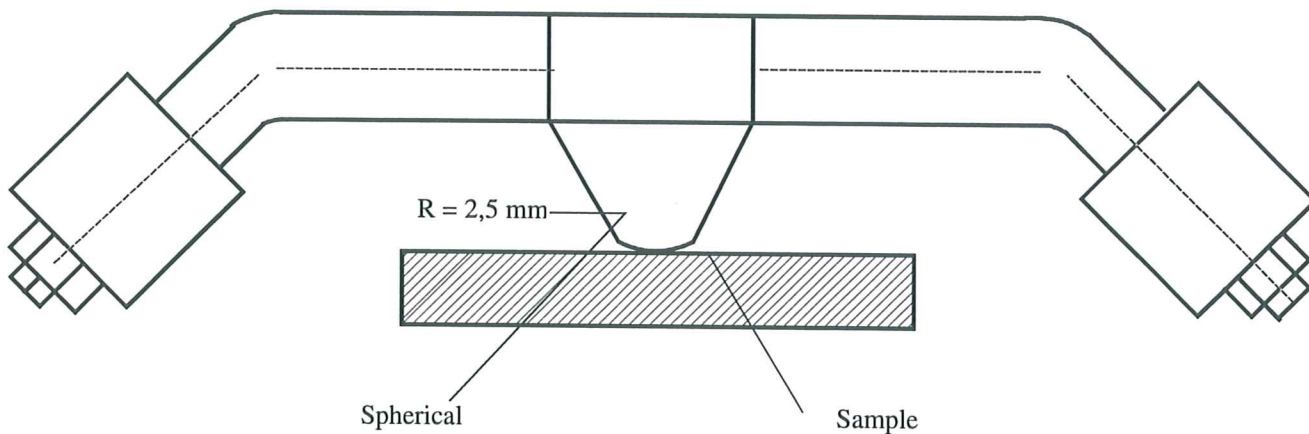
The test finger is from IEC 529.

Figure 19 - Test finger



ECMA-93-0087-B

Figure 20 - Test pin



ECMA-93-0088-B

Figure 21 - Ball-pressure apparatus

Index to Standard ECMA-129

Index to Standard ECMA-129

This index is derived from ECMA TR/63, Index to Publication IEC 950 - Safety of Information Technology Equipment, which has been adapted for use with this second edition of Standard ECMA-129. This index is for information only and the selection of indexed items does not imply any particular importance.

Location references are clause or sub-clause numbers or annex letters. If the location reference is purely numeric (e.g. 4.3.20) the sub-clause referred to is in Volume 1. The number of the Part or Parts where the subclause is located in Volume 1 is given in Roman numerals between parentheses after the subclause number, e.g. 1.2.3 (I, IV).

If the location reference starts with a letter of the alphabet (e.g. C.3) or if the reference is to an annex, the sub-clause referred to is in volume 2. All the annexes are in volume 2.

Principal references are printed **Bold**. When a reference to more than one Part appears, and one of these references is printed in bold, the full text of the subclause is reproduced in full only in the subclause whose number is printed in bold. For example, 4.2 (I, II, **IV**, V) means that sub-clause 4.2 is printed in full in part IV and is referred to in Parts I, II and 5). Otherwise, the full text appears in all referenced Parts.

Terms that are defined in ECMA-129 are printed in SMALL CAPITALS, both in the standard and in this index. Where such a term appears in the index, its definition is indicated by an asterisk, e.g. 1.2.13.1*

A

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1.5-kV transients assumed	2.9.2 (II)	corrosion	
adequate	2.2.4 (II)	by consumable materials	4.3.4 (II)
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increased by coatings	2.9.8 (II)	Norway	1.7.2 (I, VII), 2.3.3.4 (II), 2.7.1 (IV), 2.9.1 (II), 2.11 (IV), 6.2.1.4 (II)
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	4.2.5 (V), 4.3.18 (II)	<i>NOTE - electric strength tests are required in numerous places</i>	
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	2.7.1 (IV), 2.7.3 (IV)	in SERVICE ACCESS AREAS	2.1.4 (II, III)
switches	2.6.5 (II), 2.6.8 (II)	as interconnection circuits	2.10.2 (II), 2.10.3 (II)
three-phase	2.6.7 (II)	insulation	2.2.6 (II)
multiple sources, marking	1.7.9 (I)	reed switches in	2.8.6.3 (II)
DISTANCES THROUGH INSULATION	2.2.4 (II), 2.2.5 (II), 2.9.4 (II)	ELV winding, meaning of term	C.2 (table C.2 condition 1)
of wire	2.1.3 (II) , 3.1.5 (II)	e.m.c. <i>see</i> electrical filters	
doors and covers	4.2.2 (V), 4.3.15 (IV), 4.3.16 (IV), 4.4.7 (IV)	EN-41003	M.2, annex P
access through	2.1.2 (II), 2.8.2 (II), 2.8.3 (II)	enamel, not adequate safety insulation	2.1.2 (II), 2.9.4 (II)
marking on 1.7.1 (I)		encapsulated parts	2.9.7 (II)
doors, position during stability tests	4.1.1 (V)	enclosed parts	2.9.6 (II)
DOUBLE INSULATION	0.2.1 (I), 1.2.4.1 (I), 1.2.4.2 (I), 1.2.9.4* (I),	ENCLOSURES	4.2 (II), 4.4.4 (IV, V), 5.4.9 (VIII)
	1.2.9.5 (I)	<i>see also</i> ELECTRICAL ENCLOSURES, FIRE ENCLOSURES,	
application	2.1.8 (II), 2.2.6 (II), C.3	MECHANICAL ENCLOSURES, DECORATIVE PARTS,	
in CLASS I EQUIPMENT	1.2.4.1 (I), 2.5.1 (II)	IEC-529, IEC-1032	
in CLASS II EQUIPMENT	1.2.4.2 (I), 2.5.2 (II)	definitions	1.2.6*(I)
in SELV CIRCUITS	2.3.3 (II), 2.3.3.1 (II), 2.3.5 (II)	conductive	2.1.6 (III), 2.9.2 (II), (table 3 condition 6)
in TNV CIRCUITS	6.2.1.4 (II)	flammability	A.1, A.2, A.5
on coated boards	2.9.5 (II)	inlet bushings in	3.2.6 (II)
BASIC and SUPPLEMENTARY can be interchanged	2.2.6 (II)	openings in.	1.2 (II), 2.9.1 (II), 4.3.14 (II), 4.3.15 (II), 4.3.16 (II)
care while testing	5.3.2 (II)	energy hazards	0.2.2 (I), 5.4.9 (VIII)
dimensions	2.9.2 (II) (table 3 condition 3, table 5 condition 2)	disconnection	2.6.11 (II)
integrity after a test	5.4.9 (VIII)	in LIMITED CURRENT CIRCUITS	2.4.2
integrity in service	3.3.9 (II)	in OPERATOR ACCESS AREAS	2.1.1 (II), 2.1.5 (II)
unearthed parts within	2.2.6 (II)	in SERVICE ACCESS AREAS	2.1.4 (II)
WORKING VOLTAGE	2.2.7 (II)	multiple sources	1.7.9 (I)
duty cycles, marking short-time intermittent	1.7.3 (I)	reduced by interlock	2.8.2 (II)
		within ENCLOSURES	2.1.6 (III)
E		ENERGY LEVEL, HAZARDOUS	1.2.8.7* (I)
earth <i>see</i> protective earthing		equipment electrical ratings (definitions)	1.2.1 (I)
earth fault protection	2.7 (II, III, IV)	EQUIPMENT FOR BUILDING-IN	1.2.3.5* (I), 2.1.2 (II), 5.1 (VIII)
earth leakage current, <i>see</i> leakage current		explosion	
electric shock	0.2 (I), 0.2.1 (I)	(implosion) of cathode ray tube	4.2.7 (V)
		of battery	1.7.17 (I), 4.3.21 (IV), 4.4.8 (IV)

