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INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

**Information technology equipment – Safety –
Part 1: General requirements**

**Matériels de traitement de l'information – Sécurité –
Partie 1: Exigences générales**

IEC 60950-1:2005+A1:2012+A2:2013

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Information technology equipment – Safety – Part 1: General requirements

Matériels de traitement de l'information – Sécurité – Partie 1: Exigences générales

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

INFORMATION TECHNOLOGY EQUIPMENT –
SAFETY –

Part 1: General requirements

FOREWORD

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This consolidated version of IEC 60950-1 consists of the second edition (2005) [documents 108/135A/FDIS and 108/147/RVD], its corrigendum 1 (2006), its amendment 1 (2009) [documents 108/350/FDIS and 108/357/RVD] and its corrigendum 1 (2012), and its amendment 2 (2013) [documents 108/507/FDIS and 108/510/RVD]. It bears the edition number 2.2.

The technical content is therefore identical to the base edition and its amendments and has been prepared for user convenience. A vertical line in the margin shows where the base publication has been modified by amendments 1 and 2. Additions and deletions are displayed in red, with deletions being struck through.

International Standard IEC 60950-1 has been prepared by IEC technical committee 108: Safety of electronic equipment within the field of audio/video, information technology and communication technology.

IEC 60950-1 includes the basic requirements for the safety of information technology equipment.

Additional parts of IEC 60950-1 will cover specific safety requirements for information technology equipment having limited applications or having special features as follows:

Part 21: Remote feeding (published);

Part 22: Equipment installed outdoors (planned);

Part 23: Large data storage equipment (planned);

Except for notes, all text within a normative figure, or in a box under a normative table, is also normative. Text with a superscript reference is linked to a particular item in the table. Other text in a box under a table applies to the whole table.

Informative annexes and text beginning with the word "NOTE" are not normative. They are provided only to give additional information.

"Country" notes are also informative but call attention to requirements that are normative in those countries.

In this standard, the following print types are used:

– Requirements proper and normative annexes: roman type.
– *Compliance statements and test specifications: italic type.*
– Notes in the text and in tables: smaller roman type.
– Terms that are defined in 1.2: SMALL CAPITALS.

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INTRODUCTION

0 Principles of safety

The following principles have been adopted by technical committee 108 in the development of this standard.

These principles do not cover performance or functional characteristics of equipment.

Words printed in SMALL CAPITALS are terms that are defined in 1.2 of this standard.

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.

These principles are not an alternative to the detailed requirements of this standard, but are intended to provide designers with an appreciation of the basis of these requirements. Where the equipment involves technologies, components and materials or methods of construction not specifically covered, the design of the equipment should provide a level of safety not less than those described in these principles of safety.

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

Designers shall take into account not only normal operating conditions of the equipment but also likely fault conditions, consequential faults, foreseeable misuse and external influences such as temperature, altitude, pollution, moisture, overvoltages on the MAINS SUPPLY and overvoltages on a TELECOMMUNICATION NETWORK or a CABLE DISTRIBUTION SYSTEM. Dimensioning of insulation spacings should take account of possible reductions by manufacturing tolerances, or where deformation could occur due to handling, shock and vibration likely to be encountered during manufacture, transport and normal use.

The following priorities should be observed in determining what design measures to adopt:

– where possible, specify design criteria that will eliminate, reduce or guard against hazards;

– where the above is not practicable because the functioning of the equipment would be impaired, specify the use of protective means independent of the equipment, such as personal protective equipment (which is not specified in this standard);

– where neither of the above measures is practicable, or in addition to those measures, specify the provision of markings and instructions regarding the residual risks.

There are two types of persons whose safety needs to be considered, USERS (or OPERATORS) and SERVICE PERSONS.

USER is the term applied to all persons other than SERVICE PERSONS. Requirements for protection should assume that USERS are not trained to identify hazards, but will not intentionally create a hazardous situation. Consequently, the requirements will provide protection for cleaners and casual visitors as well as the assigned USERS. In general, USERS should not have access to hazardous parts, and to this end, such parts should only be in SERVICE ACCESS AREAS or in equipment located in RESTRICTED ACCESS LOCATIONS.

When USERS are admitted to RESTRICTED ACCESS LOCATIONS they shall be suitably instructed.

SERVICE PERSONS are expected to use their training and skill to avoid possible injury to themselves and others due to obvious hazards that exist in SERVICE ACCESS AREAS of the equipment or on equipment located in RESTRICTED ACCESS LOCATIONS. However, SERVICE

PERSONS should be protected against unexpected hazards. This can be done by, for example, locating parts that need to be accessible for servicing away from electrical and mechanical hazards, providing shields to avoid accidental contact with hazardous parts, and providing labels or instructions to warn personnel about any residual risk.

Information about potential hazards can be marked on the equipment or provided with the equipment, depending on the likelihood and severity of injury, or made available for SERVICE PERSONS. In general, USERS shall not be exposed to hazards likely to cause injury, and information provided for USERS should primarily aim at avoiding misuse and situations likely to create hazards, such as connection to the wrong power source and replacement of fuses by incorrect types.

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 earthing conductor. 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. TRANSPORTABLE EQUIPMENT introduces a further factor because it can be used and carried in any orientation; if a small metallic object enters an opening in the ENCLOSURE it can move around inside the equipment, possibly creating a hazard.

0.2 Hazards

Application of a safety standard is intended to reduce the risk of injury or damage due to the following:

– electric shock;
– energy related hazards;
– fire;
– heat related hazards;
– mechanical hazards;
– radiation;
– chemical hazards.

0.2.1 Electric shock

Electric shock is due to current passing through the human body. The resulting physiological effects depend on the value and duration of the current and the path it takes through the body. The value of the current depends on the applied voltage, the impedance of the source and the impedance of the body. The body impedance depends in turn on the area of contact, moisture in the area of contact and the applied voltage and frequency. Currents of approximately half a milliampere can cause a reaction in persons in good health and may cause injury indirectly due to involuntary reaction. Higher currents can have more direct effects, such as burn or muscle tetanization leading to inability to let go or to ventricular fibrillation.

Steady state voltages up to 42,4 V peak, or 60 V d.c., are not generally regarded as hazardous under dry conditions for an area of contact equivalent to a human hand. Bare parts that have to be touched or handled should be at earth potential or properly insulated.

Some equipment will be connected to telephone and other external networks. Some TELECOMMUNICATION NETWORKS operate with signals such as voice and ringing superimposed on a steady d.c. supply voltage; the total may exceed the values given above for steady-state voltages. It is common practice for the SERVICE PERSONS of telephone companies to handle parts of such circuits bare-handed. This has not caused serious injury, because of the use of cadenced ringing and because there are limited areas of contact with bare conductors normally handled by SERVICE PERSONS. However, the area of contact of a part accessible to the USER, and the likelihood of the part being touched, should be further limited (for example, by the shape and location of the part).

It is normal to provide two levels of protection for USERS to prevent electric shock. Therefore, the operation of equipment under normal conditions and after a single fault, including any consequential faults, should not create a shock 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.

Harm may result from:	**Examples of measures to reduce risks:**
Contact with bare parts normally at HAZARDOUS VOLTAGES.	Prevent USER access to parts at HAZARDOUS VOLTAGES by fixed or locked covers, SAFETY INTERLOCKS, etc. Discharge accessible capacitors that are at HAZARDOUS VOLTAGES.
Breakdown of insulation between parts normally at HAZARDOUS VOLTAGES and accessible conductive parts.	Provide BASIC INSULATION and connect the accessible conductive parts and circuits to earth so that exposure to the voltage which can develop is limited because overcurrent protection will disconnect the parts having low impedance faults within a specified time; or provide a metal screen connected to protective earth between the parts, or provide DOUBLE INSULATION or REINFORCED INSULATION between the parts, so that breakdown to the accessible part is not likely to occur.
Contact with circuits connected to TELECOMMUNICATION NETWORKS that exceed 42,4 V peak or 60 V d.c.	Limit the accessibility and area of contact of such circuits, and separate them from unearthed parts to which access is not limited.
Breakdown of USER-accessible insulation.	Insulation that is accessible to the USER should have adequate mechanical and electrical strength to reduce the likelihood of contact with HAZARDOUS VOLTAGES.
TOUCH CURRENT (leakage current) flowing from parts at HAZARDOUS VOLTAGES to accessible parts, or failure of a protective earthing connection. TOUCH CURRENT may include current due to EMC filter components connected between PRIMARY CIRCUITS and accessible parts.	Limit TOUCH CURRENT to a specified value, or provide a high integrity protective earthing connection.

0.2.2 Energy related hazards

Injury or fire may result from a short-circuit between adjacent poles of high current supplies or high capacitance circuits, causing:

– burns;

– arcing;

– ejection of molten metal.

Even circuits whose voltages are safe to touch may be hazardous in this respect.

Examples of measures to reduce risks include:

– separation;

– shielding;

– provision of SAFETY INTERLOCKS.

0.2.3 Fire

Risk of fire may result from excessive temperatures either under normal operating conditions or due to overload, component failure, insulation breakdown or loose connections. 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.

Examples of measures to reduce risks include:

– providing overcurrent protection;

– using constructional materials having appropriate flammability properties for their purpose;

– selection of parts, components and consumable materials to avoid high temperature which might cause ignition;

– limiting the quantity of combustible materials used;

– shielding or separating combustible materials from likely ignition sources;

– using ENCLOSURES or barriers to limit the spread of fire within the equipment;

– using suitable materials for ENCLOSURES so as to reduce the likelihood of fire spreading from the equipment.

0.2.4 Heat related hazards

Injury may result from high temperatures under normal operating conditions, causing:

– burns due to contact with hot accessible parts;

– degradation of insulation and of safety-critical components;

– ignition of flammable liquids.

Examples of measures to reduce risks include:

– taking steps to avoid high temperature of accessible parts;

– avoiding temperatures above the ignition point of liquids;

– provision of markings to warn USERS where access to hot parts is unavoidable.

0.2.5 Mechanical hazards

Injury may result from:

– sharp edges and corners;

– moving parts that have the potential to cause injury;

– equipment instability;

– flying particles from imploding cathode ray tubes and exploding high pressure lamps.

Examples of measures to reduce risks include:

– rounding of sharp edges and corners;

– guarding;

– provision of SAFETY INTERLOCKS;

– providing sufficient stability to free-standing equipment;

– selecting cathode ray tubes and high pressure lamps that are resistant to implosion and explosion respectively;
– provision of markings to warn USERS where access is unavoidable.

0.2.6 Radiation

Injury to USERS and to SERVICE PERSONS may result from some forms of radiation emitted by equipment. Examples are sonic (acoustic), radio frequency, infra-red, ultraviolet and ionizing radiation, and high intensity visible and coherent light (lasers).

Examples of measures to reduce risks include:

– limiting the energy level of potential radiation sources;
– screening radiation sources;
– provision of SAFETY INTERLOCKS;
– provision of markings to warn USERS where exposure to the radiation hazard is unavoidable.

0.2.7 Chemical hazards

Injury may result from contact with some chemicals or from inhalation of their vapours and fumes.

Examples of measures to reduce risks include:

– avoiding the use of constructional and consumable materials likely to cause injury by contact or inhalation during intended and normal conditions of use;
– avoiding conditions likely to cause leakage or vaporization;
– provision of markings to warn USERS about the hazards.

0.3 Materials and components

Materials and components used in the construction of equipment should be so selected and arranged that they can be expected to perform in a reliable manner for the anticipated life of the equipment without creating a hazard, and would not contribute significantly to the development of a serious fire hazard. Components should be selected so that they remain within their manufacturers' ratings under normal operating conditions, and do not create a hazard under fault conditions.

INFORMATION TECHNOLOGY EQUIPMENT – SAFETY –

Part 1: General requirements

1 General

1.1 Scope

1.1.1 Equipment covered by this standard

This standard is applicable to mains-powered or battery-powered 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 information technology equipment:

– designed for use as telecommunication terminal equipment and TELECOMMUNICATION NETWORK infrastructure equipment, regardless of the source of power;

– designed and intended to be connected directly to, or used as infrastructure equipment in, a CABLE DISTRIBUTION SYSTEM, regardless of the source of power;

– designed to use the AC MAINS SUPPLY as a communication transmission medium (see Clause 6, Note 4 and 7.1, Note 4).

This part of IEC 60950 is also applicable to:

– components and subassemblies intended for incorporation in ~~information technology~~ this equipment. ~~It is not expected that~~ Such components and subassemblies need not comply with every ~~aspect~~ requirement of the standard, provided that the complete ~~information technology~~ equipment, incorporating such components and subassemblies, does comply;

– external power supply units intended to supply other equipment within the scope of this part of IEC 60950;

– accessories intended to be used with equipment within the scope of this part of IEC 60950.

NOTE 1 Examples of aspects with which uninstalled components, subassemblies and accessories may not comply include the marking of the power rating and access to hazardous parts.

NOTE 2 This standard may be applied to the electronic parts of equipment even if that equipment does not wholly fall within its Scope, such as large-scale air conditioning systems, fire detection systems and fire extinguishing systems. Different requirements may be necessary for some applications.

This standard specifies requirements intended to reduce risks of fire, electric shock or injury for the OPERATOR and layman who may come into contact with the equipment and, where specifically stated, for a SERVICE PERSON.

This standard is intended to reduce such risks with respect to 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 that is in the scope of this standard are:

Generic product type	Specific example of generic type
banking equipment	monetary processing machines including automated teller (cash dispensing) machines (ATM)
data and text processing machines and associated equipment	data preparation equipment, data processing equipment, data storage equipment, personal computers, plotters, printers, scanners, text processing equipment, visual display units
data network equipment	bridges, data circuit terminating equipment, data terminal equipment, routers
electrical and electronic retail equipment	cash registers, point of sale terminals including associated electronic scales
electrical and electronic office machines	calculators, copying machines, dictation equipment, document shredding machines, duplicators, erasers, micrographic office equipment, motor-operated files, paper trimmers (punchers, cutting machines, separators), paper jogging machines, pencil sharpeners, staplers, typewriters
other information technology equipment	photoprinting equipment, public information terminals, multimedia equipment
postage equipment	mail processing machines, postage machines
telecommunication network infrastructure equipment	billing equipment, multiplexers, network powering equipment, network terminating equipment, radio basestations, repeaters, transmission equipment, telecommunication switching equipment
telecommunication terminal equipment	facsimile equipment, key telephone systems, modems, PABXs, pagers, telephone answering machines, telephone sets (wired and wireless)

NOTE 3 The requirements of IEC 60065 may also be used to meet safety requirements for multimedia equipment. See IEC Guide 112, *Guide on the safety of multimedia equipment*.

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 in special environments (for example, extremes of temperature; excessive dust, moisture or vibration; flammable gases; and 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 altitudes greater than 2 000 m;

– 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:

– power supply systems which are not an integral part of the equipment, such as motor-generator sets, battery backup systems and distribution transformers;

– building installation wiring;

– devices requiring no electric power.

1.2 Definitions

For the purpose of this International 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
AREA, SERVICE ACCESS 1.2.7.2
BODY 1.2.7.5
CABLE, INTERCONNECTING 1.2.11.6
CABLE DISTRIBUTION SYSTEM 1.2.13.14
CHEESECLOTH 1.2.13.15
CIRCUIT, ELV 1.2.8.7
CIRCUIT, LIMITED CURRENT 1.2.8.9
CIRCUIT, PRIMARY 1.2.8.4
CIRCUIT, SECONDARY 1.2.8.5
CIRCUIT, SELV 1.2.8.8
CIRCUIT, TNV 1.2.8.11
CIRCUIT, TNV-1 .... 1.2.8.12
CIRCUIT, TNV-2 .... 1.2.8.13
CIRCUIT, TNV-3 .... 1.2.8.14
CLEARANCE 1.2.10.1
CONDUCTOR, PROTECTIVE BONDING 1.2.13.11
CONDUCTOR, PROTECTIVE EARTHING 1.2.13.10
CORD, DETACHABLE POWER SUPPLY 1.2.5.5
CORD, NON-DETACHABLE POWER SUPPLY 1.2.5.6
CREEPAGE DISTANCE 1.2.10.2
CURRENT, PROTECTIVE CONDUCTOR 1.2.13.13
CURRENT, RATED 1.2.1.3
CURRENT, TOUCH 1.2.13.12
CUT-OUT, THERMAL 1.2.11.3
CUT-OUT, THERMAL, AUTOMATIC RESET 1.2.11.4
CUT-OUT, THERMAL, MANUAL RESET 1.2.11.5
EARTHING, FUNCTIONAL 1.2.13.9
ENCLOSURE 1.2.6.1
ENCLOSURE, ELECTRICAL 1.2.6.4
ENCLOSURE, FIRE 1.2.6.2
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EQUIPMENT, PLUGGABLE 1.2.5.3
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EQUIPMENT, PLUGGABLE, TYPE B 1.2.5.2

EQUIPMENT, STATIONARY 1.2.3.4
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FREQUENCY, RATED 1.2.1.4
INSULATION, BASIC 1.2.9.2
INSULATION, DOUBLE 1.2.9.4
INSULATION, FUNCTIONAL 1.2.9.1
INSULATION, REINFORCED 1.2.9.5
INSULATION, SOLID 1.2.10.4
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MATERIAL, V-0 CLASS 1.2.12.2
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MATERIAL, VTM-0 CLASS 1.2.12.12
MATERIAL, VTM-1 CLASS 1.2.12.13
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OPERATOR 1.2.13.7
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VOLTAGE, TELECOMMUNICATION NETWORK TRANSIENT 1.2.9.11
VOLTAGE, WORKING 1.2.9.6

1.2.1 Equipment electrical ratings

1.2.1.1
RATED VOLTAGE
supply voltage ~~(for a three-phase AC MAINS SUPPLY, the line-to-line voltage)~~ from which the equipment is to be operated as declared by the manufacturer

1.2.1.2
RATED VOLTAGE RANGE
supply voltage range as declared by the manufacturer, expressed by its lower and upper RATED VOLTAGES

1.2.1.3
RATED CURRENT
input current of the equipment as declared by the manufacturer

1.2.1.4
RATED FREQUENCY
supply frequency as declared by the manufacturer

1.2.1.5
RATED FREQUENCY RANGE
supply 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
mode of operation, used for testing purposes, which represents as closely as possible the most severe conditions of normal use which can reasonably be expected

If the conditions of actual use can reasonably be expected to be more severe than the maximum load conditions recommended by the manufacturer, including RATED OPERATING TIME and RATED RESTING TIME, a mode of operation is used that represents these more severe conditions.

NOTE NORMAL LOAD conditions for some types of equipment are given in Annex L.

1.2.2.2
RATED OPERATING TIME
maximum operating time assigned to the equipment by the manufacturer

1.2.2.3
RATED RESTING TIME
minimum time, assigned by the manufacturer, during which the equipment is switched off or running idle between periods of RATED OPERATING TIME

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, or a part of any kind of equipment, that is intended to be held in the hand during normal use

1.2.3.3
TRANSPORTABLE EQUIPMENT
MOVABLE EQUIPMENT that is intended to be routinely carried by a USER

NOTE Examples include laptop and notebook personal computers, pen-based tablet computers, and their portable accessories such as printers and CD-ROM drives.

1.2.3.4
STATIONARY EQUIPMENT
equipment that is not MOVABLE EQUIPMENT

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

NOTE Some information technology equipment cannot be identified as conforming to one of the following classes.

1.2.4.1
CLASS I EQUIPMENT
equipment where protection against electric shock is achieved by

– using BASIC INSULATION and

– providing a means of connection 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 CLASS I EQUIPMENT may have parts with DOUBLE INSULATION or REINFORCED INSULATION.

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 reliance on protective earthing

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

NOTE For CLASS III EQUIPMENT, although there is no requirement for protection against electric shock, all other requirements of the standard apply.

1.2.5 Connection to the supply

1.2.5.1
PLUGGABLE EQUIPMENT TYPE A
equipment that is intended for connection to a MAINS SUPPLY via a non-industrial plug and socket-outlet or a non-industrial appliance coupler, or both

1.2.5.2
PLUGGABLE EQUIPMENT TYPE B
equipment that is intended for connection to a MAINS SUPPLY via an industrial plug and socket-outlet or an appliance coupler, or both, complying with IEC 60309 or with a comparable national standard

1.2.5.3
PLUGGABLE EQUIPMENT
equipment that is either **PLUGGABLE EQUIPMENT TYPE A** or **PLUGGABLE EQUIPMENT TYPE B**

1.2.5.4
PERMANENTLY CONNECTED EQUIPMENT
equipment that is intended for connection to the building installation wiring using screw terminals or other reliable means

1.2.5.5
DETACHABLE POWER SUPPLY CORD
flexible cord, for supply purposes, intended to be connected to the equipment by means of a suitable appliance coupler

1.2.5.6
NON-DETACHABLE POWER SUPPLY CORD
flexible cord, for supply purposes, fixed to or assembled with the equipment

Such a cord may be either:

Ordinary: a flexible cord that can be easily replaced without special preparation of the cord or special TOOLS; or

Special: a flexible cord that 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 reshaping 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
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

NOTE One type of ENCLOSURE can be inside another type (for example, an ELECTRICAL ENCLOSURE inside a FIRE ENCLOSURE or a FIRE ENCLOSURE inside an ELECTRICAL ENCLOSURE). Also, a single ENCLOSURE can provide the functions of more than one type (for example, the functions of both an ELECTRICAL ENCLOSURE and a FIRE ENCLOSURE).

1.2.6.2
FIRE ENCLOSURE
part of the equipment intended to minimize the spread of fire or flames from within

1.2.6.3
MECHANICAL ENCLOSURE
part of the equipment intended to reduce the risk of injury due to mechanical and other physical hazards

1.2.6.4
ELECTRICAL ENCLOSURE
part of the equipment intended to limit access to parts that may be at HAZARDOUS VOLTAGES or HAZARDOUS ENERGY LEVELS or are in TNV CIRCUITS

1.2.6.5
DECORATIVE PART
part of the equipment, outside the ENCLOSURE, which has no safety function

1.2.7 Accessibility

1.2.7.1
OPERATOR ACCESS AREA
part of the equipment to which, under normal operating conditions, one of the following applies:

– access can be gained without the use of a TOOL;
– the means of access is deliberately provided to the OPERATOR;
– the OPERATOR is instructed to enter regardless of whether or not a TOOL is needed to gain access

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

1.2.7.2
SERVICE ACCESS AREA
part of the equipment, other than an OPERATOR ACCESS AREA, where it is necessary for SERVICE PERSONS to have access even with the equipment switched on

1.2.7.3
RESTRICTED ACCESS LOCATION
location for equipment where both of the following apply:

– access can only be gained by SERVICE PERSONS or by USERS who have been instructed about the reasons for the restrictions applied to the location and about any precautions that shall be taken; and
– access is through the use of a TOOL or lock and key, or other means of security, and is controlled by the authority responsible for the location

NOTE The requirements for equipment intended for installation in RESTRICTED ACCESS LOCATIONS are the same as for OPERATOR ACCESS AREAS, except as given in 1.7.14, 2.1.3, 4.5.4, 4.6.2 and 5.1.7.

1.2.7.4
TOOL
screwdriver or any other object that may 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
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 Circuits and circuit characteristics

1.2.8.1
AC MAINS SUPPLY
a.c. power distribution system external to the equipment for supplying power to a.c. powered equipment

These power sources include public or private utilities and, unless otherwise specified in the standard (for example, 1.4.5), equivalent sources such as motor-driven generators and uninterruptible power supplies.

NOTE See Annex V for typical examples of a.c. power distribution systems.

1.2.8.2
DC MAINS SUPPLY
d.c. power distribution system, with or without batteries, external to the equipment, for supplying power to d.c. powered equipment, excluding the following:

– a d.c. supply providing power over TELECOMMUNICATION NETWORK wiring to remote equipment;

– a limited power source (see 2.5) whose open circuit voltage is less than or equal to 42,4 V d.c.;

– a d.c. supply whose open circuit voltage is greater than 42,4 V d.c. and less than or equal to 60 V d.c., and whose available power output is less than 240 VA

Circuitry connected to a DC MAINS SUPPLY is considered to be a SECONDARY CIRCUIT (for example, an SELV CIRCUIT, a TNV CIRCUIT or a HAZARDOUS VOLTAGE SECONDARY CIRCUIT) in the meaning of this standard.

NOTE See ITU-T Recommendation K.27 for bonding configurations and earthing inside a telecommunication building.

1.2.8.3
MAINS SUPPLY
power distribution system that is either an AC MAINS SUPPLY or a DC MAINS SUPPLY

1.2.8.4
PRIMARY CIRCUIT
circuit that is directly connected to the AC MAINS SUPPLY

It includes, for example, the means for connection to the AC MAINS SUPPLY, the primary windings of transformers, motors and other loading devices.

NOTE Conductive parts of an INTERCONNECTING CABLE may be part of a PRIMARY CIRCUIT as stated in 1.2.11.6.

1.2.8.5

SECONDARY CIRCUIT

circuit that has no direct connection to a PRIMARY CIRCUIT and derives its power from a transformer, converter or equivalent isolation device, or from a battery

NOTE Conductive parts of an INTERCONNECTING CABLE may be part of a SECONDARY CIRCUIT as stated in 1.2.11.6.

1.2.8.6

HAZARDOUS VOLTAGE

voltage exceeding 42,4 V peak, or 60 V d.c., existing in a circuit that does not meet the requirements for either a LIMITED CURRENT CIRCUIT or a TNV CIRCUIT

1.2.8.7

ELV CIRCUIT

SECONDARY CIRCUIT with voltages between any two conductors of the circuit, and between any one such conductor and earth (see 1.4.9), not exceeding 42,4 V peak, or 60 V d.c., under normal operating conditions, which is separated from HAZARDOUS VOLTAGE by 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

1.2.8.8

SELV CIRCUIT

SECONDARY CIRCUIT that is so designed and protected that under normal operating conditions and single fault conditions, its voltages do not exceed a safe value

NOTE 1 The limit values of voltages under normal operating conditions and single fault conditions (see 1.4.14) are specified in 2.2. See also Table 1A.

NOTE 2 This definition of an SELV CIRCUIT differs from the term "SELV system" as used in IEC 61140.

1.2.8.9

LIMITED CURRENT CIRCUIT

circuit that is so designed and protected that, under both normal operating conditions and single fault conditions, the current that can be drawn is not hazardous

NOTE The limit values of currents under normal operating conditions and single fault conditions (see 1.4.14) are specified in 2.4.

1.2.8.10

HAZARDOUS ENERGY LEVEL

available power level of 240 VA or more, having a duration of 60 s or more, or a stored energy level of 20 J or more (for example, from one or more capacitors), at a potential of 2 V or more

1.2.8.11

TNV CIRCUIT

circuit that is in the equipment and to which the accessible area of contact is limited and that is so designed and protected that, under normal operating conditions and single fault conditions (see 1.4.14), the voltages do not exceed specified limit values

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

NOTE 1 The specified limit values of voltages under normal operating conditions and single fault conditions (see 1.4.14) are given in 2.3.1. Requirements regarding accessibility of TNV CIRCUITS are given in 2.1.1.1.

NOTE 2 Conductive parts of an INTERCONNECTING CABLE may be part of a TNV CIRCUIT as stated in 1.2.11.6.

TNV CIRCUITS are classified as TNV-1 CIRCUITS, TNV-2 CIRCUITS and TNV-3 CIRCUITS as defined in 1.2.8.12, 1.2.8.13 and 1.2.8.14.

NOTE 3 The voltage relationships between SELV and TNV CIRCUITS are shown in Table 1A.

Table 1A – Voltage ranges of SELV and TNV circuits

Overvoltages from TELECOMMUNICATION NETWORKS possible?	Overvoltages from CABLE DISTRIBUTION SYSTEMS possible ?	Normal operating voltages: Within SELV CIRCUIT limits	Normal operating voltages: Exceeding SELV CIRCUIT limits but within TNV CIRCUIT limits
Yes	Yes	TNV-1 CIRCUIT	TNV-3 CIRCUIT
No	Not applicable	SELV CIRCUIT	TNV-2 CIRCUIT

1.2.8.12
TNV-1 CIRCUIT
TNV CIRCUIT

– whose normal operating voltages do not exceed the limits for an SELV CIRCUIT under normal operating conditions and

– on which overvoltages from TELECOMMUNICATION NETWORKS and CABLE DISTRIBUTION SYSTEMS are possible

1.2.8.13
TNV-2 CIRCUIT
TNV CIRCUIT

– whose normal operating voltages exceed the limits for an SELV CIRCUIT under normal operating conditions and

– which is not subject to overvoltages from TELECOMMUNICATION NETWORKS

1.2.8.14
TNV-3 CIRCUIT
TNV CIRCUIT

– whose normal operating voltages exceed the limits for an SELV CIRCUIT under normal operating conditions and

– on which overvoltages from TELECOMMUNICATION NETWORKS and CABLE DISTRIBUTION SYSTEMS are possible

1.2.9 Insulation

1.2.9.1
FUNCTIONAL INSULATION
insulation that is necessary only for the correct functioning of the equipment

NOTE FUNCTIONAL INSULATION by definition does not protect against electric shock. It may, however, reduce the likelihood of 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 reduce the risk of 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

single insulation system that 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 that cannot be tested as BASIC INSULATION and SUPPLEMENTARY INSULATION.

1.2.9.6

WORKING VOLTAGE

highest voltage to which the insulation or the component under consideration is, or can be, subjected when the equipment is operating under conditions of normal use

Overvoltages that originate outside the equipment are not taken into account.

1.2.9.7

RMS WORKING VOLTAGE

r.m.s. value of a WORKING VOLTAGE, including any d.c. component

NOTE For the purpose of determining RMS WORKING VOLTAGES, the rules of 2.10.2.2 apply, and where relevant those of 1.4.8.

1.2.9.8

PEAK WORKING VOLTAGE

peak value of a WORKING VOLTAGE, including any d.c. component and any repetitive peak impulses generated in the equipment

Where peak-to-peak ripple exceeds 10 % of the average value, the requirements related to peak or a.c. voltages are applicable.

NOTE For the purpose of determining PEAK WORKING VOLTAGES, the rules of 2.10.2.3 apply, and where relevant those of 1.4.8.

1.2.9.9

REQUIRED WITHSTAND VOLTAGE

peak voltage that the insulation under consideration is required to withstand

1.2.9.10

MAINS TRANSIENT VOLTAGE

highest peak voltage expected at the power input to the equipment, arising from external transients on the MAINS SUPPLY

1.2.9.11

TELECOMMUNICATION NETWORK TRANSIENT VOLTAGE

highest peak voltage expected at the TELECOMMUNICATION NETWORK connection point of the equipment, arising from external transients on the network

NOTE The effect of transients from CABLE DISTRIBUTION SYSTEMS is not taken into account.

1.2.10 Properties of insulation

1.2.10.1

CLEARANCE

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

1.2.10.2

CREEPAGE DISTANCE

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

1.2.10.3
BOUNDING SURFACE
outer surface of the ELECTRICAL ENCLOSURE, considered as though metal foil were pressed into contact with accessible surfaces of insulating material

1.2.10.4
SOLID INSULATION
material that provides electrical insulation between two opposite surfaces, not along an outer surface

NOTE The required properties of SOLID INSULATION are specified either as

– the actual minimum distance through the insulation (see 2.10.5.2), or by
– other requirements and tests in this standard instead of a minimum distance.

1.2.11 Components

1.2.11.1
THERMOSTAT
cycling temperature-sensing control intended to keep a temperature between two particular values under normal operating conditions and that may have provision for setting by the OPERATOR

1.2.11.2
TEMPERATURE LIMITER
temperature-sensing control intended to keep a temperature below or above one particular value during normal operating conditions and that may have provision for setting by the OPERATOR

NOTE A TEMPERATURE LIMITER may be of the automatic reset or of the manual reset type.

1.2.11.3
THERMAL CUT-OUT
temperature-sensing control intended to operate under abnormal operating conditions and that 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.

1.2.11.4
THERMAL CUT-OUT, AUTOMATIC RESET
THERMAL CUT-OUT that automatically restores the current after the relevant part of the equipment has cooled down sufficiently

1.2.11.5
THERMAL CUT-OUT, MANUAL RESET
THERMAL CUT-OUT that requires resetting by hand, or replacement of a part, in order to restore the current

1.2.11.6
INTERCONNECTING CABLE
cable used to

– electrically connect an accessory to a unit of information technology equipment,
– interconnect units in a system, or
– connect a unit to a TELECOMMUNICATION NETWORK or to a CABLE DISTRIBUTION SYSTEM

Such a cable may carry any type of circuit from one unit to another.

NOTE A power supply cord for connection to the MAINS SUPPLY is not an INTERCONNECTING CABLE.

1.2.12 Flammability

1.2.12.1
FLAMMABILITY CLASSIFICATION OF MATERIALS

recognition of the burning behaviour of materials and their ability to extinguish if ignited

Materials are classified as in 1.2.12.2 to 1.2.12.14 when tested in accordance with IEC 60695-11-10, IEC 60695-11-20, ISO 9772 or ISO 9773.

NOTE 1 When applying the requirements in this standard, HF-1 CLASS FOAMED MATERIAL is regarded as better than HF-2 CLASS, and HF-2 CLASS better than HBF CLASS.

NOTE 2 Similarly, material of 5VA CLASS is regarded as better than 5VB CLASS, 5VB CLASS better than V-0 CLASS, V-0 CLASS better than V-1 CLASS, V-1 CLASS better than V-2 CLASS, V-2 CLASS better than HB40 CLASS and HB40 CLASS better than HB75 CLASS.