of high pressure lamp	4.1.5 (V)	controls	4.3.5 (II)
limit <i>see</i> LIMIT, EXPLOSION		minor parts	4.3.9 (II)
		two fixings not loose at the same time	3.3.4 (II), 4.3.9 (II)
F			C.2
failure	5.4.1 (VIII)	units of equipment	1.2.3.4 (I), 4.1.1 (V)
<i>see also</i> faults		FLAMMABILITY CLASS	
of components	0.2.1 (I), 5.4.6 (VIII)	5V	1.2.13.5* (I), A.9
in LIMITED CURRENT CIRCUITS	2.4.1 (II), 2.4.3 (II)	applications	1.2.13.1 (I), 4.4.1 (IV), 4.4.4 (IV,V)
in SELV CIRCUITS	2.3.1 (II), 2.3.5 (VIII)	HB	1.2.13.8* (I), A.8
in TNV CIRCUITS	6.2.1.2 (II), 6.2.1.5 (II)	applications	1.2.13.1 (I), 4.4.3.3 (IV), 4.4.3.5 (IV)
mechanical	5.4.5 (VIII)	4.4.3.6 (IV), 4.4.1 (IV), 4.4.4 (IV)	
of ENCLOSURES	4.1.2 (V), 4.2.4 (V)	HBF (foamed material)	1.2.13.9* (I), A.7
of equipment to operate	4.4.6 (IV), 5.4.5 (VIII)	applications	1.2.13.1 (I), 4.4.3.3 (IV), 4.4.3.6 (IV)
of motor capacitors	B.8	4.4.1 (IV)	
of screwed connections	4.3.13 (II)	HF 1 (foamed material)	1.2.13.6* (I), A.7
fault conditions		applications	1.2.13.1 (I), 4.4.1 (IV)
difference between ELV and SELV CIRCUITS	2.3.3 (II)	HF-2 (foamed material)	1.2.13.7* (I), A.7
protection required	2.7.1 (IV), 2.7.3 (IV), 2.7.4 (IV), 4.4.3.3 (IV)	applications	1.2.13.1 (I), 4.4.1 (IV)
fault current	2.3.3.3 (II), 2.7.3 (IV), 2.7.4 (IV)	V-0	1.2.13.2* (I), A.6
faults	1.3.1 (I), 5.4 (II, III, IV, V, VI, VII, VIII)	applications	1.2.13.1 (I), 4.4.1 (IV), A.3.6
<i>see also</i> abnormal conditions, failure		V-1	1.2.13.3* (I), A.6
affecting air filters	4.4.3.6 (IV)	applications	1.2.13.1 (I), 4.4.1 (IV), 4.4.2 (IV)
consequential	0.2.1 (I), 1.4.12 (I), 1.5.3 (I), 2.4.1 (II, III)	4.4.3.3 (IV), 4.4.3.6 (IV), 4.4.4 (IV, V)	
earth	2.7.1 (IV)	4.4.5 (IV), 4.4.6 (IV), 5.4.4 (VIII)	
in capacitors	1.4.12 (I), 4.4.1 (IV), 4.4.3.3 (IV)	V-2	1.2.13.4* (I), A.6
in CLASS I EQUIPMENT	2.5.1 (I)	applications	1.2.13.1 (I), 1.5.4 (I), 4.4.1 (IV)
in LIMITED CURRENT CIRCUITS	1.2.8.6 (I), 2.4.1 (II)	4.4.3.2 (IV), 4.4.3.3 (IV)	
in limited power sources	2.11 (IV)	4.4.3.4 (IV), 4.4.3.6 (IV)	
in protective earth connections	5.2 (II), annex G	flammability	4.4.3.2 (IV)
in ringing signal circuits	M.2	exemptions	4.4.3.3 (IV)
not covered in sub-clause 5.4	2.7.2 (IV)	tests	annex A
simulated	1.4.12 (I), 2.7.4 (IV), 5.4.5 (VIII), 5.4.6 (VIII)	for FIRE ENCLOSURES	A.1, A.2
single	0.2.1 (I), 1.2.8.5 (I), 1.2.8.6 (I), 2.3.1 (II),	floating parts and windings <i>see</i> unearthed parts and windings	
	2.11 (IV), 6.2.1.2 (II), M.2	foil (conductive)	
FCC Rules, Part 68	M.3, annex P	in definitions	1.2.7.5 (I), 1.2.10.3 (I)
filters, air, flammability	4.4.3.1 (III), 4.4.3.6 (III)	in tests	2.9.1 (II), 3.1.5 (II), 5.2.2 (II), 5.3.2 (II),
filters, electrical <i>see</i> electrical filters and capacitors, filter			6.4.2 (II), G.2
FIRE ENCLOSURES	1.2.6.2* (I), 4.4.5 (IV), 4.4.6 (IV),	frequency	
	4.4.7 (IV), A.1, A.2, A.5	in LIMITED CURRENT CIRCUITS	2.4.2 (II, III)
<i>see also</i> ENCLOSURES		of supply	1.4.11 (I), 1.7.1 (I), 2.6.12 (II), 3.2.1 (II), C.1
air filters in	4.4.3.6 (IV)	of test voltage	5.3.2 (II), 6.4.2.2 (II), annex R
fire protection equipment, not in Scope of standard	1.1.3 (I)	of WORKING VOLTAGE	2.2.2 (II), 2.9.1 (II)
fire risks	0.2.3 (I), 1.3.1 (I), 4.4.2 (IV), annex P (IEC-695)	ringing signal	M.2, M.3
caused by		in TNV CIRCUITS	6.4.2.1 (II)
batteries	4.3.21 (IV)	FREQUENCY, RATED	1.2.1.4* (I), 1.4.6 (I), 1.7.1 (I), 1.7.4 (I)
flammable liquids	4.4.8 (IV)	FREQUENCY RANGE, RATED	1.2.1.5* (I), 1.4.6 (I), 1.7.1 (I), 1.7.4
ingress of water	annex T	(I)	
OPERATIONAL INSULATION	5.4.4 (VIII)	fuses	
overloads	5.4.1 (VIII)	breaking capacity	2.7.3 (IV)
FIXED EQUIPMENT	1.2.3.4* (I), 1.7.1 (I), 3.2.2 (II)	in neutral conductors	2.7.6 (IV)
fixing (securing) of		location	1.7.11 (I), 2.7.3 (IV)
parts		marking	1.7.6 (I)
insulation	2.5.1 (II), 2.9.6 (II), 3.1.7 (II)	minimum number	2.7.4 (IV)
inlet bushings	3.2.6 (II)	not allowed in protective earth conductors	2.5.3 (II)
cord guards	3.2.7 (II)	operating during motor tests	B.2
conductors	3.3.2 (VIII), 3.3.4 (VIII), 3.3.7 (VIII)	performance	2.11 (IV), (table 9 condition 4)