NOTE 3 Similarly, MATERIAL of VTM-0 CLASS is regarded as better than VTM-1 CLASS and VTM-1 CLASS better than VTM-2 CLASS.

NOTE 4 VTM-0 CLASS, VTM-1 CLASS and VTM-2 CLASS MATERIALS are considered to be equivalent to V-0 CLASS, V-1 CLASS and V-2 CLASS MATERIALS, respectively, but only for their flammability properties. Their electrical and mechanical properties are not necessarily equivalent.

NOTE 5 Certain flammability classes have replaced the classes used in earlier editions of this standard. The equivalence of the old and the new classes is shown in Table 1B.

Table 1B – Equivalence of flammability classes

Old class	New class	Equivalence
–	5VA (1.2.12.5)	5VA is not required in this standard.
5V	5VB (1.2.12.6)	Materials that pass the tests for class 5V in Clause A.9 of earlier editions of this standard are equivalent to 5VB or better.
HB	HB40 (1.2.12.10)	Samples of materials in a thickness of 3 mm that pass the tests of Clause A.8 in earlier editions of this standard (maximum burning rate 40 mm/min during test) are equivalent to HB40.
	HB75 (1.2.12.11)	Samples of materials in a thickness of less than 3 mm that pass the tests of Clause A.8 in earlier editions of this standard (maximum burning rate 75 mm/min during test) are equivalent to HB75.

1.2.12.2
V-0 CLASS MATERIAL

material tested in the thinnest significant thickness used and classified V-0 according to IEC 60695-11-10

1.2.12.3
V-1 CLASS MATERIAL

material tested in the thinnest significant thickness used and classified V-1 according to IEC 60695-11-10

1.2.12.4
V-2 CLASS MATERIAL

material tested in the thinnest significant thickness used and classified V-2 according to IEC 60695-11-10

1.2.12.5
5VA CLASS MATERIAL

material tested in the thinnest significant thickness used and classified 5VA according to IEC 60695-11-20

1.2.12.6
5VB CLASS MATERIAL

material tested in the thinnest significant thickness used and classified 5VB according to IEC 60695-11-20

1.2.12.7
HF-1 CLASS FOAMED MATERIAL
foamed material tested in the thinnest significant thickness used and classified HF-1 according to ISO 9772

1.2.12.8
HF-2 CLASS FOAMED MATERIAL
foamed material tested in the thinnest significant thickness used and classified HF-2 according to ISO 9772

1.2.12.9
HBF CLASS FOAMED MATERIAL
foamed material tested in the thinnest significant thickness used and classified HBF according to ISO 9772

1.2.12.10
HB40 CLASS MATERIAL
material tested in the thinnest significant thickness used and classified HB40 according to IEC 60695-11-10

1.2.12.11
HB75 CLASS MATERIAL
material tested in the thinnest significant thickness used and classified HB75 according to IEC 60695-11-10

1.2.12.12
VTM-0 CLASS MATERIAL
material tested in the thinnest significant thickness used and classified VTM-0 according to ISO 9773

1.2.12.13
VTM-1 CLASS MATERIAL
material tested in the thinnest significant thickness used and classified VTM-1 according to ISO 9773

1.2.12.14
VTM-2 CLASS MATERIAL
material tested in the thinnest significant thickness used and classified VTM-2 according to ISO 9773

1.2.12.15
EXPLOSION LIMIT
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

1.2.13 Miscellaneous

1.2.13.1
TYPE TEST
test on a representative sample with the objective of determining if, as designed and manufactured, it can meet the requirements of this standard

1.2.13.2
SAMPLING TEST

test on a number of samples taken at random from a batch

1.2.13.3
ROUTINE TEST
test to which each individual sample is subjected during or after manufacture to check if the sample complies with certain criteria

1.2.13.4
DC VOLTAGE
average value of a voltage 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.

1.2.13.5
SERVICE PERSON
person having appropriate technical training and experience necessary to be aware of hazards to which that person may be exposed in performing a task and of measures to minimize the risks to that person or other persons

1.2.13.6
USER
any person, other than a SERVICE PERSON

The term USER in this standard is the same as the term OPERATOR and the two terms can be interchanged.

1.2.13.7
OPERATOR
see USER (1.2.13.6)

1.2.13.8
TELECOMMUNICATION NETWORK
metallically terminated transmission medium intended for communication between equipment that may be located in separate buildings, excluding:

– the mains system for supply, transmission and distribution of electrical power, if used as a telecommunication transmission medium;

– CABLE DISTRIBUTION SYSTEMS;

– SELV CIRCUITS connecting units of information technology equipment

NOTE 1 The term TELECOMMUNICATION NETWORK is defined in terms of its functionality, not its electrical characteristics. A TELECOMMUNICATION NETWORK is not itself defined as being either an SELV CIRCUIT or a TNV CIRCUIT. Only the circuits in the equipment are so classified.

NOTE 2 A TELECOMMUNICATION NETWORK may be:

– publicly or privately owned;
– subject to transient overvoltages due to atmospheric discharges and faults in power distribution systems;
– subject to longitudinal (common mode) voltages induced from nearby power lines or electric traction lines.

NOTE 3 Examples of TELECOMMUNICATION NETWORKS are:

– a public switched telephone network;
– a public data network;
– an Integrated Services Digital Network (ISDN);
– a private network with electrical interface characteristics similar to the above.

1.2.13.9

FUNCTIONAL EARTHING

earthing of a point in equipment or in a system, which is necessary for a purpose other than safety

1.2.13.10

PROTECTIVE EARTHING CONDUCTOR

conductor in the building installation wiring, or in the power supply cord, connecting a main protective earthing terminal in the equipment to an earth point in the building installation

NOTE In some countries, the term "grounding conductor" is used instead of "PROTECTIVE EARTHING CONDUCTOR".

1.2.13.11

PROTECTIVE BONDING CONDUCTOR

conductor in the equipment, or a combination of conductive parts in the equipment, connecting a main protective earthing terminal to a part of the equipment that is required to be earthed for safety purposes

1.2.13.12

TOUCH CURRENT

electric current through a human body when it touches one or more accessible parts

NOTE TOUCH CURRENT was previously included in the term "leakage current".

1.2.13.13

PROTECTIVE CONDUCTOR CURRENT

current flowing through the PROTECTIVE EARTHING CONDUCTOR under normal operating conditions

NOTE PROTECTIVE CONDUCTOR CURRENT was previously included in the term "leakage current".

1.2.13.14

CABLE DISTRIBUTION SYSTEM

metallically terminated transmission medium using coaxial cable, mainly intended for transmission of video and/or audio signals between separate buildings or between outdoor antennas and buildings, excluding:

– the mains system for supply, transmission and distribution of electric power, if used as a communication transmission medium;

– TELECOMMUNICATION NETWORKS;

– SELV CIRCUITS connecting units of information technology equipment

NOTE 1 Examples of CABLE DISTRIBUTION SYSTEMS are:

– local area cable networks, community antenna television systems and master antenna television systems providing video and audio signal distribution;

– outdoor antennas including satellite dishes, receiving antennas, and other similar devices.

NOTE 2 CABLE DISTRIBUTION SYSTEMS may be subjected to greater transients than TELECOMMUNICATION NETWORKS (see 7.4.1).

1.2.13.15

CHEESECLOTH

bleached cotton cloth of approximately 40 g/m^2

1.2.13.16

WRAPPING TISSUE

soft and strong, lightweight wrapping paper of grammage generally between 12 g/m^2 and 30 g/m^2, primarily intended for protective packaging of delicate articles and for gift wrapping

[ISO 4046-4:2002, definition 4.215]

1.2.13.17
PROTECTIVE CURRENT RATING
rating of an overcurrent protective device that is known or assumed to be in place to protect a circuit

NOTE Rules to determine the value of the PROTECTIVE CURRENT RATING are in 2.6.3.3.

1.2.13.18
(HOUSEHOLD AND HOME/OFFICE DOCUMENT/MEDIA) SHREDDER
equipment with a plug configuration associated with PLUGGABLE EQUIPMENT TYPE A, or battery operated equipment, designed to shred paper or other forms of media as instructed by the manufacturer

NOTE 1 Examples of other forms of media include but are not limited to digital video disks, compact disks, flash memory, magnetic strip cards, or magnetic disks, or the like.

NOTE 2 HOUSEHOLD AND HOME/OFFICE DOCUMENT/MEDIA SHREDDERS are typically identified as either strip-cut type or cross-cut type. A strip-cut HOUSEHOLD AND HOME/OFFICE DOCUMENT/MEDIA SHREDDER shreds the paper into long strips using a motor-based shredding mechanism. A cross-cut DOCUMENT/MEDIA SHREDDER shreds paper two or more ways into tiny particles, typically using a more powerful motor and more complex shredding mechanism.

NOTE 3 A document/media shredder is considered to be non-household or non-home/office type if the document/media shredder is provided with a plug configuration associated with PLUGGABLE EQUIPMENT TYPE B, or is PERMANENTLY CONNECTED EQUIPMENT.

1.3 General requirements

1.3.1 Application of requirements

The requirements detailed in this standard shall be applied only if safety is involved.

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 failures.

1.3.2 Equipment design and construction

Equipment shall be so designed and constructed that, under all conditions of normal use and under likely abnormal use or single fault conditions (see 1.4.14), protection is provided to reduce the risk of personal injury from electric shock and other hazards, and against spread of fire originating in the equipment.

Compliance is checked by inspection and by the relevant tests.

1.3.3 Supply voltage

Equipment shall be designed to be safe at any supply voltage to which it is intended to be connected.

Compliance is checked by inspection and by carrying out the relevant tests of this standard using a supply voltage as specified in the corresponding subclause. If the subclause does not specify the supply voltage (explicitly or by reference to 1.4.5), then the value of the RATED VOLTAGE or any value in the RATED VOLTAGE RANGE shall be used.

1.3.4 Constructions not specifically covered

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

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

1.3.5 Equivalent materials

Where the standard specifies a particular grade of insulation, the use of a better grade of insulation is permitted. Similarly, where the standard requires material of a particular FLAMMABILITY CLASS, the use of a better class is permitted.

1.3.6 Orientation during transport and use

Where it is clear that the orientation of the equipment is likely to have a significant effect on the application of the requirements or the results of tests, all orientations of use permitted in the installation or operating instructions shall be taken into account. For TRANSPORTABLE EQUIPMENT, all orientations of transport and use shall be taken into account.

NOTE The above may apply to 4.1, 4.2, 4.3.8, 4.5, 4.6 and 5.3.

1.3.7 Choice of criteria

Where the standard permits a choice between different criteria for compliance, or between different methods or conditions of test, the choice is specified by the manufacturer.

1.3.8 Examples mentioned in the standard

Where examples of equipment, parts, methods of construction, design techniques and faults are given in the standard, prefaced by "for example" or "such as", other examples, situations and solutions are not excluded.

1.3.9 Conductive liquids

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

1.4 General conditions for tests

1.4.1 Application of tests

The tests detailed in this standard shall be conducted 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 is not made.

Unless otherwise stated, upon conclusion of the tests, the equipment need not be operational.

1.4.2 Type tests

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

1.4.3 Test samples

Unless otherwise specified, the sample or samples under test 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 complete equipment, tests may be conducted separately on circuits, components or subassemblies outside the equipment, provided that inspection of the equipment and circuit arrangements indicates that the results of such testing will be representative of the results of testing the assembled equipment. If any such test indicates a 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 conducted in the following order:

– component or material pre-selection;
– component or subassembly bench tests;
– tests where the equipment is not energized;
– live tests:
  • under normal operating conditions;
  • under abnormal operating conditions;
  • involving likely destruction.

NOTE 2 In view of the resources involved in testing and in order to minimize waste, it is recommended that all parties concerned jointly consider the test programme, the test samples and the test sequence.

1.4.4 Operating parameters 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 conducted under the most unfavourable combination within the manufacturer's operating specifications of the following parameters:

– supply voltage (see 1.4.5);
– supply frequency (see 1.4.6);
– operating temperature (see 1.4.12);
– 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 voltage for the power to energize the equipment under test (EUT), the following variables shall be taken into account:

– multiple RATED VOLTAGES;
– tolerances on RATED VOLTAGE as specified below;
– extremes of RATED VOLTAGE RANGES.

If the equipment is intended for direct connection to an AC MAINS SUPPLY, the tolerances on RATED VOLTAGE shall be taken as +6 % and –10 %, unless:

– the RATED VOLTAGE is 230 V single-phase or 400 V three-phase, in which case the tolerance shall be taken as +10 % and –10 %; or
– a wider tolerance is declared by the manufacturer, in which case the tolerance shall be taken as this wider value.

If the equipment is intended only for connection to an a.c. mains equivalent source, such as a motor-driven generator or an uninterruptible power supply (see 1.2.8.1), or a source other than a MAINS SUPPLY, the tolerances on RATED VOLTAGE shall be declared by the manufacturer.

If equipment is intended for connection to a DC MAINS SUPPLY, the tolerance shall be taken as +20 % and –15 %, unless declared otherwise by the manufacturer**.**

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 frequency for the power to energize the EUT, different RATED FREQUENCIES within the RATED FREQUENCY RANGE shall be taken into account (for example, 50 Hz and 60 Hz) but consideration of the tolerance on a RATED FREQUENCY (for example, 50 Hz ± 0,5 Hz) is not normally necessary.

1.4.7 Electrical measuring instruments

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

1.4.8 Normal operating voltages

For the purposes of:

– determining WORKING VOLTAGES (see 1.2.9.6); and

– classifying circuits in the equipment as ELV CIRCUITS, SELV CIRCUITS, TNV-1 CIRCUITS, TNV-2 CIRCUITS, TNV-3 CIRCUITS, or HAZARDOUS VOLTAGE circuits;

the following voltages shall be considered:

– normal operating voltages generated in the equipment, including repetitive peak voltages such as those associated with switch mode power supplies;

– normal operating voltages generated outside the equipment, including ringing signals received from TELECOMMUNICATION NETWORKS.

For these purposes, unwanted, externally generated, non-repetitive transient voltages (for example, MAINS TRANSIENT VOLTAGES and TELECOMMUNICATION NETWORK TRANSIENT VOLTAGES) induced by power distribution system switching and lightning surges, shall not be considered:

– when determining WORKING VOLTAGES, because such transients have been taken into account in the procedures for determining minimum CLEARANCES (see 2.10.3 and Annex G);

– when classifying circuits in the equipment, except when distinguishing between SELV CIRCUITS and TNV-1 CIRCUITS and between TNV-2 CIRCUITS and TNV-3 CIRCUITS (see 1.2.8.11, Table 1A).

NOTE 1 The effects of unwanted steady-state voltages generated outside the equipment (for example, earth potential differences and voltages induced on TELECOMMUNICATION NETWORKS by electric train systems) are controlled by installation practices or by appropriate isolation in the equipment. Such measures are application dependent and are not dealt with by this standard.

NOTE 2 In Canada and the United States, additional requirements apply for protection against overvoltages (see Clause 6 Note 5).

1.4.9 Measurement of voltage to earth

Where the standard specifies a voltage between a conductive part and earth, all of the following earthed parts are considered:

– the main protective earthing terminal (if any); and
– any other conductive part required to be connected to protective earth (for examples see 2.6.1); and
– any conductive part that is earthed within the equipment for functional reasons.

Parts that will be earthed in the application by connection to other equipment, but are unearthed in the equipment as tested, shall be connected to earth at the point by which the highest voltage is obtained. When measuring a voltage between earth and a conductor in a circuit that will not be earthed in the intended application of the equipment, a non-inductive resistor of 5 000 Ω ± 10 % shall be connected across the voltage measuring instrument.

Voltage drop in the PROTECTIVE EARTHING CONDUCTOR of the power supply cord, or in an earthed conductor in other external wiring, is not included in the measurements.

1.4.10 Loading configuration of the EUT

In determining the input current (see 1.6.2), 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 by the manufacturer for inclusion in or with the EUT;
– loads due to other units of equipment intended by the manufacturer to draw power from the EUT;
– loads that 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.

1.4.11 Power from a telecommunication network

For the purpose of this standard, the power available from a TELECOMMUNICATION NETWORK is considered to be limited to 15 VA.

1.4.12 Temperature measurement conditions

1.4.12.1 General

Temperatures measured on the EUT shall conform to 1.4.12.2 or 1.4.12.3, as applicable, all temperatures being in degrees Celsius (°C); where

T is the temperature of the given part measured under the prescribed test conditions;

T_{max} is the maximum temperature specified for compliance with the test;

T_{amb} is the ambient temperature during test;

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

1.4.12.2 Temperature dependent equipment

For equipment where the amount of heating or cooling is designed to be dependent on temperature (for example, the equipment contains a fan that has a higher speed at a higher temperature), the temperature measurement is made at the least favourable ambient temperature within the manufacturer's specified operating range. In this case:

T shall not exceed T_{max}.

NOTE 1 In order to find the highest value of T for each component, it may be necessary to conduct several tests at different values of T_{amb}.

NOTE 2 The least favourable value of T_{amb} may be different for different components.

1.4.12.3 Non-temperature dependent equipment

For equipment where the amount of heating or cooling is not designed to be dependent on ambient temperature, it is permitted to use the method in 1.4.12.2. Alternatively, the test is performed at any value of T_{amb} within the manufacturer's specified operating range. In this case:

T shall not exceed ($T_{max} + T_{amb} – T_{ma}$).

During the test, T_{amb} should not exceed T_{ma} unless agreed by all parties involved.

1.4.13 Temperature measurement methods

Unless a particular method is specified, the temperatures of windings shall be determined either by the thermocouple method or by the resistance method (see Annex E). The 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.

1.4.14 Simulated faults and abnormal conditions

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

When applying simulated faults or abnormal operating conditions, parts, supplies, consumable materials, media and recording materials shall be in place if they are likely to have an effect on the outcome of the test.

Where there is a specific reference to a single fault, the single fault consists of a single failure of any insulation (excluding DOUBLE INSULATION or REINFORCED INSULATION) or a single failure of any component (excluding components with DOUBLE INSULATION or REINFORCED INSULATION). The failure of FUNCTIONAL INSULATION is simulated only when required by 5.3.4 c).

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 (see Clause C.2);
  - parts of SELV CIRCUITS;
  - parts of LIMITED CURRENT CIRCUITS.

1.4.15 Compliance by inspection of relevant data

Where in this standard compliance of materials, components or subassemblies is checked by inspection or by testing of properties, it is permitted to confirm compliance by reviewing any relevant data or previous test results that are available instead of carrying out the specified TYPE TESTS.

1.5 Components

1.5.1 General

Where safety is involved, components shall comply ~~either~~ with the requirements of this standard or, where specified in a requirements clause, 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.

~~NOTE 2 In Sweden, switches containing mercury are not permitted.~~

~~NOTE 3 In Switzerland, switches containing mercury such as THERMOSTATS, relays and level controllers are not allowed.~~

Components and subassemblies that comply with IEC 62368-1 are acceptable as part of an equipment covered by this standard without further evaluation other than to give consideration to the appropriate use of the component or subassembly in the end-product.

1.5.2 Evaluation and testing of components

Where use of an IEC component standard is permitted above, evaluation and testing of components shall be conducted as follows:

– a component shall be checked for correct application and use in accordance with its rating;

– a component that has been demonstrated to comply with a standard harmonized with the relevant IEC component standard shall be ~~checked for correct application and use in accordance with its rating. It shall be~~ subjected to the applicable tests of this standard, as part of the equipment, with the exception of those tests that are part of the relevant IEC component standard;

– a component that has not been demonstrated to comply 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, conducted separately.

– ~~when 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.

Compliance is checked by inspection and by the relevant data or tests.

1.5.3 Thermal controls

Thermal controls shall be tested in accordance with Annex K.

1.5.4 Transformers

Transformers shall comply with the relevant requirements of this standard, including those of Annex C.

1.5.5 Interconnecting cables

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

For INTERCONNECTING CABLES supplied alone (for example, printer cables), it is permitted to apply the requirements of this subclause at the option of the manufacturer.

It is permitted to treat cables, or those parts of cables that are within an equipment ENCLOSURE, either as INTERCONNECTING CABLES or as internal wiring.

1.5.6 Capacitors bridging insulation

A capacitor connected between two line conductors in a PRIMARY CIRCUIT, or between one line conductor and the neutral conductor or between the PRIMARY CIRCUIT and protective earth shall comply with one of the subclasses of IEC 60384-14 and shall be used in accordance with its rating. This requirement also applies to a capacitor bridging DOUBLE INSULATION or REINFORCED INSULATION elsewhere in the equipment. The details of the damp heat, steady state test as specified in 4.12 of IEC 60384-14 shall be as follows:

– Temperature: 40 °C ± 2 °C;
– Humidity: (93 ~~%~~ ± 3)% relative humidity;
– Test duration: 21 days.

NOTE 1 Capacitors that have been subjected to a test duration longer than 21 days are considered to have met the test duration criteria.

The above requirement does not apply to a capacitor connected between a HAZARDOUS VOLTAGE SECONDARY CIRCUIT and protective earth, where only BASIC INSULATION is required.

NOTE 2 The test of 5.2.2 still applies between the HAZARDOUS VOLTAGE SECONDARY CIRCUIT and protective earth.

The appropriate capacitor subclass shall be selected from those listed in Table 1C, according to the rules of application in the table.

Table 1C – Capacitor ratings according to IEC 60384-14

Capacitor subclass according to IEC 60384-14	RATED VOLTAGE of the capacitor V r.m.s.	TYPE TEST impulse voltage of the capacitor kV peak	TYPE TEST r.m.s voltage of the capacitor kV r.m.s
Y1	Up to and including 500	8	4
Y2	Over 150 up to and including 300	5	1,5
Y4	Up to and including 150	2,5	0,9
X1	Up to and including 760	4 [a]	-
X2	Up to and including 760	2,5 [a]	-

Rules for the application of Table 1C

1 Capacitors used to bridge BASIC INSULATION, SUPPLEMENTARY INSULATION or REINFORCED INSULATION shall be class Y except that it is permitted to bridge BASIC INSULATION in a SECONDARY CIRCUIT by a class X capacitor.

2 For a single capacitor bridging FUNCTIONAL INSULATION, BASIC INSULATION, SUPPLEMENTARY INSULATION or REINFORCED INSULATION, the voltage rating of the single capacitor shall be at least equal to the RMS WORKING VOLTAGE across the insulation being bridged, determined according to 2.10.2.2.

3 For a single capacitor bridging functional insulation, basic insulation or supplementary insulation,

- the TYPE TEST impulse test voltage of the single capacitor shall be not less than the peak value of the test voltage (not the r.m.s. voltage) of Table 5B for BASIC INSULATION, or the peak value of the test voltage of Table 5C for BASIC INSULATION, as applicable;
- the TYPE TEST r.m.s. voltages of the single capacitor shall be not less than the required r.m.s. test voltage of Table 5B for BASIC INSULATION, or the equivalent r.m.s. test voltage (not the peak voltage) of Table 5C for BASIC INSULATION, as applicable.

4 For a single capacitor bridging DOUBLE INSULATION or REINFORCED INSULATION,

- the TYPE TEST impulse voltage of the single capacitor shall be not less than the peak value of the test voltage (not the r.m.s. voltage) of Table 5B for REINFORCED INSULATION, or the peak value of the test voltage of Table 5C for REINFORCED INSULATION, as applicable;
- the TYPE TEST r.m.s. voltage of the single capacitors shall be not less than the required r.m.s. test voltage of Table 5B for REINFORCED INSULATION, or the equivalent r.m.s. test voltage (not the peak voltage) of Table 5C for REINFORCED INSULATION, as applicable;

5 It is permitted to use a higher grade capacitor than the one specified, as follows:

- subclass Y1 if subclass Y2 is specified;
- subclass Y1 or Y2 if subclass Y4 is specified;
- subclass Y1 or Y2 if subclass X1 is specified;
- subclass X1, Y1 or Y2 if subclass X2 is specified.

6 It is permitted to use two or more capacitors in series in place of the single capacitor specified, as follows:

- subclass Y1 or Y2 if subclass Y1 is specified;
- subclass Y2 or Y4 if subclass Y2 is specified;
- subclass X1 or X2 if subclass X1 is specified.

7 If two or more capacitors are used in series, all of the following apply:

- under single fault conditions, the voltage on each of the remaining individual capacitors shall not exceed the voltage rating of the relevant individual capacitor;
- for BASIC INSULATION or SUPPLEMENTARY INSULATION, the sum of the TYPE TEST peak impulse test voltages of all capacitors shall be not less than the peak value of the test voltage (not the r.m.s. voltage) of Table 5B, or the peak value of the test voltage of Table 5C, as applicable;
- for BASIC INSULATION or SUPPLEMENTARY INSULATION, the sum of the TYPE TEST r.m.s. test voltages of all capacitors shall be not less than the required r.m.s. test voltage of Table 5B, or the equivalent r.m.s. test voltage (not the peak voltage) of Table 5C, as applicable;
- for REINFORCED INSULATION, the sum of the TYPE TEST peak impulse test voltages of all capacitors shall be not less than the peak value of the test voltage (not the r.m.s. voltage) of Table 5B, or the peak value of the test voltage of Table 5C, as applicable;
- for REINFORCED INSULATION, the sum of the TYPE TEST r.m.s. test voltages of all capacitors shall be not less than the required r.m.s. test voltage of Table 5B, or the equivalent r.m.s. test voltage (not the peak voltage) of Table 5C, as applicable;
- they shall comply with the other rules above.

[a] For capacitance values of more than 1 µF, this test voltage is reduced by a factor equal to $\sqrt{C}$, where C is the capacitance value in µF.

Table 1D gives a number of informative examples of the application of capacitors selected in accordance with Table 1C. Other examples are possible.

Table 1D – Informative examples of application of capacitors

~~AC MAINS SUPPLY VOLTAGE up to and including V r.m.s.~~	~~Overvoltage Category~~	~~MAINS TRANSIENT VOLTAGE kV~~	~~Bridged insulation~~	~~Capacitor type~~	~~Number of capacitors~~
~~150~~	~~II~~	~~1,5~~	~~B or S~~	~~Y4~~	~~1~~
	~~II~~	~~1,5~~	~~D or R~~	~~Y2~~	~~1~~
	~~II~~	~~1,5~~	~~D or R~~	~~Y4~~	~~2~~
	~~III~~	~~2,5~~	~~F~~	~~X2~~	~~1~~
	~~III~~	~~2,5~~	~~B or S~~	~~Y4~~	~~1~~
	~~III~~	~~2,5~~	~~D or R~~	~~Y1~~	~~1~~
	~~IV~~	~~4,0~~	~~F~~	~~X1~~	~~1~~
	~~IV~~	~~4,0~~	~~B or S~~	~~Y2~~	~~1~~
	~~IV~~	~~4,0~~	~~D or R~~	~~Y1~~	~~1~~
~~250~~	~~II~~	~~2,5~~	~~F~~	~~X2~~	~~1~~
~~300~~	~~II~~	~~2,5~~	~~B or S~~	~~Y2~~	~~1~~
	~~II~~	~~2,5~~	~~D or R~~	~~Y1~~	~~1~~
	~~II~~	~~2,5~~	~~D or R~~	~~Y2~~	~~2~~
~~250~~	~~III~~	~~4,0~~	~~F~~	~~X1~~	~~1~~
~~300~~	~~III~~	~~4,0~~	~~D or R~~	~~Y1~~	~~1~~
	~~III~~	~~4,0~~	~~D or R~~	~~Y2~~	~~2~~
	~~IV~~	~~6,0~~	~~B or S~~	~~Y1~~	~~1~~
	~~IV~~	~~6,0~~	~~D or R~~	~~Y1~~	~~2~~
~~500~~	~~II~~	~~4,0~~	~~B or S~~	~~Y1~~	~~1~~
	~~II~~	~~4,0~~	~~D or R~~	~~Y1~~	~~1~~
	~~III~~	~~6,0~~	~~B or S~~	~~Y1~~	~~1~~
	~~III~~	~~6,0~~	~~D or R~~	~~Y1~~	~~2~~
	~~IV~~	~~8,0~~	~~B or S~~	~~Y1~~	~~1~~
	~~IV~~	~~8,0~~	~~D or R~~	~~Y1~~	~~2~~
~~The values in the table apply to FUNCTIONAL INSULATION (F), BASIC INSULATION (B), SUPPLEMENTARY INSULATION (S), DOUBLE INSULATION (D) and REINFORCED INSULATION (R).~~					

AC MAINS SUPPLY voltage up to and including V r.m.s.	Overvoltage Category	MAINS TRANSIENT VOLTAGE kV	Bridged insulation	Capacitor type	Number of capacitors	
					Using Table 5B	Using Table 5C
150	II	1,5	B or S	Y2	1	1
	II	1,5	D or R	Y2	2	2
	II	1,5	D or R	Y1	1	1
	II	1,5	F	X2	1	1
	III	2,5	F	X2	-	1
	III	2,5	B or S	Y2	-	2
	III	2,5	D or R	Y1	-	1
	IV	4,0	F	X1	-	1
	IV	4,0	B or S	Y1	-	1
	IV	4,0	B or S	Y2	-	2
	IV	4,0	D or R	Y1	-	2
250	II	2,5	F	X2	1	1
	III	4,0	F	X1	-	1
300	II	2,5	B or S	Y2	1	2
	II	2,5	D or R	Y1	1	1
	II	2,5	D or R	Y2	2	3
	III	4,0	B or S	Y1	-	1
	III	4,0	B or S	Y2	-	2
	III	4,0	D or R	Y1	-	2
	III	4,0	D or R	Y2	-	4
	IV	6,0	F	X1	-	2
	IV	6,0	B or S	Y1	-	2
	IV	6,0	D or R	Y1	-	3
500	II	4,0	F	X1	1	1
	II	4,0	B or S	Y1	1	1
	II	4,0	D or R	Y1	1	2
	III	6,0	F	X1	-	2
	III	6,0	B or S	Y1	-	2
	III	6,0	D or R	Y1	-	3
	IV	8,0	F	X1	-	2
	IV	8,0	B or S	Y1	-	2
	IV	8,0	D or R	Y1	-	3

The values in the table apply to FUNCTIONAL INSULATION (F), BASIC INSULATION (B), SUPPLEMENTARY INSULATION (S), DOUBLE INSULATION (D) and REINFORCED INSULATION (R).

NOTE Table 5B is used for Overvoltage Categories I and II only.

If an accessible conductive part or circuit is separated from another part by DOUBLE INSULATION or REINFORCED INSULATION that is bridged by a capacitor or capacitors, the accessible part or circuit shall comply with the requirements for a LIMITED CURRENT CIRCUIT in 2.4. This requirement applies after electric strength testing of the insulation with the bridging capacitor or capacitors in place.

NOTE 3 A circuit is a LIMITED CURRENT CIRCUIT if the current through the bridging components complies with 2.4 and other requirements of 2.4 are met.

Compliance is checked by inspection and measurement.

1.5.7 Resistors bridging insulation

1.5.7.1 Resistors bridging functional insulation, basic insulation or supplementary insulation

There are no special requirements for resistors bridging FUNCTIONAL INSULATION, BASIC INSULATION or SUPPLEMENTARY INSULATION, but the relevant requirements of 2.10.3 (or Annex G) and 2.10.4 apply, and in some cases those of 2.4.

NOTE In Finland, Norway and Sweden resistors bridging BASIC INSULATION in CLASS I PLUGGABLE EQUIPMENT TYPE A must comply with ~~the requirements in 1.5.7.2~~ 1.5.7.1. In addition when a single resistor is used, the resistor must withstand the resistor test in 1.5.7.2.

1.5.7.2 Resistors bridging double insulation or reinforced insulation between the a.c. mains supply and other circuits

It is permitted to bridge DOUBLE INSULATION or REINFORCED INSULATION by one resistor or by a group of two or more resistors in series under the following conditions. For conditions applicable to circuits connected to an antenna or coaxial cable, see 1.5.7.3.

The resistor or group of resistors shall comply with the minimum CLEARANCES of 2.10.3 or Annex G and the minimum CREEPAGE DISTANCES of 2.10.4 for REINFORCED INSULATION for the total WORKING VOLTAGE across the resistor or group of resistors. For a group of resistors, see also Figure F.13.

If a single resistor is used, it shall pass the resistor test below.

If a group of resistors is used, the CLEARANCE and CREEPAGE DISTANCES are assessed as if each resistor were short-circuited in turn, unless the group passes the resistor test below.

If an accessible conductive part or circuit is separated from another part by DOUBLE INSULATION or REINFORCED INSULATION that is bridged by a resistor or group of resistors, the accessible part or circuit shall comply with the requirements for a LIMITED CURRENT CIRCUIT in 2.4 between the accessible conductive part or circuit and earth. If a group of resistors is used, the current measurement in 2.4.2 is made with each resistor short-circuited in turn, unless the group passes the resistor test below. ~~This current is measured after electric strength testing of the insulation with the bridging resistor or group of resistors in place.~~ When measuring the LIMITED CURRENT CIRCUIT, the ammeter is placed between the load side of the bridging components and any USER accessible part, including earth.

Compliance is checked by inspection and measurement and, if specified above, by the following resistor test on ten samples. A sample is a single resistor if used alone, or a group of resistors in series.

Resistor Test

Before the test, the resistance of each sample is measured.

The samples are subjected to the damp heat test according to IEC 60068-2-78, with the following details:

- *Temperature: 40 °C ± 2 °C;*
- *Humidity: (93 ~~%~~ ± 3) % relative humidity;*
- *Test duration: 21 days.*

NOTE Resistors that have been subjected to a test duration longer than 21 days are considered to have met the test duration criteria.