protecting capacitors	5.4.8 (VIII)	treatment (conditioning)	2.2.3 (II), 2.9.5 (II), 2.9.6 (II)
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G			
gas discharge tubes	5.3 (II), 6.4.2.3 (II)		
<i>see also</i> surge arrestors			
gas flame for flammability testing	annex A		
gases	4.3.4 (II), 4.3.12 (VI)		
flammable	1.2.13.10 (I), 1.1.2 (I), 4.3.12 (VI)		
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grease	4.3.11 (II), 4.4.8 (IV)		
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guards, mechanical	2.1.4 (II)		
H			
HAND-HELD EQUIPMENT	1.2.3.2* (I)		
leakage current	5.2.2 (II), G.2		
mechanical strength	4.2.1 (V), 4.2.5 (V)		
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RATED VOLTAGE	1.6.2 (I)		
separation from TELECOMMUNICATION NETWORK	6.4.1 c (II)		
handles			
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must be reliably fixed	4.3.5 (II)		
no mechanical strength test	4.2.1 (V)		
shafts of	2.1.7 (II)		
temperature rise	5.1 (VIII)		
HAZARDOUS ENERGY LEVEL	1.2.8.7* (I)		
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HAZARDOUS VOLTAGES	1.2.8.3* (I)		
multiple sources	1.7.9 (I), 2.6.11 (II)		
not to be accessible			
after tests	5.4.9 (VIII)		
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on thermoplastic parts	5.4.10 (VIII)		
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separation from SELV CIRCUITS	2.3.3 (II), 2.3.4 (II)		
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ICRP 26			annex H, annex Q
IEC 65		1.5.4 (I), 4.2.7 (V), annex P	
IEC 73		1.7.8.2 (I), annex P	
IEC 83		1.7.5 (I), 2.1.2 (II), 2.3.4 (II), annex P	
IEC 85	1.4.7 (I), 5.1 (VIII), (table 16 condition 2), annex P		
IEC 112		2.9.3 (II), 2.9.5 (II), annex P	
IEC 227		3.2.4 (II), annex P	
IEC 245		3.2.4 (II), annex P	
IEC 309		1.2.5.2 (I), annex P	
IEC 320	2.3.4 (II), 3.2.3 (II), 3.2.4 (II), annex P		
IEC 364		1.2.8.5 (I), annex P	
IEC 364-7-707		1.7.12 (I), annex Q	
IEC 384-14		1.5.6 (I), 1.6.4 (I), annex P	
IEC 417	1.7.1 (I), 1.7.7 (I), 1.7.8.3 (I), annex P		
IEC 410		annex Q, annex R	
IEC 479		M.2, annex Q	
IEC 529		annex Q	
IEC 529, extract		annex T	
IEC 664	1.1.2 (I), 2.9.1 (II), 2.9.2 (II) table 3, annex P, annex Q		
IEC 695-2-2		A.2.7, annex P	
IEC 707	1.2.13.5 (I), 1.7.12 (I), annex Q		
IEC 825		4.3.12, annex P	
IEC 885-1		3.1.5 (II), annex P	
IEC 1032	Figure 19 (p. 239), Figure 20 (p. 241), annex Q		
IEC 1058		2.6.2 (II), annex Q	
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lamps exempt from flammability requirements		4.4.3.3 (IV)	
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Scope of standard		1.1.1 (I)	
INTERCONNECTING CABLES	1.2.11.7 (I), 1.5.5 (I)		
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interconnection of equipment		2.10 (II)	
ingress of water	1.1.2 (I), 2.9.6 (II), 2.9.7 (II), annex T		
ink		4.4.8 (IV)	
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inlet bushings, power cord		3.2 (II)	
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installation categories <i>see</i> transients (overvoltage categories)			
instructions		1.7 (I)	
insulation		1.2.9 (I), 2.2 (II)	
application		2.2.5 (II), 2.2.6 (II)	
BASIC <i>see</i> BASIC INSULATION			
DOUBLE <i>see</i> DOUBLE INSULATION			
OPERATIONAL <i>see</i> OPERATIONAL INSULATION			
REINFORCED <i>see</i> REINFORCED INSULATION			
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interconnection <i>see</i> connections			
INTERLOCKS <i>see</i> SAFETY INTERLOCKS			
INTERMITTENT OPERATION	1.2.2.5* (I), 5.1 (VIII), 5.4.8 (VIII)		
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insulation spacings	2.9.1 (II), 2.9.2 (II), (tables 3 and 5), 2.9.3 (II), 2.9.5 (II), (table 7)		
electric strength test voltages	5.3.2 (II), (table 18)		
ionizing radiation	0.2.5 (I), 4.3.12 (VI), annex H		
ISO 216	1.1.3 (I), annex P		
ISO 261	3.3.3 (VIII), annex P		
ISO 262	3.3.3 (VIII), annex P		
ISO 2859	annex Q, annex R		
ISO 3864	1.7.18 (I), annex P		
ISO 4046	B.7, annex P		
ISO 7000	1.7.1 (I), annex P		
isolation (from the supply) <i>see</i> disconnection for servicing			
IT POWER SYSTEMS	1.2.12.3* (I)		
heating elements	4.3.20 (IV)		
leakage current	annex G		
marking of equipment	1.7.10 (I)		
PRIMARY power isolation (three phase)	2.6.7 (II)		
protective devices	2.7.4 (IV)		
voltage rating of components	1.6.4 (I)		
K			
knobs <i>see</i> handles			
L			
lamps			
high pressure	4.1.5 (V)		
left in place during tests	2.1.2 (II)		
no flammability requirement	4.4.3.3 (IV)		
language for instructions and marking	1.7.14 (I)		
leakage current	5.2 (II), annex G		
high	1.7.12 (I), 5.2.5 (II), G.2.5		
IT POWER SYSTEMS	annex G		
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LIMIT, EXPLOSION	1.2.13.10* (I), 4.4.8 (IV)		
limit <i>see</i> maximum			
LIMITED CURRENT CIRCUITS	1.2.8.6* (I), 2.4 (II, III), 2.10.2 (II)		
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limited power sources	2.11 (IV), 4.4.5.1 (IV), 4.4.5.2 (IV)		
LIMITER, TEMPERATURE	1.2.11.3* (I), annex K		
liquids	4.3.4 (II), 4.3.19 (IV), 4.4.3.3 (IV)		
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flammable	4.3.12 (VI), 4.4.8 (IV)		
parts in contact	5.1 (VIII)		
louvres	4.3.16 (IV)		
<i>see also</i> openings			
M			
marking	1.7 (I)		
durability	1.7.15 (I)		
equipment must be earthed	6.3.3 (II)		
high leakage current	1.7.12 (I)		
lithium batteries	1.7.17 (I)		
mating of plugs and sockets	4.3.17 (IV)		
multiple sources	2.6.12 (II)		
of stabilizing devices	4.1.1 (V)		
T-marking	5.1 (VIII)		