Each sample is then subjected to ten impulses of alternating polarity, using the impulse test generator reference 2 of Table N.1. The interval between successive impulses is 60 s, and U_c is equal to the applicable REQUIRED WITHSTAND VOLTAGE*.*

After the test, the resistance of each sample shall not have changed by more than 10 %.

No failure is permitted.

1.5.7.3 Resistors bridging double insulation or reinforced insulation between the a.c. mains supply and circuits connected to an antenna or coaxial cable

The requirements and tests of 1.5.7.2 apply except the impulse test generator is as specified in reference 3 of Table N.1 if the circuit is connected to an antenna or reference 1 of Table N.1 if the circuit is connected to a coaxial cable.

After the test, the resistance of each sample shall not have changed by more than 20 % and no failure is permitted.

NOTE If a resistor or a group of resistors is connected between the PRIMARY CIRCUIT and a CABLE DISTRIBUTION SYSTEM, 7.4 also applies.

1.5.8 Components in equipment for IT power distribution systems

For equipment to be connected to IT power distribution systems, components connected between line and earth shall be capable of withstanding the stress due to the line-to-line voltage. However, capacitors rated for the applicable line-to-neutral voltage are permitted in such applications if they comply with subclass Y1, Y2 or Y4 of IEC 60384-14.

NOTE 1 The above capacitors are endurance tested at 170 % of the voltage rating of the capacitor.

NOTE 2 In Norway, due to the IT power distribution system used (see Annex V, Figure V.7), capacitors are required to be rated for the applicable line-to-line voltage (230 V).

Compliance is checked by inspection.

1.5.9 Surge suppressors

1.5.9.1 General

It is permitted to use any type of surge suppressor, including a voltage dependent resistor (VDR), in a SECONDARY CIRCUIT.

If a surge suppressor is used in a PRIMARY CIRCUIT, it shall be a VDR and it shall comply with Annex Q.

NOTE 1 A VDR is sometimes referred to as a varistor or a metal oxide varistor (MOV). Devices such as gas discharge tubes, carbon blocks and semiconductor devices with non-linear voltage/current characteristics are not considered as VDRs in this standard.

NOTE 2 It is not a requirement of this standard to comply with any particular component standard for surge suppressors used in SECONDARY CIRCUITS. However, attention is drawn to the IEC 61643 series of standards, in particular:

- IEC 61643-21 (surge suppressors in telecommunications application)
- IEC 61643-311 (gas discharge tubes)
- IEC 61643-321 (avalanche breakdown diodes)
- IEC 61643-331 (metal oxide varistors).

Compliance is checked by inspection and application of Annex Q as appropriate.

1.5.9.2 Protection of VDRs

For protection against

– temporary overvoltages above the maximum continuous voltage,

– thermal overload due to leakage current within the VDR, and

– burning and bursting of the VDR in the event of a short-circuit fault,

an interrupting means having an adequate breaking capacity shall be connected in series with the VDR. This requirement does not apply to a VDR in a LIMITED CURRENT CIRCUIT.

NOTE 1 For temporary overvoltages from the AC MAINS SUPPLY, see IEC 60664-1.

NOTE 2 During the lifetime of a VDR the leakage current increases with the number of switching cycles in the VDR. This leakage current causes a permanent and continuously increasing temperature stress, which can cause the VDR to burn or burst.

Compliance is checked by inspection and, if necessary to determine that the circuit is a LIMITED CURRENT CIRCUIT, by measurement and test.

1.5.9.3 Bridging of functional insulation by a VDR

It is permitted to bridge FUNCTIONAL INSULATION by a VDR.

Compliance is checked by inspection.

1.5.9.4 Bridging of basic insulation by a VDR

It is permitted to bridge BASIC INSULATION by a VDR complying with the requirements of Annex Q, with or without a GDT in series, provided that one side of the ~~VDR~~ circuit is earthed in accordance with 2.6.1 a).

Equipment with such a VDR bridging BASIC INSULATION shall be one of the following:

– PLUGGABLE EQUIPMENT TYPE B; or

– PERMANENTLY CONNECTED EQUIPMENT; or

– equipment that has provision for a permanently connected PROTECTIVE EARTHING CONDUCTOR and is provided with instructions for the installation of that conductor.

NOTE In Finland, Norway and Sweden, the third dashed item is applicable only to equipment as defined in the Note to 6.1.2.2.

For all other equipment, it is permitted to bridge BASIC INSULATION by a VDR in series with a GDT provided that:

– the VDR complies with the requirements of Annex Q; and

– the GDT complies with:

  - the electric strength test for BASIC INSULATION; and
  - the external CLEARANCE and CREEPAGE DISTANCE requirements for BASIC INSULATION.

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

1.5.9.5 Bridging of supplementary, double or reinforced insulation by a VDR

It is not permitted to bridge SUPPLEMENTARY INSULATION, DOUBLE INSULATION or REINFORCED INSULATION by a VDR.

Compliance is checked by inspection.

1.6 Power interface

1.6.1 AC power distribution systems

AC power distribution systems are classified as TN-C, TN-C-S, TN-S, TT or IT (see Annex V).

1.6.2 Input current

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

NOTE See also 1.4.10.

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

- *where an equipment has more than one RATED VOLTAGE, 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 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 stabilized. 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.

1.6.3 Voltage limit of hand-held equipment

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

Compliance is checked by inspection.

1.6.4 Neutral conductor

The neutral conductor, if any, shall be insulated from earth and from the BODY throughout the equipment as if it were a line conductor. Components connected between neutral and earth shall be rated for the line-to-neutral voltage (however, see also 1.5.8).

Compliance is checked by inspection.

1.7 Markings and instructions

NOTE Additional requirements for markings and instructions are contained in the following subclauses:

2.1.1.2	Battery compartments	4.3.3	Adjustable controls
~~2.1.1.8~~	~~Energy hazards~~	4.3.5	Plugs and sockets
2.3.2.3	Protection by earthing	4.3.13.4	UV radiation
2.6.1	Unearthed parts	4.3.13.5	Lasers
2.6.2	FUNCTIONAL EARTHING	4.4.2	Hazardous moving parts

2.6.3.4 c)	Bonding conductors	4.4.5.2	Fan protection for USERS
2.6.5.1	Bonding conductors	4.4.5.3	Fan protection for service persons
2.7.1	External protective devices	~~4.5.3~~ 4.5.4 Table 4C	Marking of hot parts
2.7.6	Neutral fusing	4.5.4	Touch temperatures
2.10.3.2	Overvoltage Categories	4.6.2	Equipment on non-combustible floors
3.2.1.2	DC MAINS SUPPLY	4.6.3	Removable doors and covers
3.3.7	Grouping of wiring terminals	5.1.7.1	TOUCH CURRENT exceeding 3,5 mA
3.4.3	Disconnect devices	5.1.8.2	Summation of TOUCH CURRENTS
3.4.6	Two-pole disconnect devices	6.1.1 and 6.1.2.2	Earthing for a TELECOMMUNICATION NETWORK
3.4.7	Four-pole disconnect devices	7.2 and 7.4.1	Earthing for a CABLE DISTRIBUTION SYSTEM
3.4.9	Plugs as disconnect devices	G.2.1	Equipment in Overvoltage Categories III and IV
3.4.10	Interconnected equipment	DD.2	Maximum shelf load
3.4.11	Multiple power sources	EE.2	Shredder warning
4.1	Equipment stability	EE.4	Shredder power disconnection
4.2.5	Impact test		

Compliance with each subclause of 1.7 is checked by inspection unless otherwise specified (see 1.7.11).

1.7.1 Power rating and identification markings

~~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 a MAINS SUPPLY, 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 an OPERATOR, the marking shall be readily visible in an OPERATOR ACCESS AREA, including any area that is directly visible only after an OPERATOR has opened a door or cover. If a manual voltage selector is not OPERATOR-accessible, the marking shall indicate the RATED VOLTAGE for which the equipment is set during manufacture; a temporary marker is permitted for this purpose. Marking is permitted on any outer surface of the equipment, except the bottom of equipment having a mass exceeding 18 kg. Additionally, on STATIONARY EQUIPMENT, the marking shall be visible after the equipment has been installed as in normal use.~~

~~For equipment intended to be installed by a SERVICE PERSON, and if the marking is in a SERVICE ACCESS AREA, the location of the permanent marking shall be indicated in the installation instructions or on a readily visible marker on the equipment. It is permitted to use a temporary marker for this purpose.~~

~~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 and when 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 an AC MAINS SUPPLY having any voltage between 220 V and 240 V.~~

~~– Multiple RATED VOLTAGE: 120/230/240 V. This means that the equipment is designed to be connected to an AC MAINS SUPPLY having a voltage of 120 V or 230 V or 240 V, usually after internal adjustment.~~

- ~~if equipment is to be connected to both of the line conductors and to the neutral conductor of a single-phase, three-wire power distribution system, the marking shall give the line-to-neutral voltage and the line-to-line voltage, separated by a solidus (/), with the added notation "Three wires plus protective earth", "3W + PE" or equivalent.~~

~~NOTE 2 Some examples of the above system rating markings are:~~

~~120/240 V; 3 wire + PE~~

~~120/240 V; 3W + (60417-IEC-5019)~~

~~100/200 V; 2W + N + PE~~

~~– 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 a MAINS SUPPLY. 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 3 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; 2,8-1,4 A~~

~~100-120 V; 2,8 A~~

~~200-240 V; 1,4 A~~

~~It is recognized that in some regions it is customary to use a point (.) as a decimal marker instead of a comma.~~

~~– manufacturer's name or trade-mark or identification mark;~~

~~– manufacturer's model identification or type reference;~~

~~– symbol (IEC 60417-5172 (DB:2003-02)), for CLASS II EQUIPMENT only, except where this is forbidden by 2.6.2.~~

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

~~Where symbols are used, they shall conform to ISO 7000 or IEC 60417 where appropriate symbols exist.~~

1.7.1.1 Power rating markings

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

If the equipment, or a system, has multiple MAINS SUPPLY connections, each individual MAINS SUPPLY electrical rating must be marked, unless they are the same, but the overall equipment or system electrical rating need not be marked. If the multiple MAINS SUPPLY are identical, it is permitted to mark them, for example, as “MAINS SUPPLY electrical rating x N” where N is the number of identical MAINS SUPPLY connections.

For equipment intended to be installed by an OPERATOR, the power rating marking, if required, shall be readily visible in any OPERATOR ACCESS AREA. If a manual voltage selector is not OPERATOR-accessible, the power rating marking shall indicate the RATED VOLTAGE for which the equipment is set during manufacture; a temporary marker is permitted for this purpose. The power rating marking is permitted on any outer surface of the equipment, except the bottom of equipment having a mass exceeding 18 kg.

For STATIONARY EQUIPMENT, the power rating marking shall be visible after the equipment has been installed as in normal use.

For equipment intended to be installed by a SERVICE PERSON, and if the power rating marking is in a SERVICE ACCESS AREA, the location of the permanent marking shall be indicated in the installation instructions or on a readily visible marker on the equipment. It is permitted to use a temporary marker for this purpose.

The power rating 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 and when 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 an AC MAINS SUPPLY having any voltage between 220 V and 240 V.

  – multiple RATED VOLTAGE: 120/230/240 V. This means that the equipment is designed to be connected to an AC MAINS SUPPLY having a voltage of 120 V or 230 V or 240 V, usually after internal adjustment.

  - if equipment is to be connected to both line conductors and to the neutral conductor of a single-phase, three-wire power distribution system, the power rating marking shall give the line-to-neutral voltage and the line-to-line voltage, separated by a solidus (/), with the added notation "Three wires plus protective earth", "3W + PE" or equivalent;

  NOTE 2 Some examples of the above system rating markings are:

  120/240 V; 3 wire + PE;

  120/240 V; 3W + ⏚ (60417-IEC-5019);

  100/200 V; 2W + N + PE;

  100-120/200-240 V; 2W + N + PE.

– 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 power rating 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 a MAINS SUPPLY. 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 3 Some examples of RATED CURRENT markings are:

– for equipment with multiple RATED VOLTAGES:

120/240 V; 2,4/1,2 A;

100-120/200-240 V; 2,4/1,2 A;

– for equipment with a RATED VOLTAGE RANGE:

100-240 V; 2,8 A;

100-240 V; 2,8-1,4 A;

100-120 V; 2,8 A;

200-240 V; 1,4 A.

It is recognized that in some regions it is customary to use a point (·) as a decimal marker instead of a comma.

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

Where symbols are used, they shall conform to ISO 7000 or IEC 60417 where appropriate symbols exist.

1.7.1.2 Identification markings

Equipment shall be provided by the following identification markings:

– manufacturer's name or trade-mark or identification mark;

– manufacturer's model identification or type reference;

– symbol ⧈, IEC 60417-5172 (DB:2003-02), for the identification of CLASS II EQUIPMENT only, except where this is forbidden by 2.6.2.

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

These identification markings shall be readily visible in any OPERATOR ACCESS AREA, except that they shall not be located on the bottom of equipment having a mass exceeding 18 kg. For STATIONARY EQUIPMENT, the identification markings shall be visible after the equipment has been installed as in normal use.

1.7.1.3 Use of graphical symbols

Graphical symbols placed on the equipment, whether required by this standard or not, shall be in accordance with IEC 60417 or ISO 3864-2 or ISO 7000, if available. In the absence of suitable symbols, the manufacturer may design specific graphical symbols.

Symbols placed on the equipment shall be explained in the user manual.

1.7.2 Safety instructions and marking

1.7.2.1 General

Sufficient information shall be provided to the USER concerning any condition necessary to ensure that, when used as prescribed by the manufacturer, the equipment is unlikely to present a hazard within the meaning of this standard.

If it is necessary to take special precautions to avoid the introduction of hazards when operating, installing, servicing, transporting or storing equipment, the necessary instructions shall be made available.

NOTE 1 Special precautions may be necessary, for example, for connection of the equipment to the supply and for the interconnection of separate units, if any.

NOTE 2 Where appropriate, installation instructions should include reference to national wiring rules.

NOTE 3 In many countries, instructions and equipment marking related to safety are required to be in a language that is acceptable in the country in which the equipment is to be installed. Servicing instructions are normally made available only to SERVICE PERSONS and are generally acceptable in the English language only.

NOTE 4 In Germany, safety-related information, even for SERVICE PERSONS, has to be in the German language.

NOTE 5 In Canada, the instructions and markings should be in French and English.

NOTE 6 In Finland, Norway and Sweden, CLASS I PLUGGABLE EQUIPMENT TYPE A intended for connection to other equipment or a network, must, if safety relies on connection to protective earth or if surge suppressors are connected between the network terminals and accessible parts, have a marking stating that the equipment must be connected to an earthed mains socket-outlet.

The operating instructions, and the installation instructions for PLUGGABLE EQUIPMENT intended for USER installation, shall be made available to the USER.

1.7.2.2 Disconnect devices

Where the disconnect device is not incorporated in the equipment (see 3.4.3) or where the plug on the power supply cord is intended to serve as the disconnect device, the installation instructions shall state that:

– for PERMANENTLY CONNECTED EQUIPMENT, a readily accessible disconnect device shall be incorporated external to the equipment;

– for PLUGGABLE EQUIPMENT, the socket-outlet shall be installed near the equipment and shall be easily accessible.

1.7.2.3 Overcurrent protective devices

For PLUGGABLE EQUIPMENT TYPE B or PERMANENTLY CONNECTED EQUIPMENT, the installation instructions shall specify the maximum rating of an overcurrent protective device to be provided external to the equipment, unless there are appropriate overcurrent protective devices in the equipment [see also 2.6.3.3 b)].

NOTE The specified maximum rating may not be one of the protective device ratings available in the country of installation. Allowance should be made for the use of a device with a smaller rating that will still be adequate for the equipment RATED CURRENT plus any necessary allowance for inrush current.

1.7.2.4 IT power distribution systems

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

1.7.2.5 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).

1.7.2.6 Ozone

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 The present recommended long term exposure limit for ozone is $0{,}1 \times 10^{-6}$ (0,2 mg/m^3) calculated as an 8 h time-weighted average concentration. It should be noted that ozone is heavier than air.

1.7.3 Short duty cycles

Equipment not intended for continuous operation shall be marked with its RATED OPERATING TIME, and RATED RESTING TIME unless the operating time is limited by the construction.

The marking of RATED OPERATING TIME shall correspond to normal use.

The marking of the RATED OPERATING TIME shall precede the marking of the RATED RESTING TIME (if given), the two markings being separated by a solidus (/).

1.7.4 Supply voltage adjustment

For equipment intended for connection to multiple RATED VOLTAGES or FREQUENCIES, the method of adjustment shall be fully described in the servicing 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 outlet to show the maximum load that is permitted to be connected to it.

Socket-outlets conforming to IEC 60083 are examples of standard power supply outlets.

1.7.6 Fuse identification

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

Where fuses with special fusing characteristics such as time delay or breaking capacity 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 (for example, F1, F2, etc.) to the servicing instructions that shall contain the relevant information.

NOTE See 2.7.6 regarding other warnings to SERVICE PERSONS.

1.7.7 Wiring terminals

1.7.7.1 Protective earthing and bonding terminals

A wiring terminal intended for connection of a PROTECTIVE EARTHING CONDUCTOR shall be indicated by the symbol ⏚, IEC 60417-5019 (DB:2002-10). This symbol shall not be used for other earthing terminals, except that the symbol may also be used to identify the separate protective earthing terminal specified in 5.1.7.1.

It is not a requirement to mark terminals for PROTECTIVE BONDING CONDUCTORS, but where such terminals are marked, the symbol ⏚ (IEC 60417-5017 (DB:2002-10)) shall be used.

The following situations are exempt from the above requirements:

– where terminals for the connection of a supply are provided on a component (for example, a terminal block) or subassembly (for example, a power supply unit), the symbol ⏚ is permitted for the protective earthing terminal instead of ⏚;

– on subassemblies or components, the symbol ⏚ is permitted in place of the symbol ⏚ provided that it does not give rise to confusion.

These symbols shall not be located on screws, or other parts that might be removed when conductors are being connected.

These requirements are 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.

1.7.7.2 Terminals for a.c. mains supply conductors

For PERMANENTLY CONNECTED EQUIPMENT and equipment with ordinary NON-DETACHABLE POWER SUPPLY CORDS:

– terminals intended exclusively for connection of the AC MAINS SUPPLY neutral conductor, if any, shall be indicated by the capital letter N; and

– on three-phase equipment, if incorrect phase rotation could cause overheating or other hazard, terminals intended for connection of the AC MAINS SUPPLY line 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 located on screws, or other parts that might be removed when conductors are being connected.

1.7.7.3 Terminals for d.c. mains supply conductors

For PERMANENTLY CONNECTED EQUIPMENT and equipment with ordinary NON-DETACHABLE POWER SUPPLY CORDS, terminals intended exclusively for connection of a DC MAINS SUPPLY shall be marked to indicate polarity.

If a single terminal is provided, both as a main protective earthing terminal in the equipment and for the connection to one pole of the DC MAINS SUPPLY, it shall be marked as specified in 1.7.7.1, in addition to polarity marking.

These indications shall not be located on screws or other parts that might be removed when conductors are being connected.

1.7.8 Controls and indicators

1.7.8.1 Identification, location and marking

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

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

– on or adjacent to the switch or control, or

– elsewhere, provided that it is obvious to which switch or control the marking applies.

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 60073. 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 and push buttons) to indicate "ON" and "OFF" conditions, they shall be the line | for "ON" and circle O for "OFF" (IEC 60417-5007 (DB:2002-10)) and IEC 60417-5008 (DB:2002-10). For push-push type switches the symbol ⏼ shall be used (IEC 60417-5010 (DB:2002-10)).

It is permitted to use the symbols O and | to indicate the "OFF" and "ON" positions of any primary or secondary power switches, including isolating switches.

A "STAND-BY" condition shall be indicated by the symbol ⏻ (IEC 60417-5009 (DB:2002-10)).

1.7.8.4 Markings 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.

1.7.9 Isolation of multiple power sources

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

1.7.10 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.

1.7.11 Durability

Any 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 kauributenol 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.

As an alternative, it is permitted to use a reagent grade hexane with a minimum of 85 % as n-hexane.

NOTE The designation “n-hexane” is chemical nomenclature for a "normal" or straight chain hydrocarbon. This petroleum spirit may further be identified as a certified ACS (American Chemical Society) reagent grade hexane (CAS# 110-54-3).

1.7.12 Removable parts

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

1.7.13 Replaceable batteries

If an equipment is provided with a replaceable battery, and if replacement by an incorrect type could result in an explosion (for example, with some lithium batteries), the following applies:

– if the battery is placed in an OPERATOR ACCESS AREA, there shall be a marking close to the battery or a statement in both the operating and the servicing instructions;

– if the battery is placed elsewhere in the equipment, there shall be a marking close to the battery or a statement in the servicing instructions.

This marking or statement shall include the following or similar text:

CAUTION
RISK OF EXPLOSION IF BATTERY IS REPLACED
BY AN INCORRECT TYPE.
DISPOSE OF USED BATTERIES ACCORDING
TO THE INSTRUCTIONS

1.7.14 Equipment for restricted access locations

For equipment intended only for installation in a RESTRICTED ACCESS LOCATION, the installation instructions shall contain a statement to this effect.

2 Protection from hazards

2.1 Protection from electric shock and energy hazards

2.1.1 Protection in operator access areas

This subclause specifies requirements for protection against electric shock from energized parts based on the principle that the OPERATOR is permitted to have access to:

– bare parts of SELV CIRCUITS; and

– bare parts of LIMITED CURRENT CIRCUITS; and

– TNV CIRCUITS under the conditions specified in 2.1.1.1.

Access to other energized parts, and to their insulation, is restricted as specified in 2.1.1.1.

Additional requirements are specified in 2.1.1.5 and 2.1.1.8 for protection against energy hazards.

2.1.1.1 Access to energized parts

The equipment shall be so constructed that in OPERATOR ACCESS AREAS there is adequate protection against contact with:

– bare parts of ELV CIRCUITS; and

– bare parts at HAZARDOUS VOLTAGES; and

– SOLID INSULATION providing FUNCTIONAL INSULATION or BASIC INSULATION of parts or wiring in ELV CIRCUITS, except as permitted in 2.1.1.3; and

– SOLID INSULATION providing functional insulation or basic insulation of parts or wiring at hazardous voltages; and

NOTE 1 FUNCTIONAL INSULATION includes, but is not limited to, insulation, such as lacquer, solvent-based enamel, ordinary paper, cotton and oxide film, or displaceable insulation such as beads and sealing compounds other than self-hardening resin.

– unearthed conductive parts separated from ELV CIRCUITS or from parts at HAZARDOUS VOLTAGES by FUNCTIONAL INSULATION or BASIC INSULATION only; and

– bare parts of TNV CIRCUITS, except that access is permitted to:

  - contacts of connectors that cannot be touched by the test probe (Figure 2C);
  - bare conductive parts in the interior of a battery compartment that complies with 2.1.1.2;
  - bare conductive parts of TNV-1 CIRCUITS that have any point connected in accordance with 2.6.1 d) to a protective earthing terminal;
  - bare conductive parts of connectors in TNV-1 CIRCUITS that are separated from unearthed accessible conductive parts of the equipment in accordance with 6.2.1.

NOTE 2 A typical application is the shell for a coaxial connector.

NOTE 3 Access to TNV-1 CIRCUITS and TNV-3 CIRCUITS via other circuits is also restricted by 6.2.1 in some cases.

Unrestricted access is permitted to LIMITED CURRENT CIRCUITS.

These requirements apply 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 all of the following.

a) Inspection.

b) A test with the test finger, Figure 2A, which shall not contact parts described above when applied to openings in the ENCLOSURES after removal of parts that can be detached by an OPERATOR, including fuseholders, and with OPERATOR access doors and covers open. It is permitted to leave lamps in place for this test. Connectors that can be separated by an OPERATOR, other than those complying with IEC 60083, IEC 60309, IEC 60320, IEC 60906-1 or IEC 60906-2, shall also be tested during disconnection.

c) *A test with the test pin, Figure 2B, which shall not contact bare parts at* HAZARDOUS VOLTAGES *when applied to openings in an external* ELECTRICAL ENCLOSURE*. Parts that can be detached by an* OPERATOR*, including fuseholders and lamps, are left in place, and* OPERATOR *access doors and covers are closed during this test.*

d) *A test with the test probe, Figure 2C, where appropriate.*

The test finger, the test pin and the test probe 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 in the installation instructions.

Openings preventing the entry of the test finger, test b) above, 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, test b) is repeated except that the finger is pushed through the opening using any necessary force up to 30 N.

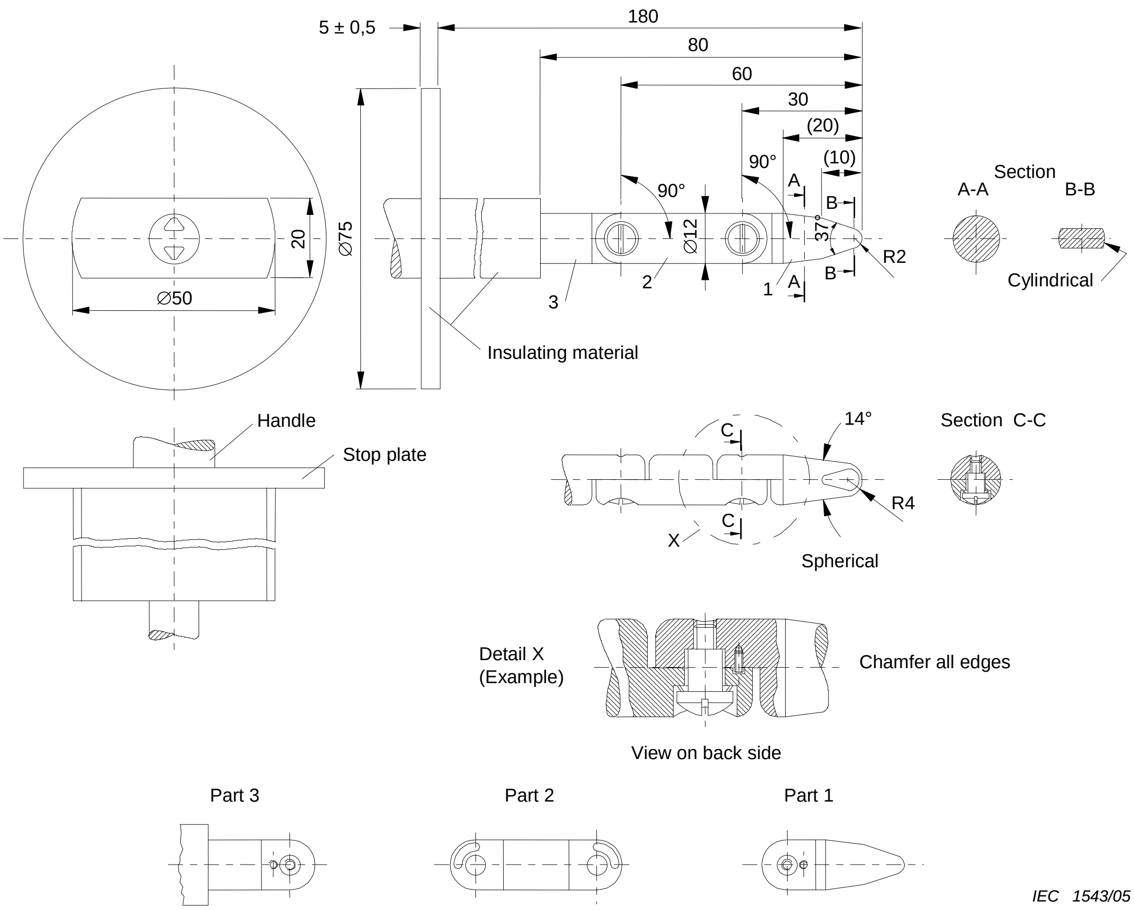
NOTE 4 If an electrical contact indicator is used to show contact, care should be taken to ensure that the application of the test does not damage components of electronic circuits.

Where contact between the test tool and the part is not permitted in the above tests, there is no requirement for a minimum air gap for voltages not exceeding 1 000 V a.c. or 1 500 V d.c. For higher voltages, there shall be an air gap between the part at HAZARDOUS VOLTAGE *and the test finger, Figure 2A, or the test pin, Figure 2B, placed in its most unfavourable position. This air gap, see Figure 2D, shall either*

– *have a minimum length equal to the minimum* CLEARANCE *for* BASIC INSULATION *specified in 2.10.3 (or Annex G), or*

– *shall withstand the relevant electric strength test in 5.2.2.*

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.



Linear dimensions in millimetres

Tolerances on dimensions without specific tolerances:

– 14° and 37° angles:	±15′
– on radii:	±0,1 mm
– on linear dimensions:	
≤15 mm:	$^{\ 0}_{-0,1}$ mm
>15 mm ≤ 25 mm:	±0,1 mm
>25 mm:	±0,3 mm

Material of finger: heat-treated steel, for example.

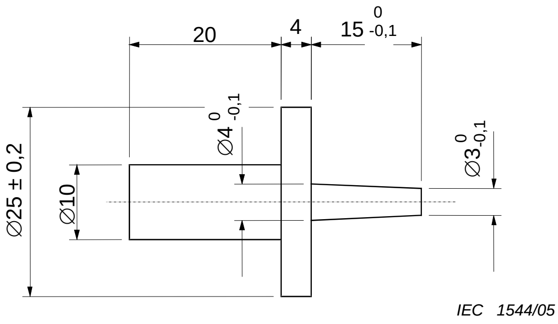
Both joints of this finger can be bent through an angle of 90° $^{+10°}_{\ 0}$ but in one and the same direction only.

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 Dimensions in parentheses are for information only.

NOTE 3 The test finger is taken from Figure 2, test probe B of IEC 61032. In some cases, the tolerances are different.

Figure 2A – Test finger

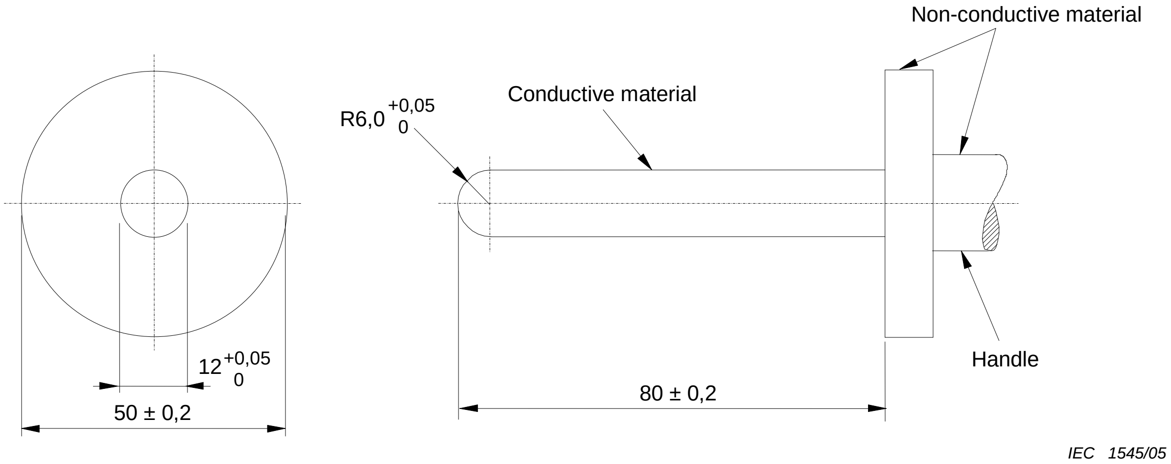


Dimensions in millimetres

The handle dimensions (Ø 10 and 20) are not critical.

NOTE The test pin dimensions are those given in Figure 9, test probe 13 of IEC 61032. In some cases the tolerances are different.

Figure 2B – Test pin



Dimensions in millimetres

Figure 2C – Test probe

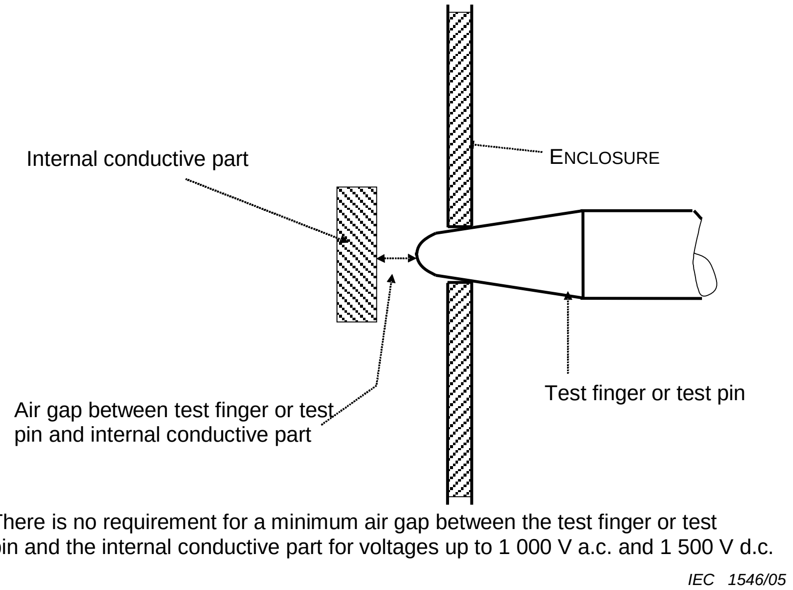


Figure 2D - Accessibility of internal conductive parts

2.1.1.2 Battery compartments

Access by an OPERATOR to bare conductive parts of TNV CIRCUITS within a battery compartment in the equipment is permitted if all of the following conditions are met:

– the compartment has a door that requires a deliberate technique to open, such as the use of a TOOL or latching device; and

– the TNV CIRCUIT is not accessible when the door is closed; and

– there is a marking next to the door, or on the door if the door is secured to the equipment, with instructions for protection of the USER once the door is opened.

Information stating that the telephone cord is to be disconnected prior to opening the door is an example of an acceptable instruction.

Compliance is checked by inspection.

2.1.1.3 Access to ELV wiring

Insulation of internal wiring in an ELV CIRCUIT is permitted to be accessible to an OPERATOR provided that:

a) the insulation meets the requirements for SUPPLEMENTARY INSULATION detailed in 3.1.4; or

b) all of the following apply:

  ï the wiring does not need to be handled by the OPERATOR and is so placed that the OPERATOR is unlikely to pull on it, or is so fixed that the connecting points are relieved from strain; and

  ï the wiring is routed and fixed so as not to touch unearthed accessible conductive parts; and

  ï the insulation passes the electric strength test of 5.2.2 for SUPPLEMENTARY INSULATION; and

  ï the distance through the insulation is not less than that given in Table 2A.

Table 2A – Distance through insulation of internal wiring

WORKING VOLTAGE (in case of failure of BASIC INSULATION)		Minimum distance through insulation
V peak or d.c.	**V r.m.s. (sinusoidal)**	**mm**
Over 71 up to and including 350	Over 50 up to and including 250	0,17
Over 350	Over 250	0,31

Compliance is checked by inspection and measurement, and by the test of 5.2.2.

2.1.1.4 Access to hazardous voltage circuit wiring

Where the insulation of internal wiring at HAZARDOUS VOLTAGE is accessible to an OPERATOR, or is not routed and fixed to prevent it from touching unearthed accessible conductive parts, it shall meet the requirements of 3.1.4 for DOUBLE INSULATION or REINFORCED INSULATION.

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

2.1.1.5 Energy hazards

There shall be no risk of injury due to an energy hazard in an OPERATOR ACCESS AREA.

Compliance is checked by inspection and measurement and, if necessary, by tests.

a) *A risk of injury due to an energy hazard exists if it is likely that two or more bare parts (one of which may be earthed) between which a HAZARDOUS ENERGY LEVEL exists, will be bridged by a metallic object.*

b) *The likelihood of bridging the parts under consideration is determined by means of the test finger, Figure 2A (see 2.1.1.1), in a straight position. It shall not be possible to bridge the parts with this test finger, applied without appreciable force.*

c) *The existence of a HAZARDOUS ENERGY LEVEL is determined as follows:*

1) *with the equipment operating under normal operating conditions, a variable resistive load is connected to the parts under consideration and adjusted to obtain a level of 240 VA. Further adjustment is made, if necessary, to maintain 240 VA for a period of 60 s. If the voltage is 2 V or more, the output power is at a HAZARDOUS ENERGY LEVEL, unless an overcurrent protective device opens during the above test, or for any other reason the power cannot be maintained at 240 VA for 60 s;*

2) *the stored energy in a capacitor is at a HAZARDOUS ENERGY LEVEL if the voltage, U, is 2 V or more, and the stored energy, E, calculated from the following equation, ~~exceeds~~ is 20 J or more:*

$$E = 0{,}5\ CU^2 \times 10^{-6}$$

where

E is the energy, in joules (J);

C is the capacitance, in microfarads (µF);

U is the measured voltage on the capacitor, in volts (V).

2.1.1.6 Manual controls

Conductive shafts of operating knobs, handles, levers and the like in OPERATOR ACCESS AREAS shall not be connected to parts at HAZARDOUS VOLTAGES, to ELV CIRCUITS or to TNV CIRCUITS.

In addition, conductive operating knobs, handles, levers and the like that are manually moved in normal use and that are earthed only through a pivot or bearing, shall either:

– be separated from parts at HAZARDOUS VOLTAGES by DOUBLE INSULATION or REINFORCED INSULATION; or

– have their accessible parts covered by SUPPLEMENTARY INSULATION for a HAZARDOUS VOLTAGE and by BASIC INSULATION for a TNV CIRCUIT.

Compliance is checked by inspection and measurement, and by the applicable electric strength tests of 5.2.2.

2.1.1.7 Discharge of capacitors in equipment

Equipment shall be so designed that, at an OPERATOR-accessible external point of disconnection of a MAINS SUPPLY, the risk of electric shock from stored charge on capacitors connected in the equipment is reduced. No test for shock hazard is required unless the nominal voltage of the MAINS SUPPLY exceeds 42,4 V peak or 60 V d.c.

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

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

– *1 s for PLUGGABLE EQUIPMENT TYPE A; and*

– *10 s 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 at the point of external disconnection can be used. When conducting the voltage decay measurement, ~~the result is~~ the measurement is either made with, or referred to, an instrument having an input impedance consisting of a resistance of 100 MΩ ± 5 MΩ in parallel with an input capacitance of ~~20 pF ± 5 pF~~ 25 pF or less.

NOTE During an interval equal to one time constant, the voltage will have decayed to 37 % of its original value.

2.1.1.8 Energy hazards - d.c. mains supplies

Equipment shall be so designed that at an OPERATOR-accessible external point of disconnection of a DC MAINS SUPPLY, either

– there is no HAZARDOUS ENERGY LEVEL (for example, due to stored charge on a capacitor or a battery in the equipment, or to a redundant DC MAINS SUPPLY for backup), or

– the HAZARDOUS ENERGY LEVEL is removed within 2 s of the disconnection.

External points of disconnection include the plugs of PLUGGABLE EQUIPMENT and isolating switches external to the equipment.

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

If necessary, the existence of a HAZARDOUS ENERGY LEVEL is determined as follows:

a) Capacitor connected to the DC MAINS SUPPLY

A test is conducted when the equipment is operating normally. The DC MAINS SUPPLY is then disconnected and the voltage across the capacitor (U) is measured 2 s after disconnection.

The stored energy is calculated from the following formula:

$$E = 0,5\ CU^2 \times 10^{-6}$$

where

E is the energy, in joules (J);

C is the capacitance, in microfarads (µF);

U is the measured voltage on the capacitor, in volts (V).

A HAZARDOUS ENERGY LEVEL exists if the voltage, U, is 2 V or more, and the stored energy, E, ~~exceeds~~ is 20 J or more.

b) Internal battery connected to the DC MAINS SUPPLY

A test is conducted with the DC MAINS SUPPLY disconnected and a variable resistive load connected to the input terminals where the DC MAINS SUPPLY is normally connected. The EUT is operated from its internal battery. The variable load is adjusted so that it draws 240 VA. Further adjustment is made, if necessary, to maintain 240 VA for a period of 60 s.

If U is more than 2 V, the output power is at a HAZARDOUS ENERGY LEVEL unless an overcurrent protective device opens during the above test, or for any other reason the power cannot be maintained at 240 VA for a period of 60 s.

If the output power is at a HAZARDOUS ENERGY LEVEL, a further test is conducted with the variable load disconnected and the EUT operated from the DC MAINS SUPPLY.

The supply is disconnected and the energy level at the input terminals, 2 s after disconnection, shall not be at a HAZARDOUS ENERGY LEVEL.

NOTE It is assumed that it will be possible to bridge the parts accidentally external to the equipment. There is no test to determine the likelihood of bridging the parts.

2.1.1.9 Audio amplifiers in information technology equipment

Accessible circuits, terminals and parts of audio amplifiers and associated circuits shall comply with either

– 2.1.1.1 of this standard, or

– 9.1.1 of IEC 60065.

Compliance is checked by inspection and, if necessary, by the tests of 9.1.1 of IEC 60065, during which the audio amplifiers are operated in accordance with 4.2.4 of IEC 60065.

2.1.2 Protection in service access areas

In a SERVICE ACCESS AREA, the following requirements apply.

The requirements of 2.1.1.7 apply to all types of equipment and for PERMANENTLY CONNECTED EQUIPMENT, the time constant limit is 10 s. In addition, the requirements of 2.1.1.8 apply.

Bare parts at HAZARDOUS VOLTAGES shall be located or guarded so that unintentional contact with such parts is unlikely during service operations involving other parts of the equipment.

Bare parts at HAZARDOUS VOLTAGE shall be located or guarded so that accidental shorting to SELV CIRCUITS or to TNV CIRCUITS (for example, by TOOLS or test probes used by a SERVICE PERSON) is unlikely.

No requirement is specified regarding access to ELV CIRCUITS or to TNV CIRCUITS. However, bare parts that present a HAZARDOUS ENERGY LEVEL shall be located or guarded so that unintentional bridging by conductive materials that might be present is unlikely during service operations involving other parts of the equipment.

Any guards required for compliance with 2.1.2 shall be easily removable and replaceable if removal is necessary for servicing.

Compliance is checked by inspection and measurement. In deciding whether or not unintentional contact is likely, account is taken of the way a SERVICE PERSON *needs to gain access past, or near to, the bare parts in order to service other parts. For determination of a* HAZARDOUS ENERGY LEVEL*, see 2.1.1.5 c).*

2.1.3 Protection in restricted access locations

For equipment to be installed in a RESTRICTED ACCESS LOCATION, the requirements for OPERATOR ACCESS AREAS apply, except as permitted in the following four paragraphs.

In general, the requirements of 2.1.1.7 and 2.1.1.8 apply except that they do not apply to PERMANENTLY CONNECTED EQUIPMENT. However, appropriate markings and instructions shall be provided for protection against energy hazards if a HAZARDOUS ENERGY LEVEL exists.

If a SECONDARY CIRCUIT at HAZARDOUS VOLTAGE is used to supply a ringing signal generator that complies with 2.3.1 b), contact with bare parts of the circuit is permitted with the test finger, Figure 2A (see 2.1.1.1). However, such parts shall be so located or guarded that unintentional contact is unlikely.

Bare parts that present a HAZARDOUS ENERGY LEVEL shall be located or guarded so that unintentional bridging by conductive materials that might be present is unlikely.

No requirement is specified regarding contact with bare parts of TNV-1 CIRCUITS, TNV-2 CIRCUITS and TNV-3 CIRCUITS.

Compliance is checked by inspection and measurement. In deciding whether or not unintentional contact is likely, account is taken of the need to gain access past, or near to, the bare parts. For determination of a HAZARDOUS ENERGY LEVEL*, see 2.1.1.5 c).*

2.2 SELV circuits

2.2.1 General requirements

SELV CIRCUITS shall exhibit voltages that are safe to touch both under normal operating conditions and after a single fault (see 1.4.14). If no external load is applied to the SELV CIRCUIT (open circuit), the voltage limits of 2.2.2 and 2.2.3 shall not be exceeded.

Compliance with 2.2.1 to 2.2.4 is checked by inspection and relevant tests.

2.2.2 Voltages under normal conditions

In a single SELV CIRCUIT or in interconnected SELV CIRCUITS, the voltage between any two conductors of the SELV CIRCUIT or CIRCUITS, and between any one such conductor and earth (see 1.4.9), shall not exceed 42,4 V peak, or 60 V d.c., under normal operating conditions.

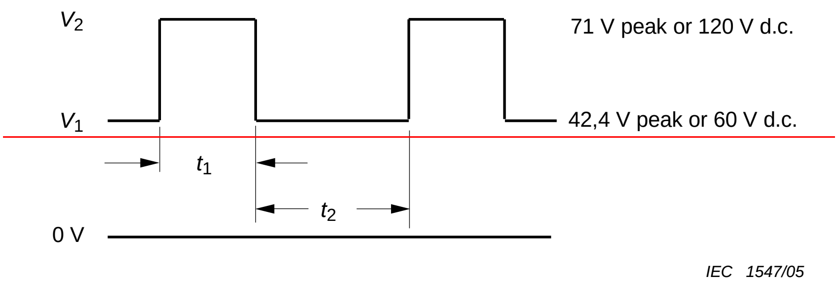
NOTE 1 A circuit that meets the above requirements, but that is subject to overvoltages from a TELECOMMUNICATION NETWORK or a CABLE DISTRIBUTION SYSTEM, is a TNV-1 CIRCUIT.

NOTE 2 For normal conditions, the SELV CIRCUIT voltage limit is the same for an ELV CIRCUIT; an SELV CIRCUIT may be regarded as an ELV CIRCUIT with additional protection under fault conditions.

2.2.3 Voltages under fault conditions

Except as permitted in 2.3.2.1 b), in the event of a single fault (see 1.4.14), the voltages between any two conductors of the SELV CIRCUIT or CIRCUITS and between any one such conductor and earth (see 1.4.9) shall not exceed 42,4 V peak, or 60 V d.c. (V_1 in Figure 2E.1 and Figure 2E.2) for longer than 200 ms. Moreover, the voltage shall not exceed 71 V peak or 120 V ~~d.c~~ $_{peak}$. (V_2 in Figure 2E.1 and Figure 2E.2).

NOTE In Canada and the United States, the exception mentioned in 2.3.2.1 b) is not permitted.



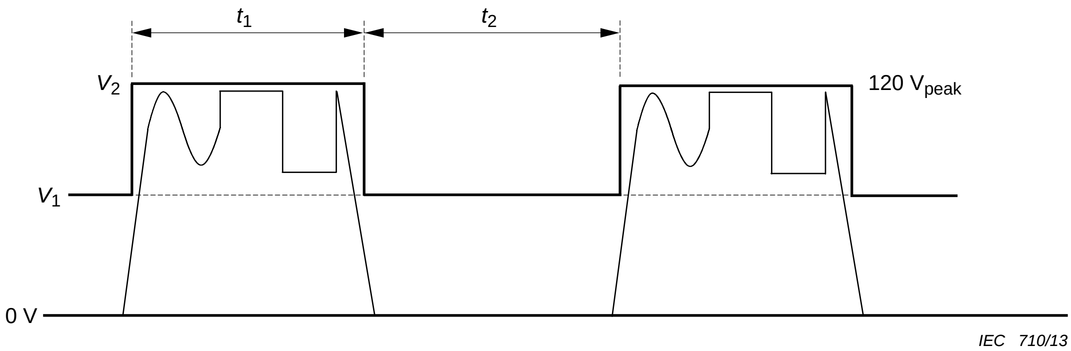


Figure 2E.1 – Voltages in SELV circuits under single fault conditions for a single pulse above *V*1

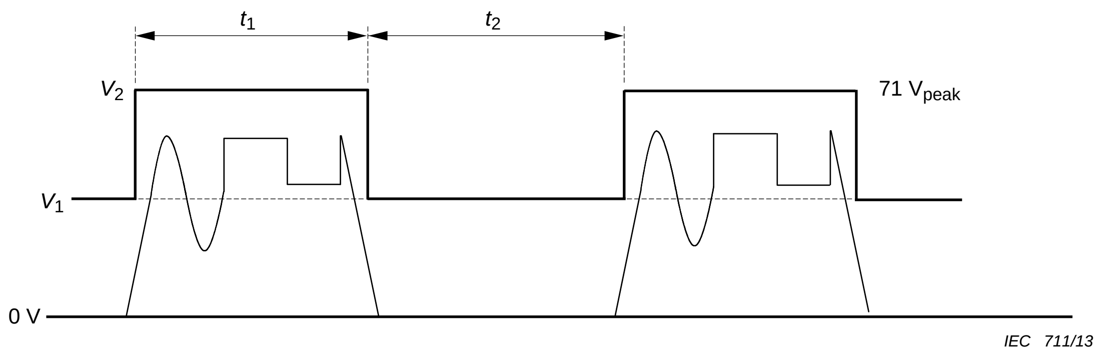


Figure 2E.2 – Voltages in SELV circuits under single fault conditions for multiple pulses above *V*1

Figure 2E – Voltages in SELV circuits under single fault conditions

For voltages having a repetitive nature after a fault (for example, from power supplies in "hiccup" mode), additional pulses exceeding V_1 (but not exceeding V_2) are permitted under the following conditions:

– if $t_1 \leq 20$ ms, t_2 shall be greater than 1 s;

– if $t_1 > 20$ ms, t_2 shall be greater than 3 s; and

– t_1 shall not exceed 200 ms.

~~Only one pulse is permitted to exceed V_1 during time period t_1, but it can have any waveform.~~

A limit of 120 V_{peak} applies if the pulse goes above V_1 only once during time t_1, for example see Figure 2E.1.

A limit of 71 V_{peak} applies if the pulse goes above V_1 more than once during time t_1, for example see Figure 2E.2.

Except as permitted in 2.2.4, an SELV CIRCUIT shall be separated from a part at a HAZARDOUS VOLTAGE by one or more of the constructions specified in 2.9.4.

It is permitted for some parts of a circuit (for example, a transformer-rectifier circuit) 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.

2.2.4 Connection of SELV circuits to other circuits

An SELV CIRCUIT is permitted to be connected to other circuits provided that, when the SELV CIRCUIT is so connected, all of the following conditions are met:

– except as permitted by 1.5.7 and 2.4.3, the SELV CIRCUIT is separated by BASIC INSULATION from any PRIMARY CIRCUIT (including the neutral) within the equipment; and

– the SELV CIRCUIT meets the limits of 2.2.2 under normal operating conditions; and

– except as specified in 2.3.2.1 b), the SELV CIRCUIT meets the limits of 2.2.3 in the event of a single fault (see 1.4.14) in the SELV CIRCUIT or in the SECONDARY CIRCUIT to which the SELV CIRCUIT 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 2.2.2 and 2.2.3.

If an SELV CIRCUIT obtains its supply conductively from a SECONDARY CIRCUIT that is separated from a HAZARDOUS VOLTAGE circuit by either:

- DOUBLE INSULATION or REINFORCED INSULATION; or
- an earthed conductive screen that is separated from the HAZARDOUS VOLTAGE circuit by BASIC INSULATION,

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

NOTE For requirements in Norway, see 1.7.2.1 Note 6, 6.1.2.1 Note 2 and 6.1.2.2 Note.

If an SELV CIRCUIT is derived from a HAZARDOUS VOLTAGE SECONDARY CIRCUIT, and the HAZARDOUS VOLTAGE SECONDARY CIRCUIT is separated from the PRIMARY CIRCUIT by DOUBLE INSULATION or REINFORCED INSULATION, the SELV CIRCUIT shall remain within the limits given in 2.2.3 under single fault conditions (see 1.4.14). In such a case, the short-circuiting of the insulation in a transformer that provides the separation between the HAZARDOUS VOLTAGE SECONDARY CIRCUIT and the SELV CIRCUIT is considered to be a single fault, for the purpose of applying the single fault conditions, provided the insulation in the transformer passes an electrical strength test for BASIC INSULATION in accordance with 5.2.2.

2.3 TNV circuits

2.3.1 Limits

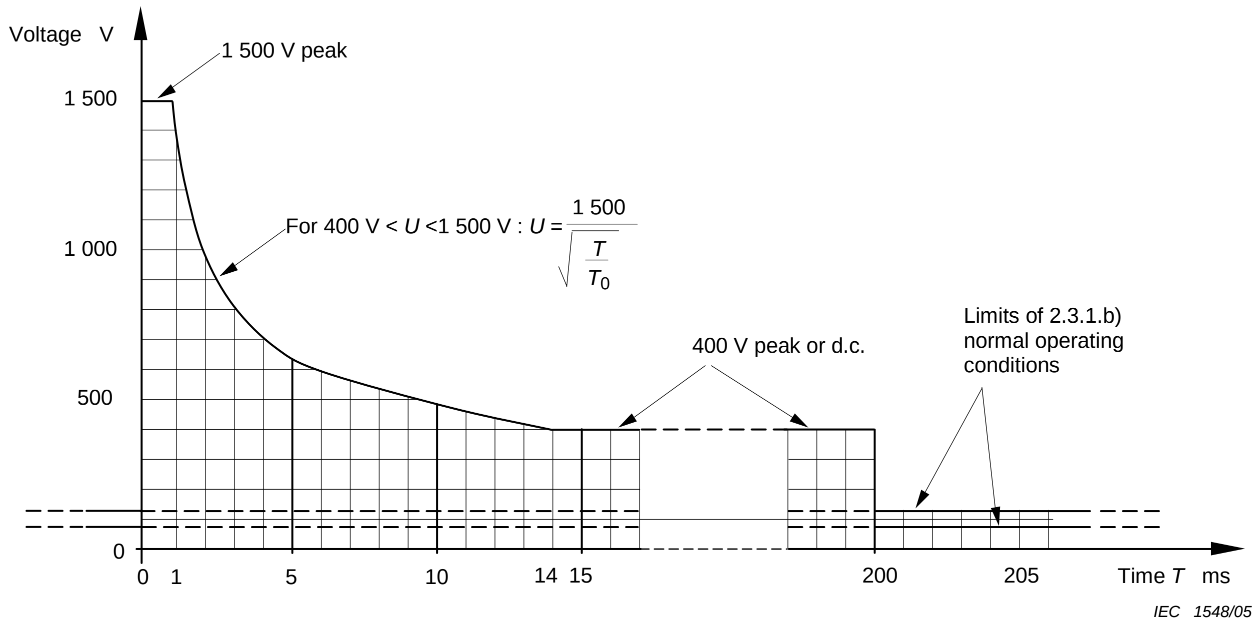
In a single TNV CIRCUIT or interconnected TNV CIRCUITS, the voltage between any two conductors of the TNV CIRCUIT or CIRCUITS and between any one such conductor and earth (see 1.4.9) shall comply with the following.

a) TNV-1 CIRCUITS

The voltages do not exceed the following:

- the voltage limits in 2.2.2 for an SELV CIRCUIT under normal operating conditions;
- the voltage limits of Figure 2F measured across a 5 000 Ω ± 2 % resistor in the event of a single fault (see 1.4.14) within the equipment.

NOTE 1 In the event of a single insulation or component failure, the limit after 200 ms is the limit in 2.3.1 b) for a TNV-2 CIRCUIT or TNV-3 CIRCUIT for normal operating conditions.



U V
T ms
T_0 1 ms

Figure 2F – Maximum voltages permitted after a single fault

b) TNV-2 CIRCUITS **and** TNV-3 CIRCUITS

The voltages exceed the limits in 2.2.2 for an SELV CIRCUIT but do not exceed the following:

– when telephone ringing signals are present, voltages such that the signal complies with the criteria of either Clause M.2 or Clause M.3;

– when telephone ringing signals are not present:

- a combination of voltages, a.c. and d.c., such that under normal operating conditions:

$$\frac{U_{ac}}{71} + \frac{U_{dc}}{120} \leq 1$$

where

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

U_{dc} is the value of the DC VOLTAGE (V)

NOTE 2 When U_{dc} is zero, U_{ac} can be up to 71 V peak.

NOTE 3 When U_{ac} is zero, U_{dc} can be up to 120 V.

and

- the voltage limits of Figure 2F measured across a 5 000 Ω ± 2 % resistor in the event of a single fault (see 1.4.14) within the equipment.

Compliance is checked by inspection and measurement.

NOTE 4 Telegraph and teletypewriter signals may be present on existing TELECOMMUNICATION NETWORKS. However, these signals are considered to be obsolescent and their characteristics are not considered in this standard.

2.3.2 Separation of TNV circuits from other circuits and from accessible parts

NOTE In Finland, Norway and Sweden, there are additional requirements for the insulation, see 6.1.2.1 Note 2 and 6.1.2.2 Note.

2.3.2.1 General requirements

NOTE 1 See also 6.1.2, 6.2 and 7.3.

SELV-CIRCUITS, TNV-1 CIRCUITS and accessible conductive parts shall be separated from TNV-2 CIRCUITS and TNV-3 CIRCUITS in such a way that in the event of a single fault (see 1.4.14) both of the following conditions are met:

a) the voltages of TNV-1 CIRCUITS do not exceed the limits of Figure 2F; and

b) the voltages of the SELV CIRCUITS and accessible conductive parts do not exceed the limits specified in 2.3.1 b) for TNV-2 CIRCUITS and TNV-3 CIRCUITS under normal operating conditions.

NOTE 2 In Canada and the United States, in the event of a single fault as described above, the limits of 2.2.3 apply to SELV CIRCUITS and to accessible conductive parts.

NOTE 3 Under normal operating conditions, the limits of 2.2.2 always apply to each SELV CIRCUIT and accessible conductive part.

NOTE 4 The limits of 2.3.1 always apply to each TNV CIRCUIT.

At the choice of the manufacturer, it is permitted to treat a TNV-1 CIRCUIT or a TNV-2 CIRCUIT as a TNV-3 CIRCUIT. In this case, the TNV-1 CIRCUIT or TNV-2 CIRCUIT shall meet all the separation requirements for a TNV-3 CIRCUIT.

One of the methods specified in 2.3.2.2, 2.3.2.3, 2.3.2.4 and 2.10.5.13 shall be used**.**

Compliance is checked as specified in 2.3.2.2, 2.3.2.3, 2.3.2.4 or 2.10.5.13.

2.3.2.2 Protection by basic insulation

The requirements of 2.3.2.1 are met if the parts are separated by BASIC INSULATION.

Compliance is checked by inspection, measurement and electric strength testing of the BASIC INSULATION and, if necessary, by simulation of failures of components and the BASIC INSULATION (see 1.4.14). However, if it is clear from a study of the circuit diagrams that the specified limits of 2.3.1 b) will not be exceeded, failure of components and the BASIC INSULATION need not be simulated.

NOTE 1 The test of 2.3.5 is not required.

NOTE 2 Where BASIC INSULATION is provided and 6.2.1 also applies to this insulation, the test voltage prescribed in 6.2.2 is in most cases higher than that for BASIC INSULATION.

2.3.2.3 Protection by earthing

The requirements of 2.3.2.1 are considered to be met if the SELV CIRCUIT, TNV-1 CIRCUIT or accessible conductive part is connected to the main protective earthing terminal in accordance with 2.6.1 c) or d); and one of the following, a), b), c) or d) applies.

a) For PLUGGABLE EQUIPMENT, a separate protective earthing terminal is provided in addition to the main protective earthing terminal, if any (see 2.6.4.1). The installation instructions shall specify that this separate protective earthing terminal be permanently connected to earth.

b) For PLUGGABLE EQUIPMENT TYPE B, having connections to TELECOMMUNICATION NETWORKS or to CABLE DISTRIBUTION SYSTEMS that are all pluggable, a marking on the equipment and a statement in the installation instructions shall be provided. These shall specify that the USER is to disconnect all TELECOMMUNICATION NETWORK connectors and CABLE DISTRIBUTION SYSTEM connectors before disconnecting the POWER SUPPLY CORD.

c) For PLUGGABLE EQUIPMENT TYPE A, the requirements of b) above apply, and in addition the installation instructions shall specify that it be installed by a SERVICE PERSON and connected to a socket-outlet with a protective earthing contact.

d) For PERMANENTLY CONNECTED EQUIPMENT there is no additional requirement.

NOTE If earthing is provided that is not in accordance with a), b), c) or d), see 2.3.2.4.

Compliance is checked by inspection and, if necessary, by simulation of failures of components and insulation such as are likely to occur in the equipment (see 1.4.14). The voltage limits specified in 2.3.2.1 shall be met.

Additionally, the test of 2.3.5 shall be conducted if the TNV-2 CIRCUIT or TNV-3 CIRCUIT is intended to receive signals or power that are generated externally during normal operation (for example, in a TELECOMMUNICATION NETWORK). Single faults are not simulated while conducting the test of 2.3.5.

Prior to the above tests, insulation that does not meet the requirements for BASIC INSULATION is short-circuited. However, if simulation of failures would be more severe if conducted without short-circuiting the insulation, the test is conducted without short-circuiting.

2.3.2.4 Protection by other constructions

Other constructions are permitted if they ensure that the voltage limits specified in 2.3.2.1 are met, but do not rely on BASIC INSULATION or earthing, or by separation as specified in 2.10.5.13.

Compliance is checked by simulation of failures of components and insulation such as are likely to occur in the equipment (see 1.4.14).

If earthing is provided that is not in accordance with 2.3.2.3 a), b), c) or d), the tests are conducted with the EUT not connected to earth. The voltage limits specified in 2.3.2.1 shall be met.

*Additionally, the test of 2.3.5 shall be conducted if the TNV-2 CIRCUIT or TNV-3 CIRCUIT is intended to receive signals or power that are generated externally during normal operation (for example, in a TELECOMMUNICATION NETWORK)***.** *Single faults are not simulated while conducting the test of 2.3.5.*

Prior to the above tests, insulation that does not meet the requirements for BASIC INSULATION is short-circuited. However, if simulation of failures would be more severe if conducted without short-circuiting the insulation, the test is conducted without short-circuiting.

2.3.3 Separation from hazardous voltages

Except as permitted in 2.3.4, a TNV CIRCUIT shall be separated from circuits at HAZARDOUS VOLTAGE by one or more of the constructions specified in 2.9.4.

Compliance is checked by inspection and measurement.

2.3.4 Connection of TNV circuits to other circuits

Except as permitted in 1.5.7, a TNV CIRCUIT is permitted to be connected to other circuits, provided that it is separated by BASIC INSULATION from any PRIMARY CIRCUIT (including the neutral) within the equipment.

NOTE 1 The limits of 2.3.1 always apply to TNV CIRCUITS.

If a TNV CIRCUIT is connected to one or more other circuits, the TNV CIRCUIT is that part which complies with 2.3.1.

If a TNV CIRCUIT obtains its supply conductively from a SECONDARY CIRCUIT that is separated from a HAZARDOUS VOLTAGE circuit by:

– DOUBLE INSULATION or REINFORCED INSULATION; or

– the use of an earthed conductive screen that is separated from a HAZARDOUS VOLTAGE circuit by BASIC INSULATION;

the TNV CIRCUIT shall be considered as being separated from the HAZARDOUS VOLTAGE circuit by the same method.

If a TNV CIRCUIT is derived from a HAZARDOUS VOLTAGE SECONDARY CIRCUIT, and the HAZARDOUS VOLTAGE SECONDARY CIRCUIT is separated from the PRIMARY CIRCUIT by DOUBLE INSULATION or REINFORCED INSULATION, the TNV CIRCUIT shall remain within the limits given in 2.3.1 under single fault conditions (see 1.4.14). In such a case, the short-circuiting of the insulation in a transformer that provides the separation between the HAZARDOUS VOLTAGE SECONDARY CIRCUIT and the TNV CIRCUIT is considered to be a single fault, for the purpose of applying the single fault conditions, provided the insulation in the transformer passes an electrical strength test for BASIC INSULATION in accordance with 5.2.2.

Compliance is checked by inspection, and by simulation of single faults (see 1.4.14) such as are likely to occur in the equipment. No such simulated fault shall cause the voltage across a 5 000 $\Omega \pm 2$ % resistor, connected between any two conductors of the TNV CIRCUIT or between one such conductor and earth, to fall outside the shaded area of Figure 2F (see 2.3.1). Observation is continued until stable conditions have existed for at least 5 s.

NOTE 2 For requirements in Norway, see 1.7.2.1 Note 6, 6.1.2.1 Note 2 and 6.1.2.2 Note.

2.3.5 Test for operating voltages generated externally

This test is only conducted if specified in 2.3.2.3 or 2.3.2.4.

A test generator specified by the manufacturer is used, representing the maximum normal operating voltage expected to be received from the external source. In the absence of such a specification, a test generator is used that provides 120 V ± 2 V a.c. at 50 Hz or 60 Hz and has an internal impedance of 1 200 $\Omega \pm 2$ %.

NOTE The above test generator is not intended to represent the actual voltages on the TELECOMMUNICATION NETWORK but to stress the circuit of the EUT in a repeatable manner.

The test generator is connected between the TELECOMMUNICATION NETWORK terminals of the equipment. One pole of the test generator is also connected to the earthing terminal of the equipment (see Figure 2G). The test voltage is applied for a maximum of 30 min. If it is clear that no further deterioration will take place, the test is terminated earlier.

During the test, the SELV CIRCUIT, TNV-1 CIRCUIT or accessible conductive part shall continue to comply with 2.2.2.

The test is repeated after reversing the connections to the TELECOMMUNICATION NETWORK terminals of the equipment.

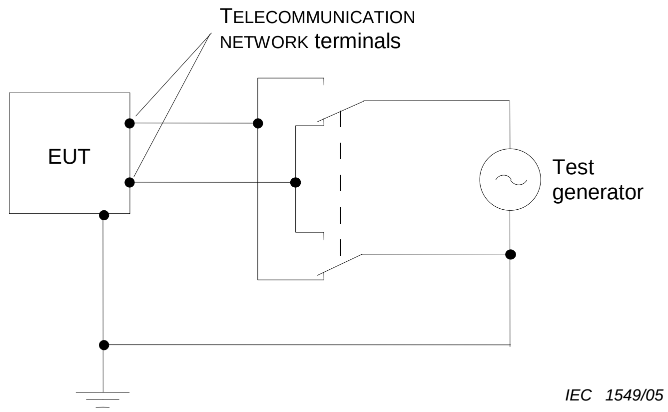


Figure 2G – Test generator

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 a single failure within the equipment (see 1.4.14 and 1.5.7).

Except as permitted in 2.4.3, segregation of accessible parts of LIMITED CURRENT CIRCUITS from other circuits shall be as described in 2.2 for SELV CIRCUITS.

Compliance with 2.4.1 to 2.4.3 is checked by inspection, measurement and, when necessary, by test.

NOTE 1 An accessible conductive part or circuit separated from another part by DOUBLE INSULATION or REINFORCED INSULATION that is bridged by a resistor or group of resistors is treated as a LIMITED CURRENT CIRCUIT (see 1.5.7).

NOTE 2 A LIMITED CURRENT CIRCUIT may be derived from either a PRIMARY CIRCUIT or a SECONDARY CIRCUIT.

2.4.2 Limit values

For frequencies not exceeding 1 kHz, the steady-state current drawn through a non-inductive resistor of 2 000 Ω ± 10 % connected between any two parts of a LIMITED CURRENT CIRCUIT, or between any such part and earth (see 1.4.9), 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.