unearthed parts in SERVICE ACCESS AREAS	2.5.1 (II)		
material group (tracking) <i>see</i> c.t.i.			
materials to be reliable	0.2 (I)		
maximum			
amount of flammable liquid	4.4.8 (IV)		
input current	1.6.1 (I)		
ionizing radiation	4.3.12 (IV), annex H		
leakage current	5.2.2 (II), G.2		
levels in TNV CIRCUITS			
normal	6.2.1.1 (II)		
fault conditions	6.2.1.5 (II)		
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levels in limited power source	2.11 (IV)		
ozone level	1.7.2 (I, VII)		
RATED VOLTAGE	1.1.1 (I)		
handheld equipment	1.6.2 (I)		
ringing signal current	M.2, M.3		
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temperature (rise)	1.4.7 (I), 5.1 (VIII)		
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voltage in SELV CIRCUITS			
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fault conditions	2.3.3 (II)		
MECHANICAL ENCLOSURES	1.2.6.3* (I), 4.1.2 (V), 4.1.5 (V)		
<i>see also</i> ENCLOSURES			
mechanical hazards	0.2.7 (I), 2.8.2 (II), 4.1 (V)		
mechanical shock			
affecting CLEARANCE	2.9.2 (II), 2.9.6 (II)		
affecting interlocks	2.8.3 (II)		
mechanical strength	4.2 (II, III, IV, V, VI)		
cathode ray tubes	4.2.7 (V)		
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no test in MECHANICAL ENCLOSURES	4.2.1 (V)		
mobility of equipment (definitions)	1.2.3 (I)		
moisture <i>see</i> humidity, water ingress			
motor overload	5.4.2 (VIII)		
motor tests	annex B		
motor-generator sets, not in Scope of standard	1.1.3 (I)		
motors			
requirements	5.4.2 (VIII)		
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MOVABLE EQUIPMENT	1.2.3.1* (I), 1.2.3.3 (I)	insulation of ELV CIRCUIT	2.1.3 (II)
FIRE ENCLOSURES	4.4.4 (IV, V), A.1, A.2	ionizing radiation in	0.2.5 (I), 4.3.12 (VI), annex H
leakage current	5.2.2 (II), G.2	LIMITED CURRENT CIRCUITS	2.4.1 (II, III)
power supply cord flexing test	3.2.4 (II)	marking for lithium batteries	1.7.17 (I)
movable parts of equipment	2.9.1 (II)	marking of power outlet	1.7.5 (I)
moving parts of equipment	2.8.2 (II), 4.1.2 (V), 4.1.3 (V)	markings to be visible	1.7.1 (I)
		TOOL required for access	1.2.7.3 (I), 1.7.18 (I)
N		overcurrent and earth fault protection	2.7.1 (IV)
neutral conductors		overcurrent protection device	4.2.7 (V)
marking of terminals	1.7.7 (I)	in limited power source	2.11 (IV)
disconnected by disconnect device	2.6.6 (II), 2.6.7 (II)	overcurrent protection for transformer	5.4.3 (VIII), C.1
disconnected by protective device	2.7.4 (IV), 4.3.20 (IV)	overriding interlocks	2.8.5 (II)
fuse in neutral, warning required	2.7.6 (IV)	overvoltages 1.1.2 (I), 1.2.14.5 (I), 6.4.2.1 (II), annex Q (K.11)	
nominal mains voltages	2.2.7 (II), 2.9.2 (II), table 3	<i>see also</i> transients	
NON-DETACHABLE POWER SUPPLY CORDS		overload	
<i>see</i> power (supply) cords		mechanical	5.4.1 (VIII)
NORMAL LOAD conditions	1.2.2.1* (I), 5.1 (VIII), annex L	electrical	3.1.1 (VIII), 5.4.1 (VIII), 6.2.1 (II)
normative references	annex P	motor	5.4.2 (VIII), B.2, (table B.2), B.4, B.5, B.6, B.7
		transformer	5.4.3 (VIII), C.1
O		ozone	1.7.2 (I, VII)
oil	4.3.11 (II), 4.4.8 (IV)	P	
<i>see also</i> liquids		Part 68, FCC Rules	M.3, annex P
hot flaming oil test	A.5	passive devices, not in Scope of standard	1.1.3 (I)
openings	4.3.14 (II, IV)	peak, overvoltage	1.2.14.5 (I), 2.9.2 (II), 6.4.2.5
for power cords	3.2.6 (II), 3.2.7 (II)	peak voltage, repetitive	2.9.2 (II)
in FIRE ENCLOSURES	4.4.3.3 (IV)	PERMANENTLY CONNECTED EQUIPMENT	1.2.5.3* (I)
in OPERATOR ACCESS AREAS	2.1.2 (II)	personnel, network service	6.3 (II)
in sides of ENCLOSURES	4.3.16 (II, IV)	PERSONNEL, SERVICE <i>see</i> SERVICE PERSONNEL	
in tops of ENCLOSURES	4.3.15 (II, IV)	plating, protective earth components	2.5.10 (II)
measuring through	2.9.1 (II)	PLUGGABLE EQUIPMENT	1.7.2 (I, VII)
ventilation	4.4.3.3 (IV)	TYPE A	1.2.5.1* (I), 4.3.20 (IV)
operating conditions (definitions)	1.2.2 (I)	separation from TELECOMMUNICATION NETWORK	6.3.3 (II)
operating instructions 1.2.2.1 (I), 1.4.4 (I), 1.7.2 (I, VII), 1.7.17 (I)		TYPE B	1.2.5.2* (I), 1.7.11 (I), 5.2.5 (II), G.5
OPERATION, CONTINUOUS	1.2.2.3* (I), 5.1 (VIII)	discharging filter capacitors	2.1.10 (II)
OPERATION, INTERMITTENT	1.2.2.5* (I), 5.1 (VIII), 5.4.2 (VIII)	isolation	2.6.2 (II), 2.6.6 (II)
OPERATION, SHORT-TIME	1.2.2.4* (I), 5.1 (VIII), 5.4.2 (VIII), 5.4.8 (VIII)	leakage current	5.2.2 (II), G.2
OPERATIONAL INSULATION	1.2.9.1* (I)	overcurrent protection	2.7.3 (IV), 2.7.4 (IV)
application	2.1.1 (II), 2.1.2 (II), 2.2.6 (II)	plugs	2.3.4 (II), 3.2.1 (II)
in transformers	C.3	mismatching	4.3.19 (IV)
dimensions 2.9.2 (II), annex F		pollution (degree)	2.2.2 (II), 2.9.1 (II), 2.9.3 (II)
smaller spacings permitted	2.9.1 (II), 5.4.4 (VIII)	pollution degree 1 applies	2.9.6 (II), 2.9.7 (II)
electric strength	5.3.2 (II)	powder	4.3.4 (II)
WORKING VOLTAGE	2.2.7 (II)	containers	4.4.3.3 (IV)
OPERATOR	1.2.14.4* (I)	power	
servicing by OPERATOR		connections to equipment	3.2 (II)
handling insulation	2.9.4 (II)	distribution (definitions)	1.2.12 (I)
high pressure lamps	4.1.5 (V)	<i>see also</i> IT, TT, TN POWER SYSTEMS	
stability	4.1.1 (V)	factor	A.3.3
OPERATOR ACCESS AREAS	0.2.1 (I), 1.2.7.1* (I), 2.1 (II)	for equipment from TELECOMMUNICATION NETWORK	1.1.3 (I)
access probes	2.1.2 (II), 6.2.2 (II)	interfaces	1.6 (I)
batteries in	1.7.17 (I)	outlets on equipment <i>see</i> socket-outlets on equipment	
door in FIRE ENCLOSURE	4.4.7 (IV)	rating, marking	1.7.1 (I), 1.7.4 (I)
energy hazard in	0.2.2 (I), 2.1.5 (III)	sources, multiple	2.6.12 (II)
fuses	1.7.6 (I)	marking	1.7.9 (I)

power (supply) cords	3.2.4 (II)	input current not to exceed	1.6.1 (I)
DETACHABLE POWER SUPPLY CORDS	1.2.5.4* (I)	marking	1.7.1 (I)
NON-DETACHABLE POWER SUPPLY CORDS	1.2.5.5* (I)	POWER SUPPLY CORD calibres	3.2.5 (II)
special	3.3.2 (VIII)	purpose of marking	1.7.1 (I)
inside the equipment	3.1.5 (II)	range	1.7.1 (I)
screened	3.2.5 (II)	terminal sizes	3.3.6 (VIII)
POWER SYSTEMS <i>see</i> IT, TN, TT POWER SYSTEMS		rated current of overcurrent devices	1.7.6 (I), 2.11 (IV)
PRIMARY CIRCUITS	1.2.8.1* (I), 1.2.8.2 (I), 2.9.2 (II) (table 5 condition 5)	RATED FREQUENCY	1.2.1.4* (I), 1.4.6 (I), 1.7.1 (I), 1.7.4 (I)
protection	2.7.1 (IV)	RATED FREQUENCY RANGE	1.2.1.5* (I), 1.4.6 (I), 1.7.1 (I), 1.7.4 (I)
components in	2.8.6.1 (II), 5.4.6 (VIII)	RATED OPERATING TIME	1.2.2.2* (I), 1.7.3 (I), 5.1 (VIII), 5.4.8 (VIII)
filters in	0.2.1 (I), 5.2 (II), annex G	RATED VOLTAGE	1.2.1.1* (I)
marking of switch	1.7.8.3 (I)	IT EQUIPMENT	1.6.4 (I)
marking of terminals	1.7.7 (I)	marking	1.7.1 (I)
PRIMARY power		maximum value	
connections	3.2 (II)	600 V in Scope of standard	1.1.1 (I)
isolation <i>see</i> disconnection		250 V for handheld equipment	1.6.2 (I)
overload	3.1.1 (VIII)	tolerance	1.6.5 (I)
principles of safety	(page 17)	used for tests	1.4.5 (I)
printed boards	2.9.4 (II), 2.9.8 (II)	when measuring input current	1.6.1 (I)
coated	2.9.5 (II), annex F (figure F.13)	RATED VOLTAGE RANGE	1.2.1.2* (I)
quality control	annex R	marking	1.7.1 (I)
multi-layer	2.9.4 (II)	used for tests	1.4.5 (I)
printed wiring		when measuring input current	1.6.1 (I)
<i>see also</i> printed boards		rated voltage of fuses	1.7.6 (I)
colour of flexible	2.5.5 (II)	reed switches, reliability tests	2.8.6.3 (II)
protection		REINFORCED INSULATION	0.2.1 (I), 1.2.4.1 (I), 1.2.4.2 (I), 1.2.9.5* (I)
against electric shock and energy hazards	2.1 (II, III)	application	2.1.8 (II), 2.2.6 (II), C.3
in BUILDING INSTALLATIONS	1.7.11 (II), 2.7.1 (IV), 2.7.3 (IV), 2.7.4 (IV)	in CLASS I EQUIPMENT	1.2.4.1 (I), 2.5.1 (II)
of network SERVICE PERSONNEL	6.3 (II)	in CLASS II EQUIPMENT	1.2.4.2 (I), 2.5.2 (II)
of (telecommunication) equipment users	6.3 (II), 6.4 (II)	in SELV CIRCUITS	2.3.3 (II), 2.3.3.1 (II), 2.3.5 (II)
protective coverings in place during tests	5.4.7 (VIII)	in TNV CIRCUITS	6.2.1.4 (II)
protective devices	1.7.11 (I), 2.7.4 (IV)	on coated boards	2.9.5 (II)
protective earth and TELECOMMUNICATION NETWORKS	6.3.2 (II)	dimensions	2.9.2 (II), annex R
protective earthing	2.5 (II), 2.5.1 (II)	electric strength	5.3.2 (II)
colour of insulation	2.5.5 (II), 3.1.6 (II)	integrity after a test	4.2.7 (V), 5.4.4 (VIII), 5.4.6 (VIII), 5.4.9 (VIII)
conductors	2.5.3 (II)	integrity in service	3.1.8 (II), 4.3.9 (II), 4.3.10 (II)
materials for conductors	2.5.10 (II)	WORKING VOLTAGE	2.2.7 (II)
Q		relative humidity <i>see</i> humidity	
quality control	2.9.2 (II) (table 3 condition 3, table 5 condition 3), 2.9.5 (II), 2.9.8 (II)	relays	
quality control programmes	annex R	in FIRE ENCLOSURES	1.5.1 (I), 4.4.5.1 (IV)
R		motor starting	B.5
radiation hazards	0.2.5 (I), 4.3.12 (VI), annex H	repetitive peak voltage	2.9.2 (II)
radiation, laser	4.3.12 (VI), annex P, annex Q	resistance, protective earthing conductors	2.5.11 (II)
range		resistance to fire <i>see</i> fire risk	
of conductor sizes	3.2.8 (II), 3.3.5 (VIII)	RESTRICTED ACCESS LOCATIONS	1.2.7.3* (I), 4.3.14 (II, IV), 6.2.2 (II)
current	1.7.1 (I)	r.f.i. <i>see</i> electrical filters	
frequency <i>see</i> RATED FREQUENCY RANGE		ripple in D.C. VOLTAGE, definition	1.2.14.2 (I)
voltage, <i>see</i> RATED VOLTAGE RANGE		in WORKING VOLTAGE	2.2.7 (II)
RATED CURRENT	1.2.1.3* (I)	for CLEARANCE	2.9.2 (II), (table 5 condition 4)
		for electric strength tests	5.3.2 (II)
		in limited power source	2.11 (IV), (tables 8 and 9, condition 1)
		r.m.s. values implied unless otherwise specified	1.2 (I)