Alternatively, it is permitted to use the measuring instruments of Annex D instead of the non-inductive resistor of 2 000 Ω ± 10 % mentioned above.

When using the measuring instrument of Figure D.1, the voltage, U_2, is measured and the current is calculated by dividing the measured voltage, U_2, by 500. The calculated value shall not exceed 0,7 mA peak.

NOTE 1 If one side of the LIMITED CURRENT CIRCUIT has a conductive connection to earth, point B of the measuring instrument of Figure D.1 should be connected to that side.

When using the measuring instrument of Figure D.2, the measured value of the current shall not exceed 0,7 mA peak.

For parts not exceeding 450 V peak or d.c., the circuit capacitance shall not exceed 0,1 µF.

For parts whose voltage, *U*, exceeds 0,45 kV peak or d.c., but does not exceed 15 kV peak or d.c., the circuit capacitance shall not exceed 45/*U* nF, where *U* is expressed in kilovolts.

NOTE 2 The limit of 45/*U* corresponds to an available stored charge of 45 µC.

For parts whose voltage, *U*, exceeds 15 kV peak or d.c., the circuit capacitance shall not exceed 700/U^2 nF, where *U* is expressed in kilovolts.

NOTE 3 The limit of 700/U^2 corresponds to an available energy of 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.

2.5 Limited power sources

A limited power source shall comply with one of the following, a), b), c) or d):

a) the output is inherently limited in compliance with Table 2B; or

b) a linear or non-linear impedance limits the output in compliance with Table 2B. If a positive temperature coefficient device is used, it shall:
   – pass the tests specified in IEC 60730-1, Clauses 15, 17, J.15 and J.17; or
   – meet the requirements in IEC 60730-1 for a device for Type 2.AL action;

c) a regulating network, or an integrated circuit (IC) current limiter, limits the output in compliance with Table 2B, both with and without a simulated single fault (see 1.4.14) in the regulating network or the IC current limiter (open circuit or short circuit). A single fault between the input and output is not conducted if the IC current limiter meets a suitable test program as given in Annex CC;

d) an overcurrent protective device is used and the output is limited in compliance with Table 2C.

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

A limited power source operated from an AC MAINS SUPPLY, or a battery-operated limited power source that is recharged from an AC MAINS SUPPLY while supplying the load, shall incorporate an isolating transformer.

Compliance is checked by inspection and measurement and, where appropriate, by examination of the manufacturer's data for batteries. Batteries shall be fully charged when conducting the measurements for U_{oc} and I_{sc} according to Tables 2B and 2C.

The non-capacitive load referred to in Tables 2B and 2C is adjusted to give the maximum measured value of I_{sc} or S.

Simulated faults in a regulating network, required according to item c) above, are applied under the above maximum measured values of I_{sc} or S.

Table 2B – Limits for power sources without an overcurrent protective device

Output voltage [a] (U_{oc})		Output current [b d] (I_{sc})	Apparent power [c d] (S)
V a.c.	V d.c.	A	VA
≤ 30	≤ 30	≤ 8,0	≤ 100
–	$30 < U_{oc} \leq 60$	$\leq 150/U_{oc}$	≤ 100

[a] U_{oc}: Output voltage measured in accordance with 1.4.5 with all load circuits disconnected. Voltages are for substantially sinusoidal a.c. and ripple free d.c. For non-sinusoidal a.c. and d.c. with ripple greater than 10 % of the peak, the peak voltage shall not exceed 42,4 V.

[b] I_{sc}: Maximum output current with any non-capacitive load, including a short-circuit.

[c] S (VA): Maximum output VA with any non-capacitive load.

[d] Measurement of I_{sc} and S are made 5 s after application of the load if protection is by an electronic circuit and 60 s for a positive temperature coefficient device~~, and 60 s~~ or in other cases.

Table 2C – Limits for power sources with an overcurrent protective device

Output voltage [a] (U_{oc})		Output current [b d] (I_{sc})	Apparent power [c d] (S)	Current rating of overcurrent protective device [e]
V a.c.	V d.c.	A	VA	A
≤ 20	≤ 20	$\leq 1\,000/U_{oc}$	≤ 250	≤ 5,0
$20 < U_{oc} \leq 30$	$20 < U_{oc} \leq 30$			$\leq 100/U_{oc}$
–	$30 < U_{oc} \leq 60$			$\leq 100/U_{oc}$

[a] U_{oc}: Output voltage measured in accordance with 1.4.5 with all load circuits disconnected. Voltages are for substantially sinusoidal a.c. and ripple free d.c. For non-sinusoidal a.c. and for d.c. with ripple greater than 10 % of the peak, the peak voltage shall not exceed 42,4 V.

[b] I_{sc}: Maximum output current with any non-capacitive load, including a short-circuit, measured 60 s after application of the load.

[c] S (VA): Maximum output VA with any non-capacitive load measured 60 s after application of the load.

[d] Current limiting impedances remain in the circuit during measurement, but overcurrent protective devices are bypassed.

NOTE The reason for making measurements with overcurrent protective devices bypassed is to determine the amount of energy that is available to cause possible overheating during the operating time of the overcurrent protective devices.

[e] The current ratings 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 current rating specified in the table.

2.6 Provisions for earthing and bonding

NOTE For additional requirements with regard to earthing of equipment to be connected to TELECOMMUNICATION NETWORKS, see 2.3.2.3, 2.3.2.4, 2.3.3, 2.3.4, 6.1.1 and 6.1.2; and for CABLE DISTRIBUTION SYSTEMS, see 7.2 and 7.4.1.

2.6.1 Protective earthing

The following parts of equipment shall be reliably connected to the main protective earthing terminal of the equipment.

a) Accessible conductive parts that might assume a HAZARDOUS VOLTAGE in the event of a single fault (see 1.4.14).

b) Parts to be earthed as required by 2.9.4 d) or e).

c) SELV CIRCUITS, TNV CIRCUITS and accessible conductive parts required to be earthed by 2.3.2.3 or 2.3.2.4, if the power source is not a TELECOMMUNICATION NETWORK or a CABLE DISTRIBUTION SYSTEM.

d) SELV CIRCUITS, TNV CIRCUITS and accessible conductive parts required to be earthed by 2.3.2.3, if the power source is a TELECOMMUNICATION NETWORK or a CABLE DISTRIBUTION SYSTEM.

e) Circuits, transformer screens and components (such as surge suppressors) that could not assume a HAZARDOUS VOLTAGE in the event of a single fault (see 1.4.14) but are required to be earthed in order to reduce transients that might affect insulation (for example, see 6.2.1 and 7.4.1).

f) SELV CIRCUITS and TNV CIRCUITS that are required to be earthed in order to reduce or eliminate TOUCH CURRENT to a TELECOMMUNICATION NETWORK or a CABLE DISTRIBUTION SYSTEM (see 5.1.8.1).

NOTE Parts a), b) and c) are likely to carry fault currents intended to operate overcurrent protective devices. Parts d), e) and f) carry other currents.

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 fault (see 1.4.14), either these conductive parts shall be connected to the main protective earthing terminal or, if this is impossible or impracticable, a suitable marking shall indicate to a SERVICE PERSON that such parts are not earthed and should be checked for HAZARDOUS VOLTAGE before being touched.

Compliance is checked by inspection and, where appropriate, by the test specified in 2.6.3.

2.6.2 Functional earthing

If FUNCTIONAL EARTHING of accessible ~~or inaccessible~~ conductive parts is necessary, all of the following apply to the FUNCTIONAL EARTHING circuit:

– the FUNCTIONAL EARTHING circuit shall be separated from parts at HAZARDOUS VOLTAGES in the equipment by either:

  • DOUBLE INSULATION or REINFORCED INSULATION; or

  • a protectively earthed screen or another protectively earthed conductive part, separated from parts at HAZARDOUS VOLTAGES by at least BASIC INSULATION; and

– it is permitted to connect the FUNCTIONAL EARTHING circuit to a protective earth terminal or to a PROTECTIVE BONDING CONDUCTOR; and

– wiring terminals to be used only for FUNCTIONAL EARTHING shall not be marked by the symbol ⏚ (60417-IEC-5017) or by the symbol ⏚⃝ (60417-IEC-5019), except that, where a wiring terminal is provided on a component (for example, a terminal block) or subassembly, the symbol ⏚ is permitted; and

NOTE Other markings such as one of the symbols, (IEC 60417-5018 (DB:2002-10)) or (IEC 60417-5020 (DB:2002-10)), if appropriate, are permitted.

– for internal FUNCTIONAL EARTHING conductors, the colour combination green-and-yellow shall not be used except in multipurpose preassembled components (for example, multi-conductor cables or EMC filters); and

- ~~in a power supply cord where a conductor having green-and-yellow insulation is used only to provide a FUNCTIONAL EARTHING connection:~~
  - ~~the equipment shall not be marked with the symbol (IEC 60417-5172 (DB:2003:02)); and~~
  - ~~there are no requirements other than those in 3.1.9 regarding the termination of this conductor at the equipment end.~~

For equipment having a power supply cord where a conductor with green-and-yellow insulation is used only to provide a FUNCTIONAL EARTHING connection:

- the equipment shall not be marked with the symbol , IEC 60417-5172 (2003-02); and
- the equipment may be marked with:
  - the symbol , IEC 60417-5018 (2011-07); or
  - the symbol , IEC 60417-6092 (2011-10).

These symbols shall not be used for CLASS I EQUIPMENT.

There are no requirements other than those in 3.1.9 regarding the termination of this FUNCTIONAL EARTHING conductor at the equipment end.

Compliance is checked by inspection.

2.6.3 Protective earthing conductors and protective bonding conductors

2.6.3.1 General

PROTECTIVE EARTHING CONDUCTORS and PROTECTIVE BONDING CONDUCTORS shall have sufficient current-carrying capacity.

The requirements of 2.6.3.2, 2.6.3.3 and 2.6.3.4 apply to PROTECTIVE EARTHING CONDUCTORS and PROTECTIVE BONDING CONDUCTORS provided to comply with 2.6.1 a), b) and c).

For PROTECTIVE EARTHING CONDUCTORS and PROTECTIVE BONDING CONDUCTORS provided to comply with 2.6.1 d), the requirements and test of 2.6.3.4 e) apply.

For PROTECTIVE EARTHING CONDUCTORS and PROTECTIVE BONDING CONDUCTORS provided to comply with 2.6.1 e) and 2.6.1 f), and for FUNCTIONAL EARTHING conductors, the current-carrying capacity shall be adequate for the actual current under normal operating conditions, in accordance with 3.1.1, that is the conductors are not required to carry fault currents to earth.

2.6.3.2 Size of protective earthing conductors

PROTECTIVE EARTHING CONDUCTORS in power supply cords supplied with the equipment shall comply with the minimum conductor sizes in Table 3B (see 3.2.5).

Compliance is checked by inspection and measurement.

2.6.3.3 Size of protective bonding conductors

PROTECTIVE BONDING CONDUCTORS shall comply with one of the following:

- the minimum conductor sizes in Table 3B (see 3.2.5); or

– the requirements of 2.6.3.4 and also, if the PROTECTIVE CURRENT RATING of the circuit is more than 16 A, with the minimum conductor sizes in Table 2D; or
– for components only, be not smaller than the conductors supplying power to the component.

The PROTECTIVE CURRENT RATING of the circuit (used in Table 2D and in the test of 2.6.3.4) depends on the provision and location of overcurrent protective devices. It shall be taken as the smallest of a) or b) or c), as applicable.

a) For PLUGGABLE EQUIPMENT TYPE A, the PROTECTIVE CURRENT RATING is the rating of an overcurrent protective device provided external to the equipment (for example, in the building wiring, in the mains plug or in an equipment rack) to protect the equipment, with a minimum of 16 A.

NOTE 1 In most countries, 16 A is considered to be suitable as the PROTECTIVE CURRENT RATING of the circuit.

NOTE 2 In Canada and the United States, the PROTECTIVE CURRENT RATING of the circuit is taken as 20 A.

NOTE 3 In the United Kingdom, the current rating of the circuit shall be taken as 13 A, not 16 A.

b) For PLUGGABLE EQUIPMENT TYPE B and PERMANENTLY CONNECTED EQUIPMENT (see 2.7.1), the PROTECTIVE CURRENT RATING is the maximum rating of the overcurrent protective device specified in the equipment installation instructions to be provided external to the equipment (see 1.7.2.3).

c) For any of the above equipment, the PROTECTIVE CURRENT RATING is the rating of an overcurrent protective device, if provided in or as part of the equipment, that protects the circuit or part required to be earthed.

Compliance is checked by inspection and measurement.

Table 2D – Minimum size of protective bonding conductors

PROTECTIVE CURRENT RATING **of the circuit under consideration**	**Minimum conductor sizes**	
Up to and including **A**	**Cross-sectional area** **mm²**	**AWG or kcmil (cross-sectional area in mm²)**
~~16~~ 20	Size not specified	Size not specified
25	1,5	14 (2)
32	2,5	12 (3)
40	4,0	10 (5)
63	6,0	8 (8)
80	10	6 (13)
100	16	4 (21)
125	25	2 (33)
160	35	1 (42)
190	50	0 (53)
230	70	000 (85)
260	95	0000 (107)
300	120	250 kcmil (126)
340	150	300 kcmil (152)
400	185	400 kcmil (202)
460	240	500 kcmil (253)

NOTE AWG and kcmil sizes are provided for information only. The associated cross-sectional areas have been rounded to show significant figures only. AWG refers to the American Wire Gage and the term "cmil" refers to circular mils where 1 cmil is the area of a circle having a diameter of 1 mil (one thousandth of an inch). These terms are commonly used to designate wire sizes in North America.

2.6.3.4 Resistance of earthing conductors and their terminations

Earthing conductors and their terminations shall not have excessive resistance.

PROTECTIVE EARTHING CONDUCTORS are considered to comply without test.

PROTECTIVE BONDING CONDUCTORS that meet the minimum conductor sizes in Table 3B (see 3.2.5) throughout their length and whose terminals all meet the minimum sizes in Table 3E (see 3.3.5) are considered to comply without test.

Compliance is checked by inspection, measurement and, for PROTECTIVE BONDING CONDUCTORS that do not meet the minimum conductor sizes in Table 3B (see 3.2.5) throughout their length or whose terminals do not all meet the minimum sizes in Table 3E (see 3.3.5), by the following test.

The voltage drop in a PROTECTIVE BONDING CONDUCTOR is measured after conducting the test current for the time period specified below. The test current can be either a.c. or d.c. and the test voltage shall not exceed 12 V. The measurement is made between the main protective earthing terminal and the point in the equipment that is required by 2.6.1 to be earthed. The resistance of the PROTECTIVE EARTHING CONDUCTOR is not included in the measurement. However, if the PROTECTIVE EARTHING CONDUCTOR is supplied with the equipment, it is permitted to include the conductor in the test circuit but the measurement of the voltage drop is made only from the main protective earthing terminal to the part required to be earthed.

On equipment where the protective earth connection to a subassembly or to a separate unit is by means of one core of a multicore cable that also supplies mains power to that subassembly or unit, the resistance of the PROTECTIVE BONDING CONDUCTOR in that cable is not included in the measurement. However, this option is only permitted if the cable is protected by a suitably rated protective device that takes into account the size of the conductor.

If the protection of an SELV CIRCUIT or a TNV CIRCUIT is achieved by earthing the protected circuit itself in accordance with 2.9.4 e), the resistance and the voltage drop limits apply between the earthed side of the protected circuit and the main protective earthing terminal.

If the circuit is protected by earthing the winding of a transformer supplying the protected circuit, the resistance and the voltage drop limits apply between the unearthed side of the winding and the main protective earthing terminal. The BASIC INSULATION between the primary and secondary windings is not subjected to the single fault testing required by 5.3.7 and 1.4.14.

Care is taken that the contact resistance between the tip of the measuring probe and the conductive part under test does not influence the test results.

The test current, duration of the test and test results are as follows:

a) *For equipment powered from a MAINS SUPPLY, if the PROTECTIVE CURRENT RATING of the circuit under test (see 2.6.3.3) is 16 A or less, the test current is 200 % of the PROTECTIVE CURRENT RATING applied for 120 s.*

   The resistance of the PROTECTIVE BONDING CONDUCTOR, calculated from the voltage drop, shall not exceed 0,1 Ω. After the test, the PROTECTIVE BONDING CONDUCTOR shall not be damaged.

b) *For equipment powered from an AC MAINS SUPPLY, if the PROTECTIVE CURRENT RATING of the circuit under test exceeds 16 A, the test current is 200 % of the PROTECTIVE CURRENT RATING and the duration of the test is as shown in Table 2E.*

Table 2E – Test duration, a.c. mains supplies

PROTECTIVE CURRENT RATING of the circuit (I_{pc}) A	Duration of the test min
≤ 30	2
30 < I_{pc} ≤ 60	4
60 < I_{pc} ≤ 100	6
100 < I_{pc} ≤ 200	8
> 200	10

The voltage drop in the PROTECTIVE BONDING CONDUCTOR *shall not exceed 2,5 V. After the test the* PROTECTIVE BONDING CONDUCTOR *shall not be damaged.*

c) *As an alternative to b) above, the tests are based on the time-current characteristic of the overcurrent protective device that limits the fault current in the* PROTECTIVE BONDING CONDUCTOR*. This device is either one provided in the EUT or specified in the installation instructions to be provided external to the equipment. The tests are conducted at 200 % of the* PROTECTIVE CURRENT RATING*, for the duration corresponding to 200 % on the time-current characteristic. If the duration for 200 % is not given, the nearest point on the time-current characteristic is used.*

The voltage drop in the PROTECTIVE BONDING CONDUCTOR *shall not exceed 2,5 V. After the test the* PROTECTIVE BONDING CONDUCTOR *shall not be damaged.*

d) *For equipment powered from a* DC MAINS SUPPLY*, if the* PROTECTIVE CURRENT RATING *of the circuit under test exceeds 16 A, the test current and duration are as specified by the manufacturer.*

The voltage drop in the PROTECTIVE BONDING CONDUCTOR *shall not exceed 2,5 V. After the test the* PROTECTIVE BONDING CONDUCTOR *shall not be damaged.*

e) *For* PROTECTIVE BONDING CONDUCTORS *provided to comply with 2.6.1 d), the test current is 150 % of the maximum current available under normal operating conditions from the* TELECOMMUNICATION NETWORK *or* CABLE DISTRIBUTION SYSTEM *(if known) with a minimum of 2 A, applied for 120 s. The voltage drop in the* PROTECTIVE BONDING CONDUCTOR *shall not exceed 2,5 V.*

2.6.3.5 Colour of insulation

The insulation of the PROTECTIVE EARTHING CONDUCTOR in a power supply cord supplied with the equipment shall be green-and-yellow.

If a PROTECTIVE BONDING CONDUCTOR is insulated, the insulation shall be green-and-yellow except in the following two cases:

– for an earthing braid, the insulation shall be either green-and-yellow or transparent;

– for a PROTECTIVE BONDING CONDUCTOR in assemblies such as ribbon cables, busbars, printed wiring, etc., any colour is permitted provided that no misinterpretation of the use of the conductor is likely to arise.

Except as permitted in 2.6.2, the colour combination green-and-yellow shall be used only to identify PROTECTIVE EARTHING CONDUCTORS and PROTECTIVE BONDING CONDUCTORS.

Compliance is checked by inspection.

2.6.4 Terminals

2.6.4.1 General

The requirements of 2.6.4.2 and 2.6.4.3 apply only to protective earthing terminals provided to comply with 2.6.1 a), b) and c).

NOTE For additional requirements concerning terminals, see 3.3.

For protective earthing provided to comply with 2.6.1 d), e) and f), it is sufficient for the terminals to comply with 3.3.

2.6.4.2 Protective earthing and bonding terminals

Equipment required to have protective earthing shall have a main protective earthing terminal. For equipment with a DETACHABLE POWER SUPPLY CORD, the earthing terminal in the appliance inlet is regarded as the main protective earthing terminal.

If equipment is provided with more than one supply connection (for example, with different voltages or frequencies or as backup power), it is permitted to have a main protective earthing terminal associated with each supply connection. In such a case, the terminals shall be sized according to the rating of the associated supply input.

Terminals shall be designed to resist 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 this requirement; for other designs, special provisions, such as the use of an adequately resilient part that is not likely to be removed inadvertently, shall be used.

Except as noted below, all pillar, stud or screw type protective earthing and protective bonding terminals shall comply with the minimum size requirements of Table 3E (see 3.3.5).

Where a terminal for a PROTECTIVE BONDING CONDUCTOR does not comply with Table 3E (see 3.3.5), the test of 2.6.3.4 shall be applied to the PROTECTIVE BONDING CONDUCTOR path in which the terminal is used.

The main protective earthing terminal for PERMANENTLY CONNECTED EQUIPMENT shall be

– located so that it is readily accessible while making the supply connections, and
– provided with factory installed pillar terminals, studs, screws, bolts or similar terminals, together with the necessary fixing hardware, if a PROTECTIVE EARTHING CONDUCTOR larger than 7 mm^2 (3 mm diameter) is required.

Compliance is checked by inspection and measurement.

2.6.4.3 Separation of the protective earthing conductor from protective bonding conductors

Separate wiring terminals, which may be on the same busbar, shall be provided, one for the PROTECTIVE EARTHING CONDUCTOR, or one for each PROTECTIVE EARTHING CONDUCTOR if more than one is provided, and one or more for PROTECTIVE BONDING CONDUCTORS.

However, it is permitted to provide a single wiring terminal of the screw or stud type in PERMANENTLY CONNECTED EQUIPMENT having a NON-DETACHABLE POWER SUPPLY CORD, and in PLUGGABLE EQUIPMENT having a special NON-DETACHABLE POWER SUPPLY CORD, provided that the wiring termination of the PROTECTIVE EARTHING CONDUCTOR is separated by a nut from that of the PROTECTIVE BONDING CONDUCTORS. The order of stacking of the terminations of the PROTECTIVE EARTHING CONDUCTOR and the PROTECTIVE BONDING CONDUCTORS is not specified.

It is also permitted to provide a single wiring terminal in equipment with an appliance inlet.

Compliance is checked by inspection.

2.6.5 Integrity of protective earthing

2.6.5.1 Interconnection of equipment

In a system of interconnected equipment, the protective earthing connection shall be ensured for all equipment requiring a protective earthing connection, regardless of the arrangement of equipment in the system.

Equipment that contains a PROTECTIVE BONDING CONDUCTOR to maintain continuity of protective earthing circuits to other equipment in the system, shall not be marked with the symbol ⧈ (IEC 60417-5172 (DB:2003-02)).

Such equipment shall also provide power to the other equipment in the system (see 2.6.5.3).

Compliance is checked by inspection.

2.6.5.2 Components in protective earthing conductors and protective bonding conductors

PROTECTIVE EARTHING CONDUCTORS and PROTECTIVE BONDING CONDUCTORS shall not contain switches or overcurrent protective devices.

Compliance is checked by inspection.

2.6.5.3 Disconnection of protective earth

Protective earthing connections shall be such that disconnection of a protective earth at one point in a unit or a system does not break the protective earthing connection to other parts or units in a system, unless the relevant hazard is removed at the same time.

Compliance is checked by inspection.

2.6.5.4 Parts that can be removed by an operator

Protective earthing connections shall make earlier and break later than the supply connections in each of the following:

– the connector of a part that can be removed by an OPERATOR;

– a plug on a power supply cord;

– an appliance coupler.

Compliance is checked by inspection.

2.6.5.5 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 that they protect unless the relevant hazard is removed at the same time.

Compliance is checked by inspection.

2.6.5.6 Corrosion resistance

Conductive parts in contact at protective earthing and protective bonding terminals and connections shall not be subject to significant corrosion due to electrochemical action in any working, storage or transport environment conditions as specified in the instructions supplied with the equipment. Combinations above the line in Annex J shall be avoided. 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).

2.6.5.7 Screws for protective bonding

NOTE The following requirements are additional to those in 3.1.6.

Self-tapping (thread-cutting and thread-forming) and spaced thread (sheet metal) screws are permitted to provide protective bonding but it shall not be necessary to disturb the connection during servicing.

In any case, the thickness of the metal part at the point where a screw is threaded into it shall be not less than twice the pitch of the screw thread. It is permitted to use local extrusion of a metal part to increase the effective thickness.

At least two screws shall be used for each connection. However, it is permitted to use a single self-tapping screw provided that the thickness of the metal part at the point where the screw is threaded into it is a minimum of 0,9 mm for a screw of the thread-forming type and 1,6 mm for a screw of the thread-cutting type.

Compliance is checked by inspection.

2.6.5.8 Reliance on telecommunication network or cable distribution system

Protective earthing shall not rely on a TELECOMMUNICATION NETWORK or a CABLE DISTRIBUTION SYSTEM.

Compliance is checked by inspection.

2.7 Overcurrent and earth fault protection in primary circuits

2.7.1 Basic requirements

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

If PLUGGABLE EQUIPMENT TYPE B or PERMANENTLY CONNECTED EQUIPMENT relies on protective devices external to the equipment for protection, the equipment installation instructions shall so state and shall also specify the requirements for short-circuit protection or overcurrent protection or, where necessary, for both.

NOTE In the member countries of CENELEC and in China, the protective devices necessary to comply with the requirements of 5.3 must, with certain exceptions, be included as part of the equipment.

Compliance is checked by inspection.

2.7.2 Faults not simulated in 5.3.7

Protection against faults not simulated in 5.3.7 (for example, short-circuits to protective earth from wiring in a PRIMARY CIRCUIT) need not be fitted as an integral part of the equipment.

Compliance is checked by inspection.

2.7.3 Short-circuit backup 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.

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

NOTE If fuses complying with IEC 60127 are used in PRIMARY CIRCUITS, they should have high breaking capacity (1 500 A) if the prospective short-circuit current exceeds 35 A or ten times the current rating of the fuse, whichever is greater.

Compliance is checked by inspection and by the tests of 5.3.

2.7.4 Number and location of protective devices

Protective systems or devices in PRIMARY CIRCUITS shall be in such a number and located so as to detect and to interrupt the overcurrent flowing in any possible fault current path (for example, line-to-line, line-to-neutral, line to protective earth conductor or line to PROTECTIVE BONDING CONDUCTOR).

No protection is required against earth faults in equipment that either:

– has no connection to earth; or
– has DOUBLE INSULATION or REINFORCED INSULATION between the PRIMARY CIRCUIT and all parts connected to earth.

NOTE 1 Where DOUBLE INSULATION or REINFORCED INSULATION is provided, a short-circuit to earth would be considered to be two faults.

In a supply using more than one line conductor to a 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 single fault conditions (see 1.4.14).

NOTE 2 For protective devices that are an integral part of the equipment, examples of the number and location of fuses or circuit-breaker poles necessary to provide fault current interruption in commonly encountered supply systems are given in informative Table 2F for single-phase equipment or subassemblies and in informative Table 2G for three-phase equipment. The examples are not necessarily valid for protective devices external to the equipment.

Table 2F – Informative examples of protective devices in single-phase equipment or subassemblies

Equipment supply connections	Protection against	Minimum number of fuses or circuit-breaker poles	Location
Case A: Equipment to be connected to power distribution systems with earthed neutral reliably identified, except for case C below	Earth faults	1	Line conductor
	Overcurrent	1	Either of the two conductors
Case B: Equipment to be connected to any supply, including IT power distribution systems and supplies with reversible plugs, except for case C below	Earth faults	2	Both conductors
	Overcurrent	1	Either of the two conductors
Case C: Equipment to be connected to three-wire power distribution systems with earthed neutral reliably identified	Earth faults	2	Each line conductor
	Overcurrent	2	Each line conductor

Table 2G – Informative examples of protective devices in three-phase equipment

Power distribution 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 line conductor
		Overcurrent	3	Each line conductor
With unearthed neutral	4	Earth faults	4	All four conductors
		Overcurrent	3	Each line 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 persons

Suitable marking shall be provided on the equipment or a statement shall be provided in the servicing instructions to alert a SERVICE PERSON to a possible hazard, where both of the following conditions exist:

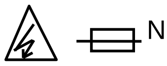
– fuse is used in the neutral of single-phase equipment either permanently connected or provided with a non-reversible plug; and

– after operation of the fuse, parts of the equipment that remain energized might represent a hazard during servicing.

The following or similar wording is regarded as suitable:

CAUTION
DOUBLE POLE/NEUTRAL FUSING

As an alternative to the above wording, use of the following combination of representative symbols, which includes the electric shock hazard symbol ISO 3864, No. 5036, the fuse symbol IEC-60417- 5016 (DB:2002-10), and an indication that the fuse is in the neutral N, is permitted. However in this case, the statement shall also be provided in the servicing instructions.



Compliance is checked by inspection.

2.8 Safety interlocks

2.8.1 General principles

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

Compliance is checked by inspection.

2.8.2 Protection requirements

SAFETY INTERLOCKS shall be so designed that the hazard will be removed before the covers, doors, etc., are in any position that will permit contact with hazardous parts by the test finger, Figure 2A (see 2.1.1.1).

For protection against electric shock, radiation and energy hazards, removal, opening or withdrawal of the cover, door, etc., shall either:

– 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 that will continue to move through momentum and will continue to present a mechanical hazard (for example, a spinning print drum), removal, opening or withdrawal of the cover, door, etc., shall either:

– necessitate previous reduction of movement to an acceptable safe level; or
– automatically initiate reduction of the movement to an acceptable safe level.

Compliance is checked by inspection, measurement and use of the test finger, Figure 2A (see 2.1.1.1).

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 SAFETY INTERLOCK that can be operated by means of the test finger, Figure 2A (see 2.1.1.1), 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 2A (see 2.1.1.1).

2.8.4 Fail-safe operation

A SAFETY INTERLOCK system shall be so designed and constructed that either:

– a failure of the SAFETY INTERLOCK system during the normal life of the equipment is not likely to occur and, even if a failure should occur, it shall not create an extreme hazard; or

– a failure of the SAFETY INTERLOCK system during the normal life of the equipment is possible, the probable failure mode(s) will not create a hazard for which protection is required.

For protection against extreme hazard, either a redundant system of two SAFETY INTERLOCK systems shall be used or the fixed separation distances in a single SAFETY INTERLOCK system circuit (for example, those associated with printed boards) shall meet the requirements for REINFORCED INSULATION.

NOTE A SAFETY INTERLOCK system is considered to consist of the components/elements that are directly capable of disconnecting the hazardous part (for example, relay contacts or a switch) including components (for example, a relay coil) and other parts forming part of the initiation circuit (for example, those mounted on printed boards).

Compliance is checked by inspection of the SAFETY INTERLOCK system, circuit diagrams and available data and, if necessary, by simulation of single faults (see 1.4.14) (for example, failure of a semi-conductor device or an electromechanical component). Moving mechanical parts in mechanical and electromechanical systems are not subjected to simulated single faults if they comply with 2.8.5 and 2.8.7. Fixed separation distances in SAFETY INTERLOCK system circuits (for example, those associated with printed boards) that protect against other than extreme hazards are not subjected to simulated single faults if the separation distances comply with 2.8.7.1.

It is permitted to use simulated SAFETY INTERLOCK systems for tests.

2.8.5 Moving parts

Moving mechanical parts in mechanical and electromechanical SAFETY INTERLOCK systems shall have adequate endurance.

Compliance is checked by inspection of the SAFETY INTERLOCK system, available data and, if necessary, by cycling the SAFETY INTERLOCK system through 10 000 operating cycles without failure other than in a safe mode.

NOTE The above test is conducted to check the endurance of moving parts other than those in SAFETY INTERLOCK switches and relays. SAFETY INTERLOCK switches and relays, if any, are subject to 2.8.7. If the test of 2.8.7.3 is required in addition to the above test, the tests should be combined.

2.8.6 Overriding

Where it may be necessary for a SERVICE PERSON to override a SAFETY INTERLOCK, the override system shall comply with all of the following:

– require an intentional effort to operate; and

– reset automatically to normal operation when servicing is complete, or prevent normal operation unless the SERVICE PERSON has reset the SAFETY INTERLOCK; and

– require a TOOL for operation when in an OPERATOR ACCESS AREA and not be operable with the test finger, Figure 2A (see 2.1.1.1); and

– not bypass a SAFETY INTERLOCK for an extreme hazard unless another reliable means of safety protection becomes effective when the SAFETY INTERLOCK is thus bypassed. The equipment shall be designed such that the SAFETY INTERLOCK cannot be bypassed until the other means of protection is fully in place and operational.

Compliance is checked by inspection.

2.8.7 Switches, relays and their related circuits

A switch in a SAFETY INTERLOCK system shall:

– conform to IEC 61058-1, with evaluation for 10 000 operating cycles in accordance with 7.1.4.4 of IEC 61058-1; or

– comply with 2.8.7.1 and pass the tests of 2.8.7.3 and 2.8.7.4; or

– pass the tests of 2.8.7.2, 2.8.7.3 and 2.8.7.4.

A relay in a SAFETY INTERLOCK system shall:

– comply with 2.8.7.1 and pass the tests of 2.8.7.3 and 2.8.7.4; or

– pass the tests of 2.8.7.2, 2.8.7.3 and 2.8.7.4.

Compliance is checked by inspection and by the relevant tests of 2.8.7.1 to 2.8.7.4.

2.8.7.1 Separation distances for contact gaps and their related circuits

If the separation distances for contact gaps and their related circuits are located in the PRIMARY CIRCUIT, the ~~contact gap~~ separation distances shall not be less than that for a disconnect device (see 3.4.2). If the ~~contact gap~~ separation distance is located in a circuit other than a PRIMARY CIRCUIT, the ~~contact gap~~ separation distance shall be not less than the relevant minimum CLEARANCE value for BASIC INSULATION in a SECONDARY CIRCUIT specified in 2.10.3 (or Annex G).

Compliance is checked by inspection of the available data and, if necessary, by measurement.

2.8.7.2 Overload test

The contact of a switch or relay in the SAFETY INTERLOCK system ~~switch or relay~~ is subjected to an overload test consisting of 50 cycles of operation at the rate of 6 to 10 cycles per minute, making and breaking 150 % of the current imposed in the application, except that where a switch or relay contact switches a motor load, the test is conducted with the rotor of the motor in a locked condition. After the test, the SAFETY INTERLOCK system, including the switch or relay, shall still be functional.

2.8.7.3 Endurance test

The contact of a switch or relay in the SAFETY INTERLOCK system ~~switch or relay~~ is subjected to an endurance test, making and breaking 100 % of the current imposed in the application at a rate of 6 to 10 cycles of operation per minute. A higher rate of cycling is permitted if requested by the manufacturer. For reed switches used in SAFETY INTERLOCK systems located in ELV CIRCUITS, SELV CIRCUITS and TNV-1 CIRCUITS, the test is 100 000 operating cycles. For other switches and relays in SAFETY INTERLOCK systems, the test is 10 000 operating cycles. After the test, the SAFETY INTERLOCK system, including a switch or relay, shall still be functional.

2.8.7.4 Electric strength test

Except for reed switches in ELV CIRCUITS, SELV CIRCUITS and TNV-1 CIRCUITS, an electric strength test as specified in 5.2.2, is applied between the contacts of the relays and switches after the tests of 2.8.7.2 and 2.8.7.3. If the contact is in a PRIMARY CIRCUIT, the test voltage is as specified for REINFORCED INSULATION. If the contact is in a circuit other than a PRIMARY CIRCUIT, the test voltage is as specified for BASIC INSULATION in a PRIMARY CIRCUIT.

2.8.8 Mechanical actuators

Where the actuating part in a mechanical SAFETY 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 Electrical insulation

2.9.1 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).

Natural rubber, hygroscopic materials and materials containing asbestos shall not be used as insulation.

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

Compliance is checked by inspection and, where necessary, by evaluation of the data for the material.

Where necessary, if the data does not confirm that the material is non-hygroscopic, the hygroscopic nature of the material is determined by subjecting the component or subassembly employing the insulation in question to the humidity treatment of 2.9.2. The insulation is then subjected to the relevant electric strength test of 5.2.2 while still in the humidity cabinet, or in the room in which the samples were brought to the prescribed temperature.

2.9.2 Humidity conditioning

Where required by 2.9.1, 2.10.8.3, 2.10.10 or 2.10.11, humidity conditioning is conducted for 48 h in a cabinet or room containing air with a relative humidity of ~~91 % to 95 %~~ (93 ± 3) %. The temperature of the air, at all places where samples can be located, is maintained within ~~1 °C~~ ± 2°C of any convenient value t between 20 °C and 30 °C such that condensation does not occur. During this conditioning the component or subassembly is not energized.

For equipment designated for use in tropical conditions, the time duration shall be 120 h at a temperature of (40 ± 2) °C and a relative humidity of (93 ± 3) %.

With the concurrence of the manufacturer, it is permitted to increase the ~~48 h~~ time durations.

Before the humidity conditioning the sample is brought to a temperature between t and t + 4 °C.

2.9.3 Grade of insulation

Insulation shall be considered to be FUNCTIONAL INSULATION, BASIC INSULATION, SUPPLEMENTARY INSULATION, REINFORCED INSULATION or DOUBLE INSULATION.

The application of insulation in many common situations is described in Table 2H and illustrated in Figure 2H, but other situations and solutions are possible. These examples are informative; in some cases the necessary grade of insulation may be higher or lower. Where a different grade may be necessary, or if a particular configuration of energized parts is not represented in the examples, the necessary grade of insulation should be determined by considering the effect of a single fault (see 1.4.14). This should leave the requirements for protection against electric shock intact.

In certain cases, insulation may be bridged by a conductive path (for example, where 1.5.6, 1.5.7, 2.2.4, 2.3.4 or 2.4.3 applies) provided that the level of safety is maintained.

For DOUBLE INSULATION it is permitted to interchange the BASIC INSULATION and SUPPLEMENTARY INSULATION elements. Where DOUBLE INSULATION is used, ELV CIRCUITS or unearthed conductive parts are permitted between the BASIC INSULATION and the SUPPLEMENTARY INSULATION provided that the overall level of insulation is maintained.

A BOUNDING SURFACE is treated as an unearthed SELV CIRCUIT if it is part of either:

– an unearthed conductive ENCLOSURE; or

– a non-conductive ENCLOSURE.

Compliance is checked by inspection.

Table 2H – Examples of application of insulation

Grade of insulation	Location of insulation		Key to Figure 2H
	between	and	
FUNCTIONAL [a]	unearthed SELV CIRCUIT or double-insulated conductive part	– earthed conductive part – double-insulated conductive part – unearthed SELV CIRCUIT – earthed SELV CIRCUIT – earthed TNV-1 CIRCUIT	F1 F2 F2 F1 F10 [f]
	earthed SELV CIRCUIT	– earthed SELV CIRCUIT – earthed conductive part – unearthed TNV-1 CIRCUIT – earthed TNV-1 CIRCUIT	F11 F11 F12 [f] F13 [f]
	ELV CIRCUIT or basic-insulated conductive part	– earthed conductive part – earthed SELV CIRCUIT – basic-insulated conductive part – ELV CIRCUIT	F3 F3 F4 F4
	earthed HAZARDOUS VOLTAGE SECONDARY CIRCUIT	earthed HAZARDOUS VOLTAGE SECONDARY CIRCUIT	F5
	TNV-1 CIRCUIT	TNV-1 CIRCUIT	F7
	TNV-2 CIRCUIT	TNV-2 CIRCUIT	F8
	TNV-3 CIRCUIT	TNV-3 CIRCUIT	F9
	series-parallel sections of a transformer winding		F6
BASIC	PRIMARY CIRCUIT	– earthed or unearthed HAZARDOUS VOLTAGE SECONDARY CIRCUIT – earthed conductive part – earthed SELV CIRCUIT – basic-insulated conductive part – ELV CIRCUIT	B1 B2 B2 B3 B3
	earthed or unearthed HAZARDOUS VOLTAGE SECONDARY CIRCUIT	– unearthed HAZARDOUS VOLTAGE SECONDARY CIRCUIT – earthed conductive part – earthed SELV CIRCUIT – basic-insulated conductive part – ELV CIRCUIT	B4 B5 B5 B6 B6
	unearthed SELV CIRCUIT or double-insulated conductive part	– unearthed TNV-1 CIRCUIT – TNV-2 CIRCUIT – TNV-3 CIRCUIT	B7 [f] B8 [d] B9 [d e]
	earthed SELV CIRCUIT	– TNV-2 CIRCUIT – TNV-3 CIRCUIT	B10 [d] B11 [d e]
	TNV-2 CIRCUIT	– unearthed TNV-1 CIRCUIT – earthed TNV-1 CIRCUIT – TNV-3 CIRCUIT	B12 [d e] B13 [d ~~e~~ f] B14 [f]
	TNV-3 CIRCUIT	– unearthed TNV-1 CIRCUIT – earthed TNV-1 CIRCUIT	B12 B13 [d]
SUPPLEMENTARY	basic-insulated conductive part or ELV CIRCUIT	– double-insulated conductive part – unearthed SELV CIRCUIT	S1 [b] S1 [b]
	TNV CIRCUIT	– basic-insulated conductive part – ELV CIRCUIT	S2 [~~d~~] S2
SUPPLEMENTARY or REINFORCED	unearthed HAZARDOUS VOLTAGE SECONDARY CIRCUIT	– double-insulated conductive part – unearthed SELV CIRCUIT – TNV CIRCUIT	S/R1 [c] S/R1 [c] S/R2 [c]
REINFORCED	PRIMARY CIRCUIT	– double-insulated conductive part – unearthed SELV CIRCUIT – TNV CIRCUIT	R1 R1 R2
	earthed HAZARDOUS VOLTAGE SECONDARY CIRCUIT	– double-insulated conductive part – unearthed SELV CIRCUIT – TNV CIRCUIT	R3 R3 R4
The term "conductive part" refers to an electrically conductive part that is			

Grade of insulation	Location of insulation		Key to Figure 2H
	between	and	

– not normally energized, and

– not connected to any of the following:

- a circuit at HAZARDOUS VOLTAGE, or
- an ELV CIRCUIT, or
- a TNV CIRCUIT, or
- an SELV CIRCUIT, or
- a LIMITED CURRENT CIRCUIT.

Examples of such a conductive part are the BODY of equipment, a transformer core, and in some cases a conductive screen in a transformer.

If such a conductive part is protected from a part at HAZARDOUS VOLTAGE by:

– DOUBLE INSULATION or REINFORCED INSULATION, it is termed a "double-insulated conductive part";

– BASIC INSULATION plus protective earthing, it is termed an "earthed conductive part";

– BASIC INSULATION but is not earthed, that is it has no second level of protection, it is termed a "basic-insulated conductive part".

A circuit or conductive part is termed "earthed" if it is connected to a protective earthing terminal or contact in such a way as to meet the requirements in 2.6 (although it will not necessarily be at earth potential). Otherwise the circuit or conductive part is termed "unearthed".

[a] For requirements for FUNCTIONAL INSULATION, see 5.3.4.

[b] The WORKING VOLTAGE of the SUPPLEMENTARY INSULATION between an ELV CIRCUIT or a basic-insulated conductive part and an unearthed accessible conductive part is equal to the most onerous WORKING VOLTAGE for the BASIC INSULATION. The most onerous WORKING VOLTAGE may be due to a PRIMARY CIRCUIT or SECONDARY CIRCUIT and the insulation is specified accordingly.

[c] Insulation between an unearthed SECONDARY CIRCUIT at HAZARDOUS VOLTAGE and an unearthed accessible conductive part or circuit (S/R, S/R1 or S/R2 in Figure 2H) shall satisfy the more onerous of the following:

– REINFORCED INSULATION whose WORKING VOLTAGE is equal to the HAZARDOUS VOLTAGE; or

– SUPPLEMENTARY INSULATION whose WORKING VOLTAGE is equal to the voltage between the SECONDARY CIRCUIT at HAZARDOUS VOLTAGE and

- another SECONDARY CIRCUIT at HAZARDOUS VOLTAGE, or
- a PRIMARY CIRCUIT.

These examples apply if:

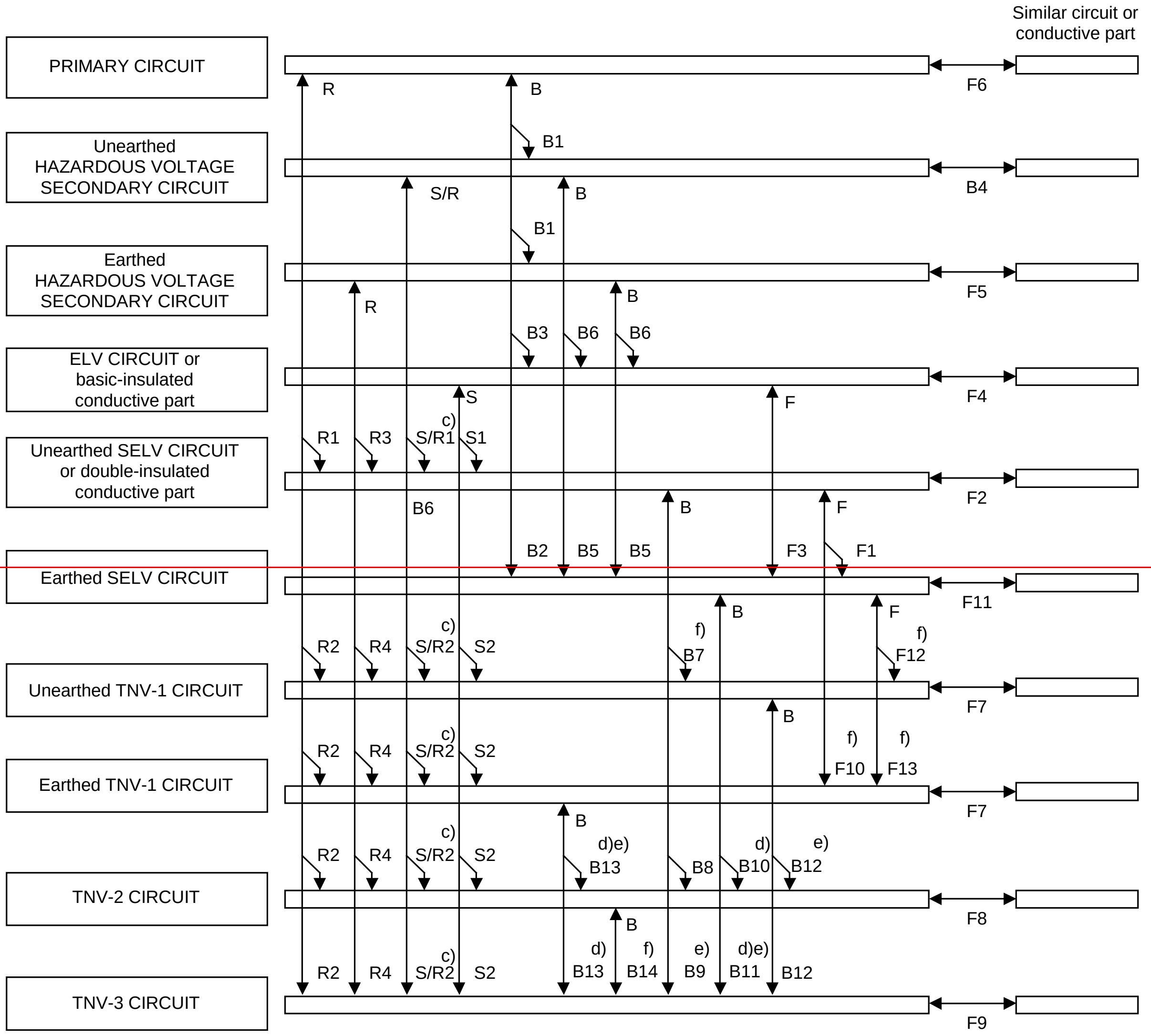
– there is only BASIC INSULATION between the SECONDARY CIRCUIT and the PRIMARY CIRCUIT; and

– there is only BASIC INSULATION between the SECONDARY CIRCUIT and earth.

[d] BASIC INSULATION is not always required (see 2.3.2.1 and 2.10.5.13).

[e] The requirements of 2.10 apply, see also 6.2.1.

[f] The requirements of 2.10 do not apply, however see 6.2.1.



F: FUNCTIONAL INSULATION
S: SUPPLEMENTARY INSULATION
R: REINFORCED INSULATION

B: BASIC INSULATION
S/R: see Footnote c in Table 2H

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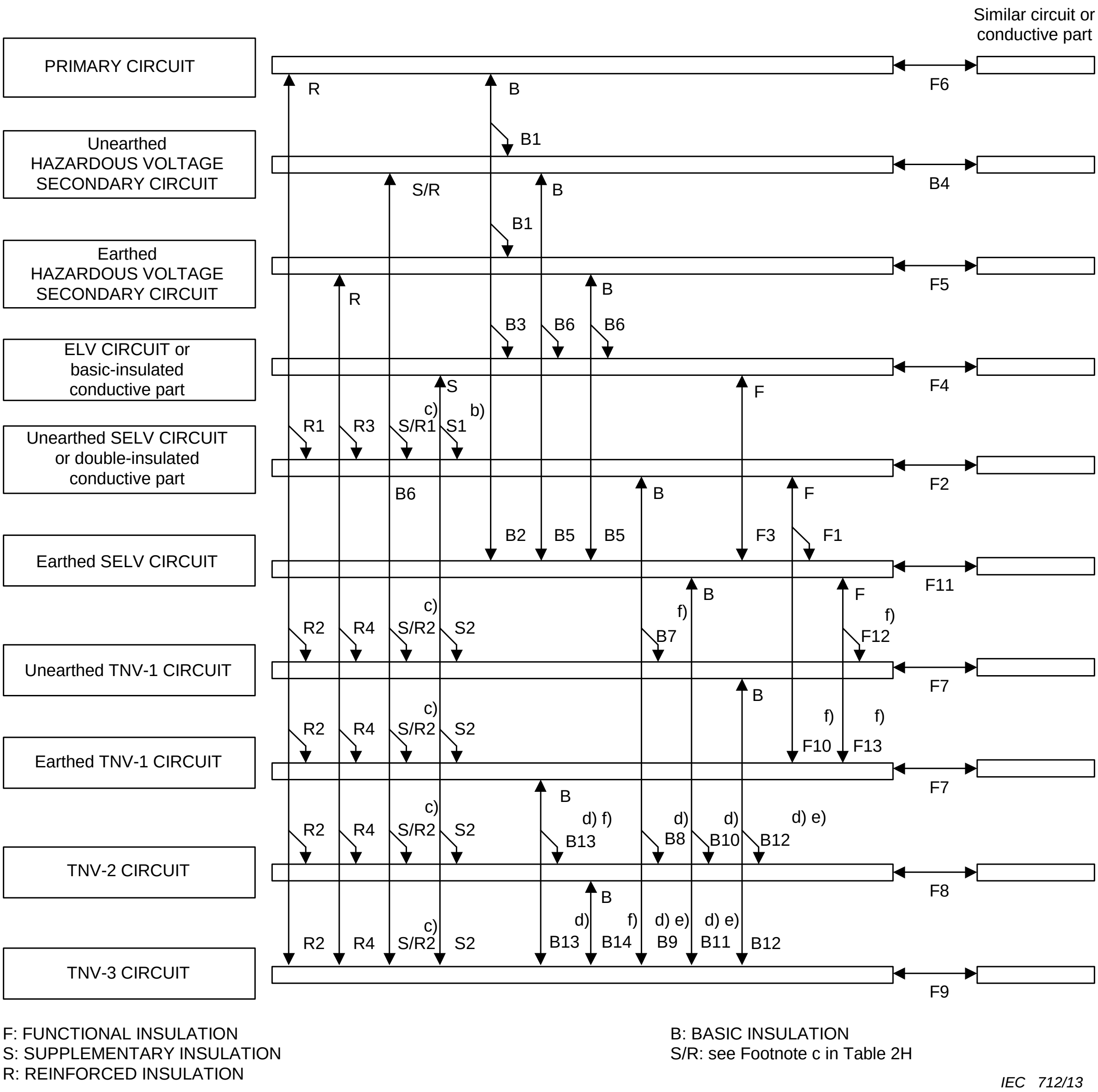

NOTE The references b), c), d), e) and f) refer to the corresponding footnotes in Table 2H.

Figure 2H – Examples of application of insulation

2.9.4 Separation from hazardous voltages

Where accessible conductive parts, including SELV CIRCUITS, TNV CIRCUITS and their related windings, are separated from parts at HAZARDOUS VOLTAGE, the following constructions are permitted. The insulation, including each element of DOUBLE INSULATION, shall be rated for the WORKING VOLTAGE, or if applicable the REQUIRED WITHSTAND VOLTAGE, between the parts. The different methods of separation fall into three groups, methods 1, 2 and 3.

a) (Method 1) DOUBLE INSULATION or REINFORCED INSULATION providing permanent separation, assured by barriers, routing or fixing; or

b) (Method 1) DOUBLE INSULATION or REINFORCED INSULATION on or between the parts to be separated; or

c) (Method 1) DOUBLE INSULATION, consisting of BASIC INSULATION on one of the parts to be separated and SUPPLEMENTARY INSULATION on the other part; or

d) (Method 2) BASIC INSULATION on the part at a HAZARDOUS VOLTAGE, together with protective screening connected to the main protective earthing terminal in accordance with 2.6.1 b); or

e) (Method 3) BASIC INSULATION on the part at a HAZARDOUS VOLTAGE, together with connection of the other part to the main protective earthing terminal in accordance with 2.6.1 b), such that the voltage limits for the accessible part are maintained by relative circuit impedances or by the operation of a protective device; or

f) any other construction providing equivalent separation.

NOTE 1 For examples of other constructions providing equivalent separation, see Table 2H and Figure 2H.

For e), it is permitted to protect a circuit by earthing a part other than the protected circuit itself, for example, the secondary winding of a transformer supplying the protected circuit.

NOTE 2 The consequences of the circuit possibly being earthed at a second point, for example, by connection to other equipment, should be considered.

Compliance is checked by inspection.

2.10 Clearances, creepage distances and distances through insulation

2.10.1 General

In general, compliance with 2.10.1 is checked by inspection and, when necessary, by measurement.

2.10.1.1 Frequency

The insulation requirements given in 2.10 are for 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.

NOTE For information on insulation behaviour in relation to frequency see IEC 60664-1 and IEC 60664-4.

2.10.1.2 Pollution degrees

Pollution degrees are classified as follows:

– Pollution Degree 1 applies where there is no pollution or only dry, non-conductive pollution. The pollution has no influence. Normally, this is achieved by having components and subassemblies adequately enclosed by enveloping or hermetic sealing so as to exclude dust and moisture (see 2.10.12).

– Pollution Degree 2 applies where there is only non-conductive pollution that might temporarily become conductive due to occasional condensation. It is generally appropriate for equipment covered by the scope of this standard.

– Pollution Degree 3 applies where a local environment within the equipment is subject to conductive pollution, or to dry non-conductive pollution that could become conductive due to expected condensation.

2.10.1.3 Reduced values for functional insulation

There is no minimum CLEARANCE or CREEPAGE DISTANCE for FUNCTIONAL INSULATION unless it is required by 5.3.4 a).

NOTE If CLEARANCES and CREEPAGE DISTANCES for FUNCTIONAL INSULATION are smaller than those specified in 2.10.3, 2.10.4 and Annex G, they are subject to the requirements of 5.3.4 b) or 5.3.4 c).

2.10.1.4 Intervening unconnected conductive parts

It is permitted for CLEARANCES and CREEPAGE DISTANCES to be divided by intervening, unconnected (floating) conductive parts, such as unused contacts of a connector, provided that the sum of the individual distances meets the specified minimum requirements, see Table F.1 and Figure F.13.

2.10.1.5 Insulation with varying dimensions

If the insulation of a transformer has different WORKING VOLTAGES along the length of the winding, it is permitted to vary CLEARANCES, CREEPAGE DISTANCES and distances through insulation accordingly.

NOTE An example of such a construction is a 30 kV winding, consisting of multiple bobbins connected in series, and earthed at one end.

2.10.1.6 Special separation requirements

The requirements of 2.10 and Annex G do not apply to separation provided to comply with 2.3.2 unless BASIC INSULATION is used, nor to separation provided to comply with 6.1.2 or 6.2.1.

NOTE See also Footnote f of Table 2H.

2.10.1.7 Insulation in circuits generating starting pulses

For a circuit generating starting pulses to ignite a discharge lamp, and if the circuit is a LIMITED CURRENT CIRCUIT complying with 2.4, the requirements for FUNCTIONAL INSULATION apply between the circuit and other conductive parts (see 5.3.4).

If the circuit is not a LIMITED CURRENT CIRCUIT, the requirements for BASIC INSULATION, SUPPLEMENTARY INSULATION and REINFORCED INSULATION apply to CREEPAGE DISTANCES and distances through insulation. For CLEARANCES, see 2.10.3.5.

NOTE For WORKING VOLTAGES in the above cases, see 2.10.2.1 i).

2.10.2 Determination of working voltage

In general, compliance with 2.10.2 is checked by inspection and, when necessary, by measurement.

2.10.2.1 General

In determining WORKING VOLTAGES, all of the following requirements apply (see also 1.4.8).

a) Unearthed accessible conductive parts shall be assumed to be earthed.

b) If a transformer winding or other part is floating (it is not connected to a circuit that establishes its potential relative to earth), it shall be assumed to be earthed at the point by which the highest WORKING VOLTAGE is obtained.

c) Except as permitted in 2.10.1.5, 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 will be connected.

d) Except as permitted in 2.10.1.5, 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.

e) 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 DOUBLE 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.

f) When the WORKING VOLTAGE is determined by measurement, the input power supplied to the EUT shall be at the RATED VOLTAGE or the voltage within the RATED VOLTAGE RANGE that results in the highest measured value.

NOTE Tolerances on the RATED VOLTAGE or RATED VOLTAGE RANGE are not taken into account.

g) The WORKING VOLTAGE between any point in the PRIMARY CIRCUIT and earth, and between any point in the PRIMARY CIRCUIT and a SECONDARY CIRCUIT, shall be assumed to be the greater of the following:

   – the RATED VOLTAGE or the upper voltage of the RATED VOLTAGE RANGE; and

   – the measured voltage.

h) When determining the WORKING VOLTAGE for a TNV CIRCUIT connected to a TELECOMMUNICATION NETWORK, the normal operating voltages shall be taken into account. If these are not known, they shall be assumed to be the following values:

   – 60 V d.c. for TNV-1 CIRCUITS;

   – 120 V d.c. for TNV-2 CIRCUITS and TNV-3 CIRCUITS.

   Telephone ringing signals shall not be taken into account for this purpose.

i) If starting pulses are used to ignite discharge lamps, the PEAK WORKING VOLTAGE is the peak value of the pulses with the lamp connected but before the lamp ignites. The RMS WORKING VOLTAGE to determine minimum CREEPAGE DISTANCES is the voltage measured after the ignition of the lamp.

2.10.2.2 RMS working voltage

Minimum CREEPAGE DISTANCES depend on RMS WORKING VOLTAGES.

When determining an RMS WORKING VOLTAGE, the following rules shall be used:

– the measured r.m.s. value shall be used for all waveforms;

– short-term conditions (for example, cadenced telephone ringing signals in TNV CIRCUITS) shall not be taken into account;

– non-repetitive transients (due, for example, to atmospheric disturbances) shall not be taken into account.

NOTE The resultant r.m.s. value of a waveform having an a.c. r.m.s. voltage "A" and a d.c. offset voltage "B" is given by the following formula:

$$\text{r.m.s. value} = (A^2 + B^2)^{1/2}$$

2.10.2.3 Peak working voltage

Minimum CLEARANCES and electric strength test voltages depend on PEAK WORKING VOLTAGES.

When determining a PEAK WORKING VOLTAGE, the following rules shall be used:

– the measured peak value shall be used for all waveforms; the peak value of any ripple (up to 10 %) on a DC VOLTAGE, shall be included;

– non-repetitive transients (due, for example, to atmospheric disturbances) shall not be taken into account;

– when determining the PEAK WORKING VOLTAGE between PRIMARY CIRCUITS and SECONDARY CIRCUITS, the voltage of any ELV CIRCUIT, SELV CIRCUIT or TNV CIRCUIT (including telephone ringing signals) shall be regarded as zero.

2.10.3 Clearances

2.10.3.1 General

CLEARANCES shall be so dimensioned that overvoltages, including transients that may enter the equipment, and peak voltages that may be generated within the equipment, do not break down the CLEARANCE.

It is permitted to use either the requirements of 2.10.3 for Overvoltage Category I or Overvoltage Category II, using the PEAK WORKING VOLTAGE; or the requirements in Annex G for Overvoltage Category I, Overvoltage Category II, Overvoltage Category III or Overvoltage Category IV, using the REQUIRED WITHSTAND VOLTAGE, for a particular component or subassembly or for the whole equipment.

These requirements apply for equipment to be operated up to 2 000 m above sea level. For equipment to be operated at more than 2 000 m above sea level, the minimum CLEARANCES shall be multiplied by the factor given in Table A.2 of IEC 60664-1. Linear interpolation is permitted between the nearest two points in Table A.2. The calculated minimum CLEARANCE using this multiplication factor shall be rounded up to the next higher 0,1 mm increment.

NOTE 1 It is considered to be good practice to design SOLID INSULATION for higher transient overvoltages than the associated CLEARANCE.

NOTE 2 China has special requirements in choosing multiplication factors at altitudes above 2 000 m.

The specified minimum CLEARANCES are subject to the following minimum values:

– 10 mm for an air gap serving as REINFORCED INSULATION between a part at 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;
– 2 mm for an air gap serving as BASIC INSULATION between a part at HAZARDOUS VOLTAGE and an earthed accessible conductive part of the ENCLOSURE of PLUGGABLE EQUIPMENT TYPE A.

NOTE ~~2~~ 3 The above two minimum CLEARANCES do not apply between a part at a HAZARDOUS VOLTAGE and the BOUNDING SURFACE of a non-conductive ENCLOSURE.

Except as required by 2.8.7.1 the specified minimum CLEARANCES do not apply to the air gap between the contacts of THERMOSTATS, THERMAL CUT-OUTS, overload protection devices, switches of microgap construction, and similar components where the air gap varies with the contacts.

NOTE ~~3~~ 4 For air gaps between contacts of interlock switches, see 2.8.7.1. For air gaps between contacts of disconnect switches, see 3.4.2.

The CLEARANCES between the BOUNDING SURFACE of a connector and conductive parts within the connector that are connected to a HAZARDOUS VOLTAGE shall comply with the requirements for REINFORCED INSULATION. As an exception, for connectors that are

– fixed to the equipment; and
– located internal to the outer ENCLOSURE of the equipment; and are
– only accessible after removal of a USER-replaceable subassembly that is required to be in place during normal operation,

these CLEARANCES shall comply with the requirements for BASIC INSULATION.

NOTE ~~4~~ 5 The tests of 2.1.1.1 for access to hazardous parts apply to such connectors after removal of the subassembly.

For all other CLEARANCES in connectors, including connectors that are not fixed to the equipment, the minimum values specified in 2.10.3.3 or 2.10.3.4 apply.

The above minimum CLEARANCES for connectors do not apply to connectors that comply with a standard harmonized with IEC 60083, IEC 60309, IEC 60320, IEC 60906-1 or IEC 60906-2, see also 1.5.2.

Compliance with 2.10.3.3 and 2.10.3.4 is checked by measurement, taking into account Annex F. The following conditions apply:

- *movable parts shall be placed in the most unfavourable position;*
- *for equipment incorporating ordinary NON-DETACHABLE POWER SUPPLY CORDS, CLEARANCE measurements are made with supply conductors of the largest cross-sectional area specified in 3.3.4, and also without conductors.*

NOTE ~~5~~ 6 The force tests of 4.2.2, 4.2.3 and 4.2.4 apply.

- *when measuring CLEARANCES from the BOUNDING SURFACE of an ENCLOSURE of insulating material through a slot or opening in the ENCLOSURE or through an opening in an accessible connector, 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 shown in Figure 2A (see 2.1.1.1), applied without appreciable force (see Figure F.12, point X).*

There is no electric strength test to verify CLEARANCES except as required in Footnote c in Table 2M and in 5.3.4 b).

2.10.3.2 Mains transient voltages

a) AC MAINS SUPPLY

For equipment to be supplied from an AC MAINS SUPPLY, the value of the MAINS TRANSIENT VOLTAGE depends on the Overvoltage Category and the AC MAINS SUPPLY voltage. In general, CLEARANCES in equipment intended to be connected to the AC MAINS SUPPLY shall be designed for Overvoltage Category II.

NOTE 1 See Annex Z for further guidance on the determination of Overvoltage Category.

Equipment that is likely, when installed, to be subjected to transient overvoltages that exceed those for its design Overvoltage Category will require additional protection to be provided external to the equipment. In this case, the installation instructions shall state the need for such external protection.

The applicable value of the MAINS TRANSIENT VOLTAGE shall be determined from the Overvoltage Category and the AC MAINS SUPPLY voltage, using Table 2J.

Table 2J – AC mains transient voltages

AC MAINS SUPPLY voltage [a] up to and including	MAINS TRANSIENT VOLTAGE [b] V peak	
	Overvoltage Category	
V r.m.s.	I	II
50	330	500
100	500	800
150 [c]	800	1 500
300 [d]	1 500	2 500
600 [e]	2 500	4 000

[a] For equipment designed to be connected to a three-phase, three-wire supply, where there is no neutral conductor, the AC MAINS SUPPLY voltage is the line-to-line voltage. In all other cases, where there is a neutral conductor, it is the line-to-neutral voltage.

[b] The MAINS TRANSIENT VOLTAGE is always one of the values in the table. Interpolation is not permitted.

[c] Including 120/208 V and 120/240 V.

[d] Including 230/400 V and 277/480 V.

[e] Including 400/690 V.

NOTE 2 For Japan, the value of the MAINS TRANSIENT VOLTAGES for the nominal AC MAINS SUPPLY voltage of 100 V is determined from the row applicable to an AC MAINS SUPPLY voltage of 150 V.

b) Earthed DC MAINS SUPPLIES

If a DC MAINS SUPPLY is connected to protective earth and is entirely within a single building, the MAINS TRANSIENT VOLTAGE shall be assumed to be 71 V peak. If this connection is within the EUT, it shall be in accordance with 2.6.1 d).

NOTE 3 The connection to protective earth can be at the source of the DC MAINS SUPPLY or at the equipment location, or both (see ITU-T Recommendation K.27).

c) Unearthed DC MAINS SUPPLIES

If a DC MAINS SUPPLY is not earthed and located as in b) above, the MAINS TRANSIENT VOLTAGE shall be assumed to be equal to the MAINS TRANSIENT VOLTAGE in the AC MAINS SUPPLY from which the DC MAINS SUPPLY is derived.

d) Battery operation

If equipment is supplied from a dedicated battery that has no provision for charging from an external MAINS SUPPLY, the MAINS TRANSIENT VOLTAGE shall be assumed to be 71 V peak.