rubber, not to be used as insulation	2.2.2 (II)	fault conditions	2.3.3 (II), 6.2.1.3 (II)
running overload tests		methods of protecting	2.3.3 (II), to 2.3.3.4 (II)
a.c. motors	B.4	separation from unearthed TNV CIRCUITS	6.2.1.2 (II)
d.c. motors	B.6	WORKING VOLTAGE	2.2.7 (II)
S		SELV winding, meaning of term	C.2 (table C.2 condition 1)
SAFETY INTERLOCKS	2.8 (II, III)	semiconductor devices	
fail-safe operation	2.8.4 (II)	<i>see also</i> components	
mechanical actuators	2.8.6 (II), 2.8.6.3	as surge arrestors	(S.3)
protection	2.8.1 (II), 2.8.2 (II), 2.8.3 (II)	faults	1.4.12 (I), 5.4.6 (VIII)
overriding interlocks		in FIRE ENCLOSURES	4.4.5.1 (IV)
by SERVICE PERSONNEL	2.8.5 (II)	separation distances	2.9.5 (II), 2.9.8 (II)
TOOLS required	2.8.5 (II)	under coating	2.9.5 (II), annex R
mechanical shock affecting	2.8.3 (II)	SERVICE ACCESS AREAS	1.2.7.2* (I)
switches	2.8 (II, III), 2.9.2 (II)	<i>see also</i> SERVICE PERSONNEL	
SAFETY ISOLATING TRANSFORMERS	1.2.11.1* (I), 5.3.1, (II)	SERVICE PERSONNEL	1.2.14.3* (I)
<i>see also</i> transformers		connectors accessible to	4.3.17 (II, IV)
requirements and testing	C.2	of TELECOMMUNICATION NETWORK	6.3 (II)
samples for test		overriding interlocks	2.8.5 (II)
components	1.5.2 (I)	protection	
equipment	1.2.14.1 (I), 1.4.3 (I)	by earthing	2.5.1 (II)
scope of standard	1.1 (I)	from unexpected hazards	2.1.4 (II, III), 2.6.4 (II)
screens		mechanical hazards	4.1.2 (V)
earthed	0.2.1 (I), 1.4.12 (I)	stability	4.1.1 (V)
for SELV CIRCUITS	2.3.3.2 (II), 2.3.5 (II)	warning notices	1.7.9 (I), 2.7.6 (IV)
for TNV CIRCUITS	6.2.1.4 (II)	servicing controls	annex H
electromagnetic	2.2.6 (II), 2.9.2 (II), (table 5 condition 5)	servicing instructions	
mechanical	4.2.1 (V), 4.4.3 (IV), 4.4.6 (IV)	<i>see also</i> SERVICE PERSONNEL	
screw connections	3.1.8 (II, VIII), 3.3.3 (VIII), 4.3.13 (II)	fuse ratings	1.7.6 (I)
screws	annex P (ISO 261, ISO 262)	language	1.7.14 (I)
in insulating material	3.1.9 (II, VIII)	lithium batteries	1.7.17 (I)
thread cutting	3.1.11 (II, VIII)	mains voltage adjustment	1.7.4 (I)
sealed parts	2.9.6 (II)	maintenance	1.7.2 (I, VII)
SECONDARY CIRCUITS	0.2.1 (I), 1.2.8.2* (I), 1.2.8.4 (I), 1.2.8.5 (I)	sheaths (of power supply cords)	3.1.5 (II), 3.2.4 (II), 3.2.6 (II)
CLEARANCES in	2.9.2 (II), (table 5)	shields, <i>see</i> screens, electromagnetic	
electromagnetic components in	5.4.5 (VIII)	shock, electric <i>see</i> electric shock	
where FIRE ENCLOSURE is not required	4.4.5.2 (IV)	shock, mechanical <i>see</i> mechanical shock	
floating	2.9.2 (II), (table 5 conditions 5 and 6)	short-circuits	2.7 (II, III, IV, VIII)
in SERVICE ACCESS AREAS	2.1.4 (II, III)	of limited power sources	2.11 (IV)
WORKING VOLTAGE	5.3.2 (II), (table 18 condition 3)	of batteries	4.3.21 (III)
SECONDARY windings	C.1	of insulation	2.2.7 (II), 2.3.3.4 (II), 5.4.4 (VIII)
securing <i>see</i> fixing		of motor capacitors	B.8
SELV CIRCUITS	0.2.1 (I), 1.2.8.5*(I), 2.3 (II)	of parts with HAZARDOUS ENERGY LEVEL	0.2.2 (I)
accessibility	2.1.1 (II)		2.1.4 (II, III), 2.1.5 (III)
as interconnection circuits	2.10.2 (II)	of temperature limiters in unattended equipment	5.4.8 (VIII)
barriers in	2.3.3.1 (II)	of transformers	C.1
connected to earthed TNV CIRCUITS	6.2.1.3 (II)	protection against	1.7.11 (I), 2.7 (II, III, IV, VIII)
connections to other circuits	2.3.5 (II)		3.1.1 (VIII), 5.4.1 (VIII)
connections to other equipment	2.10.1 (II)	SHORT-TIME OPERATION	1.2.2.4* (I), 5.1 (VIII), 5.4.8 (VIII)
connectors	2.3.4 (II)	simulated	
earthing	2.5.11 (II)	conditions for test	1.4.9 (I), 5.1 (VIII), 5.4.7 (VIII), B.2,
faults	1.2.8.5* (I), 2.3.1 (II), 2.3.3 (II)		annex C, annex L, annex T
in transformers	C.2	interference	annex N
insulation	2.2.6 (II)	sleeving as SUPPLEMENTARY INSULATION	3.1.5 (II), 4.3.7 (II)
maximum voltages		sleeving round insulating beads	3.1.7 (II)
normal conditions	2.3.2 (II)	small parts, flammability	4.4.3.3 (IV)
		socket-outlets	annex P (IEC83, IEC 309)