2.10.3.3 Clearances in primary circuits

For insulation in PRIMARY CIRCUITS, between PRIMARY CIRCUITS and earth and between PRIMARY CIRCUITS and SECONDARY CIRCUITS, the following rules apply.

For an AC MAINS SUPPLY not exceeding 300 V r.m.s. (420 V peak):

a) if the PEAK WORKING VOLTAGE does not exceed the peak value of the AC MAINS SUPPLY voltage, minimum CLEARANCES are determined from Table 2K;

b) if the PEAK WORKING VOLTAGE exceeds the peak value of the AC MAINS SUPPLY voltage, the minimum CLEARANCE is the sum of the following two values:

- the minimum CLEARANCE from Table 2K; and
- the appropriate additional CLEARANCE from Table 2L.

NOTE A minimum CLEARANCE obtained by the use of Table 2L lies between the values required for homogeneous and inhomogeneous fields. As a result, it may not pass the appropriate electric strength test if the field is substantially inhomogeneous.

For an AC MAINS SUPPLY exceeding 300 V r.m.s. (420 V peak), minimum CLEARANCES are determined from Table 2K.

Table 2K – Minimum clearances for insulation in primary circuits and between primary and secondary circuits

CLEARANCES in mm

PEAK WORKING VOLTAGE ~~a~~ up to and including V	MAINS TRANSIENT VOLTAGE														
	1 500 V [c]						2 500 V [c]						4 000 V [c]		
	Pollution degree														
	1 and 2 [b]			3			1 and 2 [b]			3			1, 2 [b] and 3		
	F	**B/S**	**R**	**F**	**B/S**	**R**	**F**	**B/S**	**R**	**F**	**B/S**	**R**	**F**	**B/S**	**R**
71 [a]	0,4	1,0 (0,5)	2,0 (1,0)	0,8	1,3 (0,8)	2,6 (1,6)	1,0	2,0 (1,5)	4,0 (3,0)	1,3	2,0 (1,5)	4,0 (3,0)	2,0	3,2 (3,0)	6,4 (6,0)
210 [a]	0,5	1,0 (0,5)	2,0 (1,0)	0,8	1,3 (0,8)	2,6 (1,6)	1,4	2,0 (1,5)	4,0 (3,0)	1,5	2,0 (1,5)	4,0 (3,0)	2,0	3,2 (3,0)	6,4 (6,0)
420 [a]	F 1,5 B/S 2,0 (1,5) R 4,0 (3,0)												2,5	3,2 (3,0)	6,4 (6,0)
840	F 3,0 B/S 3,2 (3,0) R 6,4 (6,0)														
1 400	F/B/S 4,2 R 6,4														
2 800	F/B/S/R 8,4														
7 000	F/B/S/R 17,5														
9 800	F/B/S/R 25														
14 000	F/B/S/R 37														
28 000	F/B/S/R 80														
42 000	F/B/S/R 130														

The values in the table are applicable to FUNCTIONAL INSULATION (F) if required by 5.3.4 a) (see 2.10.1.3), BASIC INSULATION (B), SUPPLEMENTARY INSULATION (S) and REINFORCED INSULATION (R).

The values in parentheses apply to BASIC INSULATION, SUPPLEMENTARY INSULATION or REINFORCED INSULATION only if manufacturing is subjected to a quality control programme that provides at least the same level of assurance as the example given in Clause R.2. DOUBLE INSULATION and REINFORCED INSULATION shall be subjected to ROUTINE TESTS for electric strength.

If the PEAK WORKING VOLTAGE exceeds the peak value of the AC MAINS SUPPLY voltage, linear interpolation is permitted between the nearest two points, the calculated minimum CLEARANCE being rounded up to the next higher 0,1 mm increment.

[a] If the PEAK WORKING VOLTAGE exceeds the peak value of the AC MAINS SUPPLY voltage, ~~see~~ use the peak value of the AC MAINS SUPPLY voltage in this column and use Table 2L in accordance with 2.10.3.3 b) regarding additional CLEARANCES

[b] It is not required to pass the tests of 2.10.10 for Pollution Degree 1.

[c] The relationship between MAINS TRANSIENT VOLTAGE and AC MAINS SUPPLY voltage is given in Table 2J.

Table 2L – Additional clearances in primary circuits

CLEARANCES in mm

MAINS TRANSIENT VOLTAGE						
1 500 V [c]				2 500 V [c]		
Pollution Degrees 1 and 2 [b]	Pollution Degree 3	FUNCTIONAL [a] BASIC or SUPPLEMENTARY INSULATION	REINFORCED INSULATION	Pollution Degrees 1, 2 and 3 [b]	FUNCTIONAL [a] BASIC or SUPPLEMENTARY INSULATION	REINFORCED INSULATION
PEAK WORKING VOLTAGE up to and including V				PEAK WORKING VOLTAGE up to and including V		
210 (210)	210 (210)	0,0	0,0	420 (420)	0,0	0,0
298 (288)	294 (293)	0,1	0,2	493 (497)	0,1	0,2
386 (366)	379 (376)	0,2	0,4	567 (575)	0,2	0,4
474 (444)	463 (459)	0,3	0,6	640 (652)	0,3	0,6
562 (522)	547 (541)	0,4	0,8	713 (729)	0,4	0,8
650 (600)	632 (624)	0,5	1,0	787 (807)	0,5	1,0
738 (678)	715 (707)	0,6	1,2	860 (884)	0,6	1,2
826 (756)	800 (790)	0,7	1,4	933 (961)	0,7	1,4
914 (839)	885 (873)	0,8	1,6	1 006 (1 039)	0,8	1,6
1 002 (912)	970 (956)	0,9	1,8	1 080 (1 116)	0,9	1,8
1 090 (990)	1055 (1039)	1,0	2,0	1 153 (1 193)	1,0	2,0
1 178 (1068)	1140 (1 122)	1,1	2,2	1 226 (1 271)	1,1	2,2
1 266 (1146)	1225 (1 205)	1,2	2,4	1 300 (1 348)	1,2	2,4
1 354 (1 224)	1310 (1288)	1,3	2,6	1 374 (1 425)	1,3	2,6

The additional CLEARANCES in the table apply if required by 2.10.3.3 b).

The values in parentheses shall be used:

- if the values in parentheses in Table 2K are used; and
- for FUNCTIONAL INSULATION if required by 5.3.4 a).

For voltage values above the PEAK WORKING VOLTAGE values given in the table, linear extrapolation is permitted.

For voltage values within the PEAK WORKING VOLTAGE values given in the table, linear interpolation is permitted between the nearest two points, the calculated minimum additional CLEARANCE being rounded up to the next higher 0,1 mm increment.

[a] There is no minimum CLEARANCE for FUNCTIONAL INSULATION unless it is required by 5.3.4 a). See 2.10.1.3.

[b] It is not required to pass the tests of 2.10.10 for Pollution Degree 1.

[c] The relationship between MAINS TRANSIENT VOLTAGE and AC MAINS SUPPLY voltage is given in Table 2J.

2.10.3.4 Clearances in secondary circuits

Minimum CLEARANCES in SECONDARY CIRCUITS are determined from Table 2M.

The PEAK WORKING VOLTAGE for use in Table 2M is:

– the peak value of a sinusoidal voltage;

– the measured peak value of a non-sinusoidal voltage.

The highest transient overvoltage for use in Table 2M is either

– the highest transient from the MAINS SUPPLY, determined in accordance with 2.10.3.6 or 2.10.3.7; or

– the highest transient from a TELECOMMUNICATION NETWORK, determined in accordance with 2.10.3.8,

whichever is the higher value.

Table 2M – Minimum clearances in secondary circuits

CLEARANCES in mm

PEAK WORKING VOLTAGE up to and including	Highest transient overvoltage in the SECONDARY CIRCUIT (V peak)														
	Up to and including 71 V			Over 71 V up to and including 800 V			Up to and including 800 V			Over 800 V up to and including 1 500 V						Over 1 500 V up to and including 2 500 V [a]		
	Pollution Degree														
	1 and 2 [b]						3			1 and 2 [b]			3			1, 2 [b] and 3		
V	F	B/S	R	F	B/S	R	F	B/S	R	F	B/S	R	F	B/S	R	F	B/S	R
71	0,2	0,4 (0,2)	0,8 (0,4)	0,2	0,7 (0,2)	1,4 (0,4)	0,8	1,3 (0,8)	2,6 (1,6)	0,5	1,0 (0,5)	2,0 (1,0)	0,8	1,3 (0,8)	2,6 (1,6)	1,5	2,0 (1,5)	4,0 (3,0)
140	0,2	0,7 (0,2)	1,4 (0,4)	0,2	0,7 (0,2)	1,4 (0,4)	0,8	1,3 (0,8)	2,6 (1,6)	0,5	1,0 (0,5)	2,0 (1,0)	0,8	1,3 (0,8)	2,6 (1,6)	1,5	2,0 (1,5)	4,0 (3,0)
210	0,2	0,7 (0,2)	1,4 (0,4)	0,2	0,9 (0,2)	1,8 (0,4)	0,8	1,3 (0,8)	2,6 (1,6)	0,5	1,0 (0,5)	2,0 (1,0)	0,8	1,3 (0,8)	2,6 (1,6)	1,5	2,0 (1,5)	4,0 (3,0)
280	0,2	1,1 (0,2)	2,2 (0,4)	F 0,8 B/S 1,4 (0,8) R 2,8 (1,6)												1,5	2,0 (1,5)	4,0 (3,0)
420	0,2	1,4 (0,2)	2,8 (0,4)	F 1,0 B/S 1,9 (1,0) R 3,8 (2,0)												1,5	2,0 (1,5)	4,0 (3,0)
700	F/B/S 2,5 R 5,0																	
840	F/B/S 3,2 R 5,0																	
1 400	F/B/S 4,2 R 5,0																	
2 800	F/B/S/R 8,4 See [c]																	
7 000	F/B/S/R ~~7,5~~ 17,5 See [c]																	
9 800	F/B/S/R 25 See [c]																	
14 000	F/B/S/R 37 See [c]																	
28 000	F/B/S/R 80 See [c]																	
42 000	F/B/S/R 130 See [c]																	

The values in the table apply to FUNCTIONAL INSULATION (F) if required by 5.3.4 a) (see 2.10.1.3), BASIC INSULATION (B), SUPPLEMENTARY INSULATION (S) and REINFORCED INSULATION (R).

Linear interpolation is permitted between the nearest two points, the calculated minimum CLEARANCE being rounded up to the next higher 0,1 mm increment.

If the CLEARANCE path is partly along the surface of insulation that is not Material Group I, the test voltage is applied across the air gap and Material Group I only. The part of the path along the surface of any other insulating material is bypassed.

The values in parentheses apply to BASIC INSULATION, SUPPLEMENTARY INSULATION or REINFORCED INSULATION if manufacturing is subjected to a quality control programme that provides at least the same level of assurance as the example given in Clause R.2 of Annex R. DOUBLE INSULATION and REINFORCED INSULATION shall be subjected to ROUTINE TESTS for electric strength.

[a] For transient overvoltages higher than 2 500 V peak, either Table 2K shall be used or the minimum CLEARANCE shall be determined using Annex G.

[b] It is not required to pass the tests of 2.10.10 for Pollution Degree 1.

[c] In a SECONDARY CIRCUIT, for PEAK WORKING VOLTAGES above 1 400 V, the minimum CLEARANCE is 5 mm provided that the CLEARANCE path passes an electric strength test according to 5.2.2 using:

- an a.c. test voltage whose r.m.s. value is 106 % of the PEAK WORKING VOLTAGE (peak value is 150 % of the PEAK WORKING VOLTAGE), or
- a d.c. test voltage equal to 150 % of the PEAK WORKING VOLTAGE.

2.10.3.5 Clearances in circuits having starting pulses

For a circuit generating starting pulses to ignite a discharge lamp, and if the circuit is not a LIMITED CURRENT CIRCUIT complying with 2.4 (see 2.10.1.7), the adequacy of CLEARANCES is determined by one of the following methods:

a) Determine the minimum CLEARANCE *in accordance with Annex G; or*

b) Conduct electric strength tests, using one of the following procedures. During the tests, the lamp terminals are shorted together.

- *Test in accordance with 5.2.2, using an a.c. peak or d.c. test voltage equal to 150 % of the* PEAK WORKING VOLTAGE*; or*
- *Apply 30 pulses having amplitude equal to 150 % the* PEAK WORKING VOLTAGE *from an external pulse generator. The pulse width shall be equal to or greater than that of the internally generated starting pulse.*

NOTE For WORKING VOLTAGES see 2.10.2.1 i).

2.10.3.6 Transients from an a.c. mains supply

Except as permitted below, the highest transient in a SECONDARY CIRCUIT due to transients on the AC MAINS SUPPLY is the value measured in accordance with 2.10.3.9 a).

Alternatively, for certain SECONDARY CIRCUITS it is permitted to assume that the highest transient is either of the following:

- the value measured in accordance with 2.10.3.9 a); or
- one step lower in the following list than the MAINS TRANSIENT VOLTAGE from Table 2J in the PRIMARY CIRCUIT:

330, 500, 800, 1 500, 2 500 and 4 000 V peak.

This is permitted in the following cases:

- a SECONDARY CIRCUIT, derived from an AC MAINS SUPPLY, that is connected to the main protective earthing terminal in accordance with 2.6.1;
- a SECONDARY CIRCUIT, derived from an AC MAINS SUPPLY and separated from the PRIMARY CIRCUIT by a metal screen that is connected to the main protective earthing terminal in accordance with 2.6.1.

2.10.3.7 Transients from a d.c. mains supply

NOTE 1 A circuit connected to a DC MAINS SUPPLY is considered to be a SECONDARY CIRCUIT(see 1.2.8.2).

The highest transient in a SECONDARY CIRCUIT due to transients on a DC MAINS SUPPLY is

- the MAINS TRANSIENT VOLTAGE, if the SECONDARY CIRCUIT is directly connected to the DC MAINS SUPPLY; or
- the value measured in accordance with 2.10.3.9 a) in other cases except as given in 2.10.3.2 b) and 2.10.3.2 c).

NOTE 2 Both of the above options depend on the value of the MAINS TRANSIENT VOLTAGE. In some cases, this value is assumed to be 71 V peak [see 2.10.3.2 b) or d)]. The appropriate column of Table 2K is used and no measurement is necessary.

2.10.3.8 Transients from telecommunication networks and cable distribution systems

If the TELECOMMUNICATION NETWORK TRANSIENT VOLTAGE is known for the TELECOMMUNICATION NETWORK in question, it is permitted to use the known value in 2.10.3.4.

If the TELECOMMUNICATION NETWORK TRANSIENT VOLTAGE is not known, the following value shall be used:

- 1 500 V peak if the circuit connected to the TELECOMMUNICATION NETWORK is a TNV-1 CIRCUIT or a TNV-3 CIRCUIT; and
- 800 V peak if the circuit connected to the TELECOMMUNICATION NETWORK is an SELV CIRCUIT or a TNV-2 CIRCUIT.

If incoming transients are attenuated within the equipment, it is permitted to use the value measured in accordance with 2.10.3.9 b).

The effect of a telephone ringing signal is not taken into account.

The effect of transients from a CABLE DISTRIBUTION SYSTEM is not taken into account (however, see 7.4.1).

2.10.3.9 Measurement of transient voltages

The following tests are conducted only if it is required to determine whether or not the transient voltage across the CLEARANCE in any circuit is lower than normal (for example, due to the effect of a filter in the equipment). The transient voltage across the CLEARANCE is measured using the following test procedure.

During the tests, the equipment is connected to its separate power supply unit, if any, but is not connected to the MAINS SUPPLY or to any TELECOMMUNICATION NETWORKS, and any surge suppressors in PRIMARY CIRCUITS are disconnected.

A voltage-measuring device is connected across the CLEARANCE in question.

a) Transients from a MAINS SUPPLY

To measure a transient voltage across a CLEARANCE due to transients on a MAINS SUPPLY, the impulse test generator reference 2 of Table N.1 is used to generate 1,2/50 µs impulses. U_c is equal to the MAINS TRANSIENT VOLTAGE given in Table 2J.

Three to six impulses of alternating polarity, with intervals of at least 1 s between impulses, are applied between each of the following points where relevant:

For an AC MAINS SUPPLY

- *line-to-line;*
- *all line conductors joined together and neutral;*
- *all line conductors joined together and protective earth;*
- *neutral and protective earth.*

For a DC MAINS SUPPLY

- *the positive and negative supply connection points;*
- *all supply connection points joined together and protective earth.*

b) Transients from a TELECOMMUNICATION NETWORK

To measure the transient voltage across a CLEARANCE due to transients on a TELECOMMUNICATION NETWORK, the impulse test generator reference 1 of Table N.1 is used to generate 10/700 µs impulses. U_c is equal to the TELECOMMUNICATION NETWORK TRANSIENT VOLTAGE determined in 2.10.3.8.

Three to six impulses of alternating polarity, with intervals of at least 1 s between impulses, are applied between each of the following TELECOMMUNICATION NETWORK connection points of a single interface type:

- *each pair of terminals (for example, A and B or tip and ring) in an interface;*
- *all terminals of a single interface type joined together and earth.*

Where there are several identical circuits, only one is tested.

2.10.4 Creepage distances

2.10.4.1 General

CREEPAGE DISTANCES shall be so dimensioned that, for a given RMS WORKING VOLTAGE and pollution degree, no flashover or breakdown of insulation (for example, due to tracking) will occur.

2.10.4.2 Material group and comparative tracking index

Material groups depend on the comparative tracking index (CTI) and are classified as follows:

Material Group I		CTI ≥ 600
Material Group II	400 ≤	CTI < 600
Material Group IIIa	175 ≤	CTI < 400
Material Group IIIb	100 ≤	CTI < 175

The material group is verified by evaluation of the test data for the material according to IEC 60112 using 50 drops of solution A.

If the material group is not known, Material Group IIIb shall be assumed.

If a CTI of 175 or greater is needed, and the data is not available, the material group can be established with a test for proof tracking index (PTI) as detailed in IEC 60112. A material may be included in a group if its PTI established by these tests is equal to, or greater than, the lower value of the CTI specified for the group.

2.10.4.3 Minimum creepage distances

CREEPAGE DISTANCES shall be not less than the appropriate minimum values specified in Table 2N.

If the minimum CREEPAGE DISTANCE derived from Table 2N is less than the applicable minimum CLEARANCE, that value of minimum CLEARANCE shall be applied as the minimum CREEPAGE DISTANCE.

For glass, mica, glazed ceramic, or similar inorganic materials, if the minimum CREEPAGE DISTANCE is greater than the applicable minimum CLEARANCE, it is permitted to apply that value of minimum CLEARANCE as the minimum CREEPAGE DISTANCE.

The CREEPAGE DISTANCE between the BOUNDING SURFACE of a connector and conductive parts within the connector that are connected to a HAZARDOUS VOLTAGE shall comply with the requirements for REINFORCED INSULATION. As an exception, for connectors that are

– fixed to the equipment; and
– located internal to the outer ENCLOSURE of the equipment; and
– only accessible after removal of a USER-replaceable subassembly that is required to be in place during normal operation,

this CREEPAGE DISTANCE shall comply with the requirements for BASIC INSULATION.

NOTE The tests of 2.1.1.1 for access to hazardous parts apply to such connectors after removal of the subassembly.

For all other CREEPAGE DISTANCES in connectors, including connectors that are not fixed to the equipment, the minimum values specified in Table 2N apply.

The above minimum CREEPAGE DISTANCES for connectors do not apply to connectors that comply with a standard harmonized with IEC 60083, IEC 60309, IEC 60320, IEC 60906-1 or IEC 60906-2, see also 1.5.2.

Compliance is checked by measurement, taking into account Annex F. The following conditions apply:

- *movable parts are placed in their most unfavourable positions;*
- *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 3.3.4 for the terminal in question, and also without conductors; and*
- *when measuring* CREEPAGE DISTANCES *from the* BOUNDING SURFACE *of an* ENCLOSURE *of insulating material through a slot or opening in the* ENCLOSURE *or through an opening in an accessible connector, the accessible surface is considered to be conductive as if it were covered by metal foil wherever it can be touched by the test finger, Figure 2A (see 2.1.1.1), applied without appreciable force (see Figure F.12, point X).*

Table 2N – Minimum creepage distances

CREEPAGE DISTANCES in mm

RMS WORKING VOLTAGE up to and including V	Pollution degree								
	1[a]	2	1[a]	2			3		
	Material group								
	Printed boards		Other materials						
	I, II, IIIa, IIIb	I, II, IIIa	I, II, IIIa, IIIb	I	II	IIIa, IIIb	I	II	IIIa, IIIb (see Note)
10	0,025	0,04	0,08	0,4	0,4	0,4	1,0	1,0	1,0
12,5	0,025	0,04	0,09	0,42	0,42	0,42	1,05	1,05	1,05
16	0,025	0,04	0,1	0,45	0,45	0,45	1,1	1,1	1,1
20	0,025	0,04	0,11	0,48	0,48	0,48	1,2	1,2	1,2
25	0,025	0,04	0,125	0,5	0,5	0,5	1,25	1,25	1,25
32	0,025	0,04	0,14	0,53	0,53	0,53	1,3	1,3	1,3
40	0,025	0,04	0,16	0,56	0,8	1,1	1,4	1,6	1,8
50	0,025	0,04	0,18	0,6	0,85	1,2	1,5	1,7	1,9
63	0,04	0,063	0,2	0,63	0,9	1,25	1,6	1,8	2,0
80	0,063	0,10	0,22	0,67	0,9	1,3	1,7	1,9	2,1
100	0,1	0,16	0,25	0,71	1,0	1,4	1,8	2,0	2,2
125	0,16	0,25	0,28	0,75	1,05	1,5	1,9	2,1	2,4
160	0,25	0,40	0,32	0,8	1,1	1,6	2,0	2,2	2,5
200	0,4	0,63	0,42	1,0	1,4	2,0	2,5	2,8	3,2
250	0,56	1,0	0,56	1,25	1,8	2,5	3,2	3,6	4,0
320	0,75	1,6	0,75	1,6	2,2	3,2	4,0	4,5	5,0
400	1,0	2,0	1,0	2,0	2,8	4,0	5,0	5,6	6,3
500	1,3	2,5	1,3	2,5	3,6	5,0	6,3	7,1	8,0
630	1,8	3,2	1,8	3,2	4,5	6,3	8,0	9.0	10
800	2,4	4,0	2,4	4,0	5,6	8,0	10	11	12,5
1 000	3,2	5,0	3,2	5,0	7,1	10	12,5	14	16
1 250			4,2	6,3	9,0	12,5	16	18	20
1 600			5,6	8,0	11	16	20	22	25
2 000			7,5	10	14	20	25	28	32
2 500			10	12,5	18	25	32	36	40
3 200			12,5	16	22	32	40	45	50
4 000			16	20	28	40	50	56	63
5 000			20	25	36	50	63	71	80
6 300			25	32	45	63	80	90	100
8 000			32	40	56	80	100	110	125
10 000			40	50	71	100	125	140	160
12 500			50	63	90	125			
16 000			63	80	110	160			
20 000			80	100	140	200			
25 000			100	125	180	250			
32 000			125	160	220	320			
40 000			160	200	280	400			
50 000			200	250	360	500			
63 000			250	320	450	600			

The values in the table apply to FUNCTIONAL INSULATION if required by 5.3.4 a) (see 2.10.1.3), BASIC INSULATION and SUPPLEMENTARY INSULATION. For REINFORCED INSULATION the values are twice those in the table.

Linear interpolation is permitted between the nearest two points, the calculated minimum CREEPAGE DISTANCE being rounded to the next higher 0,1 mm increment. For REINFORCED INSULATION, the calculated value for BASIC INSULATION shall be doubled first before applying the rounding off.

NOTE Material Group IIIb is not recommended for applications in Pollution Degree 3 with an RMS WORKING VOLTAGE above 630 V.

[a] It is permitted to use the values for Pollution Degree 1 if one sample passes the tests of 2.10.10.

RMS WORKING VOLTAGE up to and including V	Pollution degree						
	1[a]	2			3		
	Material Group						
	I, II, IIIa, IIIb	I	II	IIIa, IIIb	I	II	IIIa, IIIb (see Note)
10	0,08	0,4	0,4	0,4	1,0	1,0	1,0
12,5	0,09	0,42	0,42	0,42	1,05	1,05	1,05
16	0,1	0,45	0,45	0,45	1,1	1,1	1,1
20	0,11	0,48	0,48	0,48	1,2	1,2	1,2
25	0,125	0,5	0,5	0,5	1,25	1,25	1,25
32	0,14	0,53	0,53	0,53	1,3	1,3	1,3
40	0,16	0,56	0,8	1,1	1,4	1,6	1,8
50	0,18	0,6	0,85	1,2	1,5	1,7	1,9
63	0,2	0,63	0,9	1,25	1,6	1,8	2,0
80	0,22	0,67	0,9	1,3	1,7	1,9	2,1
100	0,25	0,71	1,0	1,4	1,8	2,0	2,2
125	0,28	0,75	1,05	1,5	1,9	2,1	2,4
160	0,32	0,8	1,1	1,6	2,0	2,2	2,5
200	0,42	1,0	1,4	2,0	2,5	2,8	3,2
250	0,56	1,25	1,8	2,5	3,2	3,6	4,0
320	0,75	1,6	2,2	3,2	4,0	4,5	5,0
400	1,0	2,0	2,8	4,0	5,0	5,6	6,3
500	1,3	2,5	3,6	5,0	6,3	7,1	8,0
630	1,8	3,2	4,5	6,3	8,0	9,0	10
800	2,4	4,0	5,6	8,0	10	11	12,5
1 000	3,2	5,0	7,1	10	12,5	14	16
1 250	4,2	6,3	9,0	12,5	16	18	20
1 600	5,6	8,0	11	16	20	22	25
2 000	7,5	10	14	20	25	28	32
2 500	10	12,5	18	25	32	36	40
3 200	12,5	16	22	32	40	45	50
4 000	16	20	28	40	50	56	63
5 000	20	25	36	50	63	71	80
6 300	25	32	45	63	80	90	100
8 000	32	40	56	80	100	110	125
10 000	40	50	71	100	125	140	160
12 500	50	63	90	125			
16 000	63	80	110	160			
20 000	80	100	140	200			
25 000	100	125	180	250			
32 000	125	160	220	320			
40 000	160	200	280	400			
50 000	200	250	360	500			
63 000	250	320	450	600			

he values in the table apply to FUNCTIONAL INSULATION if required by 5.3.4 (a) (see 2.10.1.3), BASIC INSULATION and SUPPLEMENTARY INSULATION. For REINFORCED INSULATION the values are twice those in the table.

near interpolation may be used between the nearest two points, the calculated minimum CREEPAGE DISTANCE being rounded up to the next higher specified increment, or the value in the next row below, whichever is lower. For values:

not exceeding 0,5 mm, the specified increment is 0,01 mm; and

for those exceeding 0,5 mm, the specified increment is 0,1 mm.

or REINFORCED INSULATION, the calculated value for BASIC INSULATION shall be doubled first before applying the rounding off.

NOTE Material Group IIIb is not recommended for applications in Pollution Degree 3 with an RMS WORKING VOLTAGE above 630 V.

[a] It is permitted to use the values for Pollution Degree 1 if one sample passes the tests of 2.10.10.

2.10.5 Solid insulation

2.10.5.1 General

In 2.10.5, the requirements for SOLID INSULATION (except those for thin sheet material) and for insulating compound also apply to gel materials, used for this purpose.

SOLID INSULATION shall be:

– so dimensioned that overvoltages, including transients, that enter the equipment, and peak voltages that may be generated within the equipment, do not break down the SOLID INSULATION; and

– so arranged that the likelihood of breakdown occurring due to the presence of pinholes in thin layers of insulation is limited.

Solvent-based enamel is accepted only on winding wire as described in 2.10.5.13.

Except for printed boards, SOLID INSULATION shall either

– comply with minimum distances through insulation in accordance with 2.10.5.2; or

– meet the requirements and pass the tests in 2.10.5.3 to 2.10.5.13, as applicable.

NOTE 1 For printed boards, see 2.10.6.

NOTE 2 For SOLID INSULATION on internal wiring, see 3.1.4.

Compliance with the requirements of 2.10.5.2 to 2.10.5.14 for the adequacy of SOLID INSULATION is verified by inspection and measurement, taking into account Annex F, by the electric strength tests of 5.2 and by any additional tests required in 2.10.5.4 to 2.10.5.14.

2.10.5.2 Distances through insulation

If a design is based on distances through insulation, these distances shall be dimensioned according to the application of the insulation (see 2.9) and as follows (see Figure F.14):

– if the PEAK WORKING VOLTAGE does not exceed 71 V, there is no requirement for distance through insulation;

– if the PEAK WORKING VOLTAGE exceeds 71 V, the following rules apply:

  - for FUNCTIONAL INSULATION and BASIC INSULATION there is no minimum distance through insulation;
  - SUPPLEMENTARY INSULATION or REINFORCED INSULATION shall have a distance through insulation that is 0,4 mm or greater, provided by a single layer.

For compliance criteria, see 2.10.5.1.

2.10.5.3 Insulating compound as solid insulation

NOTE 1 For printed boards, see 2.10.6 and for wound components, see 2.10.5.11, 2.10.5.12, 2.10.5.13 and 2.10.5.14.

There is no minimum internal CLEARANCE or CREEPAGE DISTANCE if insulating compound completely fills the casing of a component or subassembly, provided that each distance through insulation in the component or subassembly meets the requirements of 2.10.5.2 and a single sample passes the tests of 2.10.10.

NOTE 2 Some examples of such treatment are variously known as potting, encapsulation and vacuum impregnation.

NOTE 3 Such constructions may contain cemented joints, in which case 2.10.5.5 also applies.

For compliance criteria, see 2.10.5.1.

2.10.5.4 Semiconductor devices

There is no minimum distance through insulation for SUPPLEMENTARY INSULATION or REINFORCED INSULATION consisting of an insulating compound completely filling the casing of a semiconductor component (for example, an optocoupler, see Figure F.17), provided that the component satisfies one of the following, a) or b):

a) – passes the TYPE TESTS and inspection criteria of 2.10.11; and

– passes ROUTINE TESTS for electric strength during manufacturing, using the appropriate value of the test voltage in 5.2.2; or

b) for an optocoupler only, complies with the requirements of IEC 60747-5-5[1)], where the test voltages as specified in 5.2.6 (of IEC 60747-5-5):

– the voltage $V_{ini,a}$ for TYPE TESTING and

– the voltage $V_{ini,b}$ for ROUTINE TESTING,

shall be the appropriate value of the test voltage in 5.2.2 of this standard.

NOTE The above constructions may contain cemented joints, in which case 2.10.5.5 also applies.

As an alternative to a) and b) above, it is permitted to treat a semiconductor according to 2.10.5.3, if applicable.

For compliance criteria, see 2.10.5.1.

2.10.5.5 Cemented joints

Where the path between conductive parts is filled with insulating compound, and the insulating compound forms a cemented joint between two non-conductive parts (see Figure F.18) or between a non-conductive part and itself (see Figures F.16 and F.17), one of the following, a), b) or c) applies.

a) The distance along the path between the two conductive parts shall not be less than the minimum CLEARANCES and CREEPAGE DISTANCES for Pollution Degree 2. The requirements for distance through insulation of 2.10.5.2 do not apply along the joint.

b) The distance along the path between the two conductive parts shall not be less than the minimum CLEARANCES and CREEPAGE DISTANCES for Pollution Degree 1. Additionally, one sample shall pass the test of 2.10.10. The requirements for distance through insulation of 2.10.5.2 do not apply along the joint.

c) The requirements for distance through insulation of 2.10.5.2 apply between the conductive parts along the joint. Additionally, three samples shall pass the test of 2.10.11.

For a) and b) above, if the insulating materials involved have different material groups, the worst case is used. If a material group is not known, Material Group IIIb shall be assumed.

For b) and c) above, the tests of 2.10.10 and 2.10.11 are not applied to a printed board made using pre-preg if the temperature of the printed board measured during the test of 4.5.2 does not exceed 90 °C at any point on the printed board material.

NOTE 1 No actual CLEARANCE or CREEPAGE DISTANCE exists unless the joint comes apart, for example, due to ageing. To cover this possibility, the requirements and tests of c) apply if the minimum CLEARANCES and CREEPAGE DISTANCES according to a) or b) are not met.

NOTE 2 Some examples of cemented joints are as follows:

- between two non-conductive parts cemented together, for example, two layers of a multilayer printed board (see Figure F.16) or the split bobbin of a transformer where the partition is secured by adhesive (see Figure F.18);
- between spirally wrapped layers of insulation on winding wire, sealed by adhesive;

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1) To be published.

- between the non-conductive casing of an optocoupler and insulating compound filling the casing (see Figure F.17).

For compliance criteria, see 2.10.5.1.

2.10.5.6 Thin sheet material - General

There is no dimensional or constructional requirement for insulation in thin sheet material used as FUNCTIONAL INSULATION or BASIC INSULATION.

Insulation in thin sheet materials permitted for SUPPLEMENTARY INSULATION and REINFORCED INSULATION (see Figure F.15), irrespective of the distance through insulation, provided that all of the following apply:

– two or more layers are used;
– the insulation is within the equipment ENCLOSURE;
– the insulation is not subject to handling or abrasion during OPERATOR servicing; and
– the requirements and tests of 2.10.5.7 (for separable layers) or 2.10.5.8 (for non-separable layers) are met.

It is not required for the two or more layers to be fixed to the same conductive part. The two or more layers can be

– fixed to one of the conductive parts requiring separation, or
– shared between the two conductive parts, or
– not fixed to either conductive part.

2.10.5.7 Separable thin sheet material

For insulation in separable thin sheet layers, in addition to the requirements of 2.10.5.6,

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

It is permitted for different layers of insulation to be of different materials or different thicknesses, or both.

Compliance is checked by inspection and by the electric strength test of 2.10.5.9 or 2.10.5.10.

2.10.5.8 Non-separable thin sheet material

For insulation consisting of non-separable thin sheet materials, in addition to the requirements of 2.10.5.6, the test procedures in Table 2P are applied.

It is permitted for different layers of insulation to be of different materials or different thicknesses, or both.

Compliance is checked by inspection and by the tests specified in Table 2P.

Table 2P – Tests for insulation in non-separable layers

Number of layers	Test procedure
SUPPLEMENTARY INSULATION	
Two or more layers:	The test procedure of 2.10.5.9 is applied. [a]
REINFORCED INSULATION	
Two layers:	The test procedure of 2.10.5.9 is applied. [a]
Three or more layers:	The test procedures of 2.10.5.9 and Annex AA are applied. [a]
[a] The alternative test procedure of 2.10.5.10 cannot be used for non-separable layers NOTE The purpose of the tests in Annex AA is to ensure that the material has adequate strength to resist damage when hidden in inner layers of insulation. Therefore, the tests are not applied to insulation in two layers. The tests in Annex AA are not applied to SUPPLEMENTARY INSULATION.	

2.10.5.9 Thin sheet material - standard test procedure

For separable or non-separable layers, electric strength tests are applied in accordance with 5.2.2 to all layers together. The test voltage is:

– *200 % of U_{test} if two layers are used; or*

– *150 % of U_{test} if three or more layers are used,*

where U_{test} is the test voltage specified in 5.2.2 for SUPPLEMENTARY INSULATION or REINFORCED INSULATION as appropriate.

NOTE Unless all the layers are of the same material and have the same thickness, there is a possibility that the test voltage will be shared unequally between layers, causing breakdown of a layer that would have passed if tested separately.

2.10.5.10 Thin sheet material - alternative test procedure

If layers can be separated for individual testing, the following alternative to the standard test procedure in 2.10.5.9 is permitted.

Electric strength tests are applied in accordance with 5.2.2, using test voltages equal to the test voltage specified in 5.2.2 for SUPPLEMENTARY INSULATION or REINFORCED INSULATION as appropriate.

If two layers are used, each layer shall pass the test.

If three or more layers are used, each combination of two layers together shall pass the test.

If three or more layers are used, It is permitted to divide these layers into two or three groups for testing purposes. In the above electric strength tests, two or three groups are tested instead of two or three layers.

A test on a layer or group of layers is not repeated on an identical layer or group.

2.10.5.11 Insulation in wound components

Planar transformers are not considered to be wound components.

NOTE 1 Planar transformers are subject to the requirements covering the construction of printed boards, see 2.10.6.

There is no dimensional or constructional requirement for FUNCTIONAL INSULATION in a wound component.

It is permitted for BASIC INSULATION, SUPPLEMENTARY INSULATION or REINFORCED INSULATION in a wound component to be provided by

– the insulation on winding wire or other wire (see 2.10.5.12 or 2.10.5.13); or
– other insulation (see 2.10.5.14); or
– a combination of the two.

NOTE 2 Wound components may contain cemented joints, in which case 2.10.5.5 also applies.

For DOUBLE INSULATION between the conductor of a wire and another conductive part, it is permitted for BASIC INSULATION to be provided by insulation complying with 2.10.5.12 on one of the wires and SUPPLEMENTARY INSULATION by additional insulation complying with 2.10.5.14, or vice versa.

For compliance criteria see 2.10.5.1.

Additionally, BASIC INSULATION, SUPPLEMENTARY INSULATION and REINFORCED INSULATION in finished wound components shall pass ROUTINE TESTS for electric strength in accordance with 5.2.2.

2.10.5.12 Wire in wound components

The following requirements apply to winding wire and other wire whose insulation provides BASIC INSULATION, SUPPLEMENTARY INSULATION or REINFORCED INSULATION, as required.

Solvent-based enamel is not considered to provide BASIC INSULATION, SUPPLEMENTARY INSULATION or REINFORCED INSULATION. Solvent-based enamel is only accepted if used as winding wire insulation as described in 2.10.5.13.

NOTE 1 For insulation provided in addition to insulation on winding wire, see 2.10.5.14.

If the PEAK WORKING VOLTAGE does not exceed 71 V, there is no dimensional or constructional requirement.

If the PEAK WORKING VOLTAGE exceeds 71 V, one of the following, a), b), or c), applies:

a) For BASIC INSULATION that is not under stress (for example, from winding tension), there is no dimensional or constructional requirement. For BASIC INSULATION that is under such stress, b), or c) applies.

NOTE 2 The exception in a) does not apply to SUPPLEMENTARY INSULATION or REINFORCED INSULATION.

b) For BASIC INSULATION, SUPPLEMENTARY INSULATION or REINFORCED INSULATION, the insulation on the wire shall either:
   – have a thickness of at least of 0,4 mm provided by a single layer; or
   – comply with 2.10.5.6 and with Annex U.

c) The winding wire shall comply with Annex U. In addition, the minimum number of overlapping layers of spirally wrapped tape or extruded layers of insulation shall be as follows:
   – for BASIC INSULATION: one layer;
   – for SUPPLEMENTARY INSULATION: two layers;
   – for REINFORCED INSULATION: three layers.

For insulation between two adjacent winding wires, one layer on each conductor is considered to provide SUPPLEMENTARY INSULATION.

Spirally wrapped tape wound with less than 50 % overlap is considered to constitute one layer.

Spirally wrapped tape wound with more than 50 % overlap is considered to constitute two layers.

Spirally wrapped tape shall be sealed and pass the tests of 2.10.5.5 a), b), or c).

NOTE 3 For wires insulated by an extrusion process, sealing is inherent to the process.

Where two winding wires, or one winding wire and another wire, are in contact inside the wound component, crossing each other at an angle between 45° and 90° and subject to winding tension, protection against mechanical stress shall be provided. This protection can be achieved, for example, by providing physical separation in the form of insulating sleeving or sheet material, or by using double the required number of insulation layers.

For compliance criteria see 2.10.5.1. If the tests of Annex U are required, they are not repeated if the material data sheets confirm compliance.

2.10.5.13 Wire with solvent-based enamel in wound components

It is permitted to use solvent-based enamel on winding wire to provide electrical separation that is considered to meet the requirements of 2.3.2.1.

NOTE 1 Solvent-based enamel is not considered to provide BASIC INSULATION, SUPPLEMENTARY INSULATION or REINFORCED INSULATION, see 2.10.5.12.

The insulation on all conductors shall be enamel complying with the requirements of a grade 2 winding wire in compliance with one of the IEC 60317 series of standards with the TYPE TEST conducted at a test voltage that is not less than required by 5.2.2.

Compliance is checked by inspection and by the following tests.

The finished component is subjected to a TYPE TEST for electric strength (between windings; and between windings and the core (see Clause C.2) in accordance with 5.2.2.

The finished component is also subjected to ROUTINE TESTS for the electric strength of the electrical separation in accordance with 5.2.2, using a test voltage of 1 000 V.

The dimensional and constructional requirements of 2.10 and Annex G do not apply for compliance with 2.10.5.13.

NOTE 2 In some cases, 6.1.2.1 also applies.

NOTE 3 In Finland, Norway and Sweden, there are additional requirements for the insulation, see 6.1.2.1 Note 2 and 6.1.2.2 Note.

2.10.5.14 Additional insulation in wound components

The following requirements apply to insulation in a wound component, provided in addition to the insulation on winding wire or other wire. This includes, for example:

– insulation between windings; and
– insulation between a winding wire or other wire and any other conductive part in the wound component.

NOTE For insulation on the winding wire itself, see 2.10.5.12.

If the PEAK WORKING VOLTAGE does not exceed 71 V, there is no dimensional or constructional requirement.

If the PEAK WORKING VOLTAGE exceeds 71 V,

– for BASIC INSULATION that is not under mechanical stress, there is no dimensional or constructional requirement;

– SUPPLEMENTARY INSULATION or REINFORCED INSULATION shall either

- have a thickness of at least 0,4 mm, provided by single layer; or
- comply with 2.10.5.6.

2.10.6 Construction of printed boards

NOTE 2.10.6 also applies to the windings of a planar transformer and a ceramic transformer.

2.10.6.1 Uncoated printed boards

The insulation between conductors on the outer surfaces of an uncoated printed board shall comply with the minimum CLEARANCE requirements of 2.10.3 (or Annex G) and the minimum CREEPAGE DISTANCE requirements of 2.10.4.

Compliance is checked by inspection and measurement.

2.10.6.2 Coated printed boards

For printed boards whose outer surfaces are to be coated with a suitable coating material, the following requirements apply to conductive parts before they are coated:

– the minimum separation distances of Table 2Q shall be met; and

– manufacturing is subjected to a quality control programme that provides at least the same level of assurance as the example given in Clause R.1 of Annex R. DOUBLE INSULATION and REINFORCED INSULATION shall pass ROUTINE TESTS for electric strength.

One or both conductive parts and at least 80 % of the distances over the surface between the conductive parts shall be coated.

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 minimum CLEARANCES of 2.10.3 (or Annex G) and the minimum CREEPAGE DISTANCES of 2.10.4 apply

– if the above conditions are not met;

– between any two uncoated conductive parts; and

– over the outside of the coating.

Compliance is checked by inspection and measurement, taking Figure F.11 into account, and by the tests of 2.10.8.

Table 2Q – Minimum separation distances for coated printed boards

~~PEAK WORKING VOLTAGE up to and including V peak~~	~~FUNCTIONAL, BASIC OR SUPPLEMENTARY INSULATION mm~~	~~REINFORCED INSULATION mm~~
~~90~~	~~0,1~~	~~0,2~~
~~180~~	~~0,2~~	~~0,4~~
~~230~~	~~0,3~~	~~0,6~~
~~285~~	~~0,4~~	~~0,8~~
~~355~~	~~0,6~~	~~1,2~~
~~455~~	~~0,8~~	~~1,6~~
~~570~~	~~1,0~~	~~2,0~~
~~710~~	~~1,3~~	~~2,6~~
~~895~~	~~1,8~~	~~3,6~~
~~1 135~~	~~2,4~~	~~3,8~~
~~1 450~~	~~2,8~~	~~4,0~~
~~1 800~~	~~3,4~~	~~4,2~~
~~2 300~~	~~4,1~~	~~4,6~~
~~2 850~~	~~5,0~~	~~5,0~~
~~3 550~~	~~6,3~~	~~6,3~~
~~4 550~~	~~8,2~~	~~8,2~~
~~5 700~~	~~10~~	~~10~~
~~7 100~~	~~13~~	~~13~~
~~8 950~~	~~16~~	~~16~~
~~11 350~~	~~20~~	~~20~~
~~14 200~~	~~26~~	~~26~~
~~18 000~~	~~33~~	~~33~~
~~23 000~~	~~43~~	~~43~~
~~28 500~~	~~55~~	~~55~~
~~35 500~~	~~70~~	~~70~~
~~45 500~~	~~86~~	~~86~~

~~Linear interpolation is permitted between the nearest two points, the calculated minimum separation distance being rounded up to the next higher 0,1 mm increment.~~

~~If the minimum CREEPAGE DISTANCE specified in Table 2N is smaller than the minimum separation distance specified above, the smaller distance applies.~~

PEAK WORKING VOLTAGE up to and including V peak	BASIC INSULATION or SUPPLEMENTARY INSULATION mm	REINFORCED INSULATION mm
71 [a]	0,025	0,05
89 [a]	0,04	0,08
113 [a]	0,063	0,125
141 [a]	0,1	0,2
177 [a]	0,16	0,32
227 [a]	0,25	0,5
283 [a]	0,4	0,8
354 [a]	0,56	1,12
455 [a]	0,75	1,5
570	1,0	2,0
710	1,3	2,6
895	1,8	3,6
1 135	2,4	3,8
1 450	2,8	4,0
1 770	3,4	4,2
2 260	4,1	4,6
2 830	5,0	5,0
3 540	6,3	6,3
4 520	8,2	8,2
5 660	10,0	10,0
7 070	13,0	13,0
8 910	16,0	16,0
11 310	20,0	20,0
14 140	26,0	26,0
17 700	33,0	33,0
22 600	43,0	43,0
28 300	55,0	55,0
35 400	70,0	70,0
45 200	86,0	86,0

Linear interpolation may be used between the nearest two points, the calculated minimum separation distance being rounded up to the next higher specified increment, or the value in the next row below, whichever is lower. For values:

- not exceeding 0,5 mm, the specified increment is 0,01 mm; and

- for those exceeding 0,5 mm, the specified increment is 0,1 mm.

[a] The test of 2.10.8 is not required.

2.10.6.3 Insulation between conductors on the same inner surface of a printed board

On an inner surface of a multi-layer printed board (see Figure F.16), the path between any two conductors shall comply with the requirements for a cemented joint in 2.10.5.5

2.10.6.4 Insulation between conductors on different surfaces of a printed board

SUPPLEMENTARY INSULATION or REINFORCED INSULATION between conductive parts on different surfaces in double-sided single-layer printed boards, multi-layer printed boards and metal core printed boards, shall either:

– have a minimum thickness of 0,4 mm; or

– conform with one of the specifications and pass the relevant tests in Table 2R.

There is no corresponding requirement for FUNCTIONAL INSULATION or BASIC INSULATION.

Compliance is checked by inspection and measurement and by tests where required.

Table 2R – Insulation in printed boards

Specification of insulation	TYPE TESTS [a]	ROUTINE TESTS for electric strength [c]
Two layers of sheet insulating material including pre-preg [b]	No	Yes
Three or more layers of sheet insulating material including pre-preg [b]	No	No
An insulation system with ceramic coating over a metallic substrate, cured at ≥ 500 °C	No	Yes
An insulation system, with two or more coatings other than ceramic over a metallic substrate, cured at < 500 °C	Yes	Yes
NOTE 1 Pre-preg is the term used for a layer of glass cloth impregnated with a partially cured resin. NOTE 2 For definition of ceramic, see IEV 212-05-24.		
[a] Thermal conditioning of 2.10.8.2 followed by the electric strength test of 5.2.2. [b] Layers are counted before curing. [c] Electric strength testing is conducted on the finished printed board.		

2.10.7 Component external terminations

It is permitted to use coatings over external terminations of components to increase effective CLEARANCES and CREEPAGE DISTANCES (see Figure F.10). The minimum separation distances of Table 2Q apply to the component before coating, and the coating shall meet all the requirements of 2.10.6.2, including quality control provisions.

The mechanical arrangement and rigidity of the terminations shall be adequate to ensure that, during normal handling, assembly into equipment and subsequent use, the terminations will not be subject to deformation that would crack the coating or reduce the separation distances between conductive parts below the values in Table 2Q (see 2.10.6.2).

Compliance is checked by inspection taking into account Figure F.10 and by applying the sequence of tests covered by 2.10.8.1, 2.10.8.2 and 2.10.8.3. These tests are conducted on a completed assembly including the component(s).

Also, the abrasion resistance test of 2.10.8.4 is conducted on a specially prepared sample printed board as described for sample 3 in 2.10.8.1, except that the separation between the conductive parts shall be representative of the minimum separations and maximum potential gradients used in the assembly.

2.10.8 Tests on coated printed boards and coated components

2.10.8.1 Sample preparation and preliminary inspection

Three sample printed boards (or, for coated components in 2.10.7, two components and one board) identified as samples 1, 2 and 3 are required. It is permitted to use either actual boards or specially produced samples with representative coating and minimum separations. Each sample board shall be representative of the minimum separations used, and coated. Each sample 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, the boards shall show no evidence of pinholes or bubbles in the coating or breakthrough of conductive tracks at corners.

2.10.8.2 Thermal conditioning

Sample 1 (see 2.10.8.1) is subjected to the thermal cycling sequence of 2.10.9.

Sample 2 is aged in a full draught oven at a temperature and for a time duration chosen from the graph of Figure 2J using the temperature index line that corresponds to the maximum operating temperature of the coated board. The temperature of the oven is maintained at the specified temperature ± 2 °C. The temperature used to determine the temperature index line is the highest temperature on the board where safety is involved.

When using Figure 2J, interpolation is permitted between the nearest two temperature index lines.

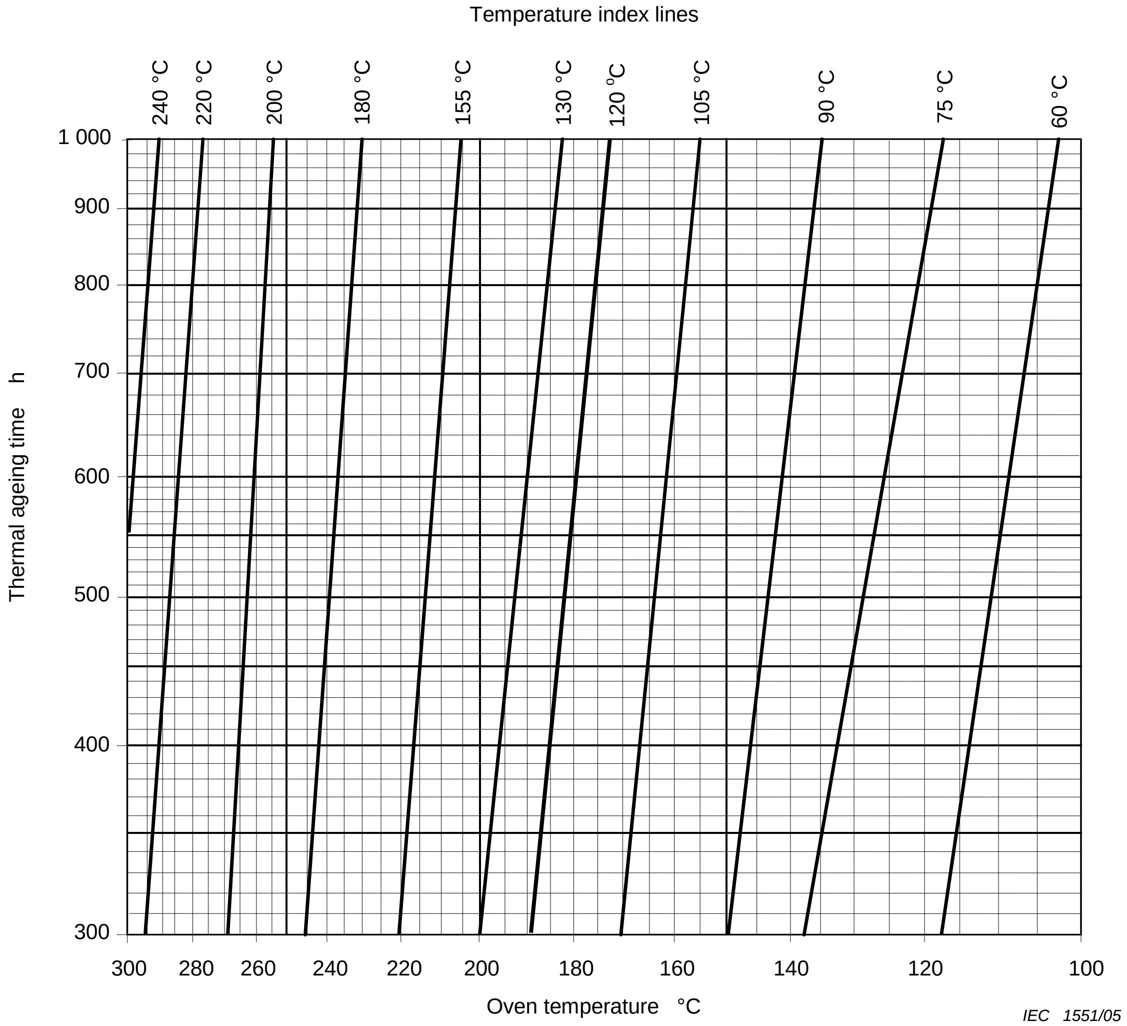


Figure 2J – Thermal ageing time

2.10.8.3 Electric strength test

Samples 1 and 2 (see 2.10.8.1) are then subjected to the humidity conditioning of 2.9.2 and shall withstand the relevant electric strength test of 5.2.2 between conductors.

2.10.8.4 Abrasion resistance test

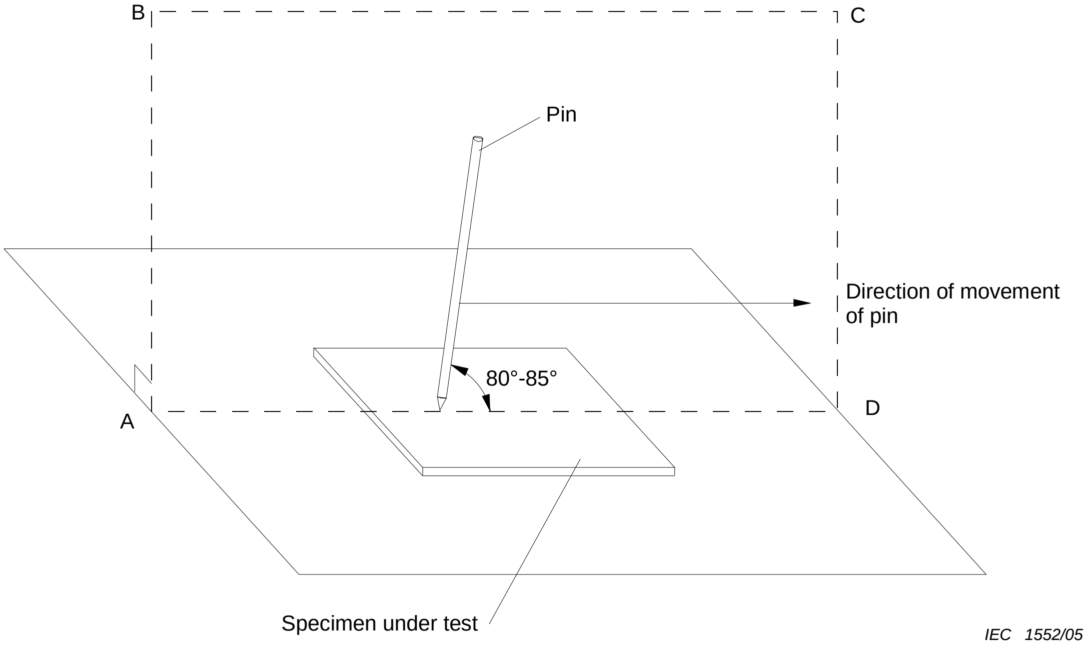
Sample 3 (see 2.10.8.1) is subjected to the following test.

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 tip angle of 40°, its tip being rounded and polished, with a radius of 0,25 mm ± 0,02 mm.

Scratches are made by drawing the pin along the surface in a plane perpendicular to the conductor edges at a speed of 20 mm/s ± 5 mm/s as shown in Figure 2K. The pin is so loaded that the force exerted along its axis is 10 N ± 0,5 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 5.2.2 between conductors. In the case of metal core printed boards, the substrate is one of the conductors.



NOTE The pin is in the plane ABCD which is perpendicular to the specimen under test.

Figure 2K – Abrasion resistance test for coating layers

2.10.9 Thermal cycling

The following thermal cycling sequence is used if required by 2.10.8.2, 2.10.10 or 2.10.11.

A sample of a component or subassembly is subjected to the following sequence of tests. For transformers, magnetic couplers and similar devices, if insulation is relied upon for safety, a voltage of 500 V r.m.s. at a frequency of 50 Hz or 60 Hz is applied between windings, and also between windings and other conductive parts during the following thermal cycling.

The sample is subjected ten times to the following sequence of thermal cycling:

	68 h at	T_1 *± 2 °C;*
	1 h at	*25 °C ± 2 °C;*
	2 h at	*0 °C ± 2 °C;*
not less than	*1 h at*	*25 °C ± 2 °C.*

$T_1 = T_2 + T_{ma} – T_{amb}$ *+ 10 K, measured in accordance with 1.4.5 and, where relevant, 1.4.13, or 85 °C, whichever is the higher. However, the 10 K margin is not added if the temperature is measured by an embedded thermocouple or by the resistance method.*

T_2 *is the temperature of the parts measured during the test of 4.5.2.*

The significance of T_{ma} *and* T_{amb} *are as given in 1.4.12.1.*

The period of time taken for the transition from one temperature to another is not specified, but the transition is permitted to be gradual.

There shall be no evidence of insulation breakdown during this conditioning.

2.10.10 Test for Pollution Degree 1 environment and for insulating compound

This test is conducted when it is required to verify a Pollution Degree 1 environment [when using Table 2N, 2.10.5.5 b) or Table G.2] or when required by 2.10.5.3 or 2.10.12.

NOTE It is not required to pass this test in connection with Tables 2K, 2L and 2M, where the requirements for Pollution Degree 1 are the same as for Pollution Degree 2.

A sample is subjected to the thermal cycling sequence of 2.10.9. The sample is permitted to cool to room temperature and is then subjected to the humidity conditioning of 2.9.2, followed immediately by the electric strength tests of 5.2.2.

~~The tests are followed by inspection and measurement. There shall be no cracks in the insulating material. For compliance with 2.10.5.3, the sample is also sectioned, and there shall be no voids in the insulating material.~~

For other than printed boards, compliance is checked by inspection of the cross-sectional area, and there shall be no visible voids, gaps or cracks in the insulating material.

In the case of insulation between conductors on the same inner surface of printed boards and the insulation between conductors on different surfaces of multilayer printed boards, compliance is checked by external visual inspection. There shall be no delamination which affects the pollution degree.

2.10.11 Tests for semiconductor devices and for cemented joints

If required by 2.10.5.4 or 2.10.5.5 c), three samples are subjected to the thermal cycling sequence of 2.10.9. Before testing a cemented joint, any winding of solvent-based enamelled wire used in the component is replaced by metal foil or by a few turns of bare wire, placed close to the cemented joint.

The three samples are then tested as follows:

– *one of the samples is subjected to the relevant electric strength test of 5.2.2, immediately after the last period at T_1 °C during thermal cycling, except that the test voltage is multiplied by 1,6;*

– *the other samples are subjected to the relevant electric strength test of 5.2.2 after the humidity conditioning of 2.9.2, except that the test voltage is multiplied by 1,6.*

~~*The tests are followed by inspection, including sectioning, and measurement. There shall be no voids or gaps or cracks in the insulating material. In the case of multilayer printed boards, there shall be no delamination.*~~

Compliance is checked by inspection and measurement.

Except for cemented joints on the same inner surface of a printed board, compliance is checked by inspection of the cross-sectional area, and there shall be no visible voids, gaps or cracks in the insulating material.

In the case of insulation between conductors on the same inner surface of printed boards and the insulation between conductors on different surfaces of multilayer boards, compliance is checked by measurement and external visual inspection. There shall be no delamination.

2.10.12 Enclosed and sealed parts

For components or subassemblies that are adequately enclosed by enveloping or hermetic sealing to prevent ingress of dirt and moisture, the values for Pollution Degree 1 apply to internal CLEARANCES and CREEPAGE DISTANCES.

NOTE Some examples of such construction include parts in boxes that are hermetically sealed by adhesive or otherwise, and parts enveloped in a dip coat.

Compliance is checked by inspection from the outside, measurement and, if necessary, by test. A component or subassembly is considered to be adequately enclosed if a sample passes the tests of 2.10.10.

3 Wiring, connections and supply

3.1 General

3.1.1 Current rating and overcurrent protection

The cross-sectional area of internal wires and INTERCONNECTING CABLES 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 busbars) and INTERCONNECTING CABLES used in the distribution of PRIMARY CIRCUIT power shall be protected against overcurrent and short-circuit by suitably rated protective devices.

Wiring not directly involved in the distribution path does not require protection if it can be shown that creation of hazards is unlikely (for example, indicating circuits).

NOTE 1 Devices for overload protection of components may also provide protection of associated wiring.

NOTE 2 Internal circuits connected to a MAINS SUPPLY 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 4.5.2 and 4.5.3.

3.1.2 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 could 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.

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

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 reduces the likelihood of:

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

Compliance is checked by inspection.

3.1.4 Insulation of conductors

Except as covered in 2.1.1.3 b), insulation of individual conductors of internal wiring shall fulfil the requirements of 2.10.5 and be capable of withstanding the applicable electric strength test specified in 5.2.2.

Where a power supply cord, whose insulating properties comply with those of the cord types of 3.2.5, is used inside the equipment, either as an extension of the external power supply cord or as an independent cable, the sheath of the power supply cord is considered to be adequate SUPPLEMENTARY INSULATION for the purpose of 3.1.4.

NOTE Requirements regarding colours of insulation are in 2.6.3.5.

Compliance is checked by inspection and evaluation of test data showing that the insulation withstands the relevant test voltage.

If such applicable test data is not available, compliance is checked by applying the electric strength test using a sample of approximately 1 m in 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 60885-1, using the relevant test voltage in 5.2.2 in this standard for the grade of insulation under consideration; and*

– *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.*

3.1.5 Beads and ceramic insulators

Beads and similar ceramic insulators on conductors shall:

– be so fixed or supported that they cannot change their position in such a way that a hazard would be created; and

– not rest on sharp edges or sharp corners.

If beads are located inside flexible metal conduits, they shall be contained within an insulating sleeve, unless the conduit is mounted or secured in such a way that movement in normal use would not create a hazard.

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

A force of 10 N is applied to the insulators or to the conduit. The resulting movement, if any, shall not create a hazard in the meaning of this standard.

3.1.6 Screws for electrical contact pressure

Where electrical contact pressure is required, a screw shall engage at least two complete threads into a metal plate, a metal nut or a metal insert.

Screws of insulating material shall not be used where electrical connections, including protective earthing, are involved, or where their replacement by metal screws could impair SUPPLEMENTARY INSULATION or REINFORCED INSULATION.

Where screws of insulating material contribute to other safety aspects, they shall be engaged by at least two complete threads.

NOTE See also 2.6.5.7 for screws used for protective earthing continuity.

Compliance is checked by inspection.

3.1.7 Insulating materials in electrical connections

Electrical connections, including those for protective earthing functions (see 2.6), 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.

3.1.8 Self-tapping and spaced thread 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.

Self-tapping (thread-cutting or thread-forming) 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.

NOTE See also 2.6.5.7 for screws used for protective earthing continuity.

Compliance is checked by inspection.

3.1.9 Termination of conductors

Conductors shall be provided with a means (for example, barriers or fixing), or be so terminated, that they and their terminators (for example, ring terminals and flat quick-connect terminals) cannot, in normal use, become so displaced that CLEARANCES or CREEPAGE DISTANCES are reduced below the values specified in 2.10 (or Annex G).

It is permitted to use soldered, welded, crimped, screwless (push-in) and similar terminations for the connection of conductors. 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.

In multiway plugs and sockets, and wherever shorting could otherwise occur, means shall be provided to prevent contact between parts in SELV CIRCUITS or TNV CIRCUITS and parts at HAZARDOUS VOLTAGE due to loosening of a terminal or breaking of a wire at a termination.

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

A force of 10 N is applied to the conductor near its termination point. The conductor shall not break away or pivot on its terminal to the extent that CLEARANCES or CREEPAGE DISTANCES are reduced below the values specified in 2.10 (or Annex G).

For the purpose of assessing compliance it is assumed that:

- *two independent fixings will not become loose at the same time; and*
- *parts fixed by means of screws or nuts provided with self-locking washers or other means of locking are not liable to become loose.*

NOTE Spring washers and the like can provide satisfactory locking.

Examples of constructions regarded as meeting the requirements include:

- *close-fitting tubing (for example, a heat shrink or rubber sleeve), applied over the wire and its termination;*

– *conductors connected by soldering and held in place near to the termination, independently of the soldered connection;*

– *conductors connected by soldering and "hooked in" before soldering, provided that the hole through which the conductor is passed is not unduly large;*

– *conductors connected to screw terminals, with an additional fixing near to the terminal that clamps, in the case of stranded conductors, the insulation and not only the conductors;*

– *conductors connected to screw terminals and provided with terminators that are unlikely to become free (for example, ring lugs crimped onto the conductors). The pivoting of such terminators is considered;*

– *short rigid conductors that remain in position when the terminal screw is loosened.*

3.1.10 Sleeving on wiring

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

Compliance is checked by inspection.

Examples of constructions that are considered to meet the intent of this requirement include:

– *sleeving that can be removed only by breaking or cutting of either the wiring or sleeving;*

– *sleeving that is clamped at both ends;*

– *heat shrinkable sleeving that tightens against the wire insulation;*

– *sleeving that is of such length that it will not slip.*

3.2 Connection to a mains supply

3.2.1 Means of connection

3.2.1.1 Connection to an a.c. mains supply

For safe and reliable connection to an AC MAINS 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;

NOTE In many countries, it is a legal requirement to provide a plug that complies with the national wiring rules.

– an appliance inlet for connection of a DETACHABLE POWER SUPPLY CORD;

– a mains plug that is part of DIRECT PLUG-IN EQUIPMENT.

Compliance is checked by inspection.

3.2.1.2 Connection to a d.c. mains supply

For safe and reliable connection to a DC MAINS 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.

Plugs and appliance inlets shall not be of a type that is used for AC MAINS SUPPLIES if a hazard could be created by their use. Plugs and appliance inlets shall be so designed that reverse polarity connections are prevented if a hazard could be created by such connection.

It is permitted for one pole of the DC MAINS SUPPLY to be connected both to an equipment mains input terminal and to the main protective earthing terminal of the equipment, if any, provided the equipment installation instructions detail the proper earthing for the system.

Compliance is checked by inspection.

3.2.2 Multiple supply connections

If equipment is provided with more than one supply connection