in building wiring			
for DIRECT PLUG-IN EQUIPMENT	1.2.3.6 (I), 4.3.18 (II)		
for PLUGGABLE EQUIPMENT	1.2.5.1 (I), 1.2.5.2 (I)		
	1.7.2 (I, VII)		
reversible	2.6.6 (II), 4.3.20 (IV), 6.3.3 (II)		
on equipment	1.7.5 (I)		
accessibility	2.1.2 (II)		
loads to be taken into account	1.4.9 (I), 5.4.6 (VIII)		
sockets, multiway	2.3.4 (II)		
mismatching	4.3.17 (II, IV)		
solenoids	5.4.5 (VIII)		
in FIRE ENCLOSURE	4.4.5.1 (IV)		
solid insulation	2.2.1 (II), 2.5.1 (II), 2.9.1 (II)		
<i>see also</i> DISTANCES THROUGH INSULATION			
electric strength	5.3.2 (II) (table 18 condition 2)		
stability	4.1 (V)		
stand-by condition, marking	1.7.8.3 (I)		
STATIONARY EQUIPMENT	1.2.3.3* (I), 1.2.3.4 (I), 4.4.4, (IV, V),		
	5.1 (VIII), (table 16 part 1)		
ENCLOSURES	4.4.4 (IV, V), A.1, A.2, A.5		
leakage current	5.2.2 (II), 5.2.5 (II), G.2, G.5		
temperature of earth terminal	5.1 (VIII), (table 16 part 1)		
strain relief			
on fluid containers	4.4.8 (IV)		
on power cords	3.2.5 (II)		
stranded conductors	1.2.5.5 (I), 3.1.10 (II, VIII), 3.3.4 (II, VIII)		
	3.3.9 (II), 4.3.9 (II)		
stress relief on plastic materials	4.2.6 (V), 4.2.7 (V)		
sub-assembly testing	1.4.3 (I), 5.4.6 (VIII)		
SUPPLEMENTARY INSULATION	0.2.1 (I), 1.2.9.3* (I)		
	1.2.9.4 (I), 1.2.9.5 (I)		
application	2.1.1 (II), 2.1.2 (II), 2.1.9 (II), 2.2.6 (II), C.3		
as sleeving	3.1.5 (II), 4.3.7 (II)		
in cord anchorages	3.2.5 (II)		
in internal wiring	2.1.3 (II)		
in SELV CIRCUITS	2.3.3 (II)		
on power supply cords	3.1.5 (II)		
to capacitor casings	2.1.9 (II)		
to isolate TELECOMMUNICATION NETWORKS			
6.3.3 (II)			
consequences of failure	2.3.3 (II)		
dimensions	2.9.2 (II), 2.9.3 (II), 2.9.4 (II)		
	annex F, annex R		
electric strength	5.3.2 (II)		
gaps in	4.3.8 (II)		
integrity after a test	4.2.7 (V), 5.4.4 (VIII), 5.4.6 (VIII)		
	5.4.9 (VIII)		
integrity in service	3.1.8 (II, VIII), 3.3.9 (II)		
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one element of DOUBLE INSULATION	2.2.7 (II)		
interchanged with BASIC INSULATION	2.2.6 (II)		
WORKING VOLTAGE	2.2.7 (II)		
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surge protection	6.1 (II) (table 13 condition 1)		
surge suppressors <i>see</i> surge arrestors			
switches			
		<i>see also</i> IEC-1058-1	
		arcing	4.4.4 (IV, V)
		as disconnect devices <i>see</i> disconnection for servicing	
		forbidden in protective earth conductors	2.5.3 (II)
		functional	2.6.2 (II)
		in FIRE ENCLOSURES	4.4.5 (IV)
		in PRIMARY CIRCUITS	5.4.6 (VIII)
		isolating	2.6.2 (II), 2.6.5 (II), 2.6.8 (II)
		marking	1.7.8 (I), 4.3.5 (II)
		microgap	2.9.2 (II)
		reed	2.8.6.3 (II)
		safety interlock	2.8 (II, III), 2.9.2 (II)
		terminals of	3.3.3 (VIII)
		thermal control	annex K
		symbols, marking	1.7.1 (I), 1.7.7 (I), 1.7.8.3 (I)
		T	
		TELECOMMUNICATION NETWORKS	1.2.14.5* (I)
		connections to	1.2.11.7 (I), 6.3.1 (II)
		equipment powered from	1.1.3 (I)
		protection by earthing	6.3.2 (II)
		ringing signals	6.2.1.1 (II), annex M
		separation from	6.3.3 (II), 6.4.1 (II)
		surge protection	6.1 (II)
		TELECOMMUNICATION SIGNALS	1.2.14.6* (I)
		telephone ringing signals	6.2.1.1 (II), annex M
		temperature	
		maximum	
		motors	B.3
		transformers	C.1
		measurement	1.4.7 (I), 1.4.8 (I)
		TEMPERATURE LIMITERS	1.2.11.3 (I), annex K
		temperature rise	
		maximum	
		in OPERATOR ACCESS AREAS	5.1 (VIII)
		of materials and components	5.1 (VIII)
		of windings	1.4.8 (I), annex E
		measurement	1.4.7 (I)
		temperature sensing devices	4.3.20 (IV)
		terminals	3.3 (II)
		access	3.2.8 (II)
		ampacity	3.3.5 (VIII), 3.3.6 (VIII)
		corrosion	2.5.10 (II)
		marking	1.7.7 (I)
		temperature	5.1 (VIII)
		test	
		fingers	2.1.2 (II), figure 19 (page 239)
		pins	2.1.2 (II), figure 20 (page 241)
		probes	6.2.2 (II)
		tests	
		abrasion resistance	2.9.5 (II)
		ball-pressure	5.4.10 (VIII), figure 21 (page 241)
		drop	4.2.5 (V)
		flammability	annex A
		electric strength	5.3.2 (II)
		impact	4.2.4 (V)

impulse voltage		annex S	to override interlocks	2.8.5 (II)
leakage current		5.2 (II), annex G	to remove bushings	3.2.6 (II)
motors		annex B	to remove guard against water ingress	annex T
resistance to heat and fire		annex A	risk of short-circuits during servicing	2.3.4 (II)
steady force (250 N)		4.2.3 (V)	touch current, <i>see</i> leakage current	
steady force (30 N)		4.2.2 (V)	TRACKING	1.2.9.7* (I), 2.9.3 (II)
steel ball		4.2.4 (V)	<i>see also</i> c.t.i.	
stress relief 4.2.6 (V)			transformers	1.5.3 (I)
thermal ageing		2.9.5 (II)	<i>see also</i> SAFETY ISOLATING TRANSFORMERS	
thermal cycling		2.9.5 (II)	BODIES of	C.2 (table C.2 condition 7)
transformers		annex C	conductive foil as screens	C.2
TESTS, TYPE	1.2.14.1* (I), 1.4.2 (I)		enclosed	2.9.6 (I)
thermal controls		annex K	in FIRE ENCLOSURE	4.4.5.1 (IV)
THERMAL CUTOUTS	1.2.11.4* (I), annex K		insulation	2.2.6 (II), C.3
not to operate during heating tests		5.1 (VIII)	isolating	2.3.3 (II), 2.11 (IV), 5.2.2 (II), 6.2 (II)
thermoplastic parts		5.4.10 (VIII)	maximum temperature	C.1
THERMOSTATS	1.2.11.2* (I), 5.4.8 (VIII)		not in Scope of standard	1.1.3 (I)
thickness (of insulation), <i>see</i> DISTANCE THROUGH INSULATION			overcurrent protection	5.4.3 (VIII), C.1
thin sheet material (insulation)		2.9.4 (II), C.2	overload	5.4.3 (VIII)
three-phase			protection	5.4.3 (VIII)
disconnect devices		2.6.7 (II)	SECONDARY CIRCUIT	1.2.8.2 (I)
equipment			testing	5.4.6 (VIII), C.1
leakage current	5.2.4 (II), 5.2.5 (II), G.4, G.5		WORKING VOLTAGE	2.2.7 (II)
protection		2.7.4 (IV)	transient voltage ratings	2.9.2 (II) (table 3)
motors		B.9	transients	2.9.2 (II), 6.1 (II)
rotation, marking if critical		1.7.7 (I)	affecting WORKING VOLTAGE	2.2.7 (II)
TIME, RATED OPERATING	1.2.2.2* (I), 1.7.3 (I), 5.1 (VIII)		overvoltage categories	1.1.2 (I), 2.9.1 (II)
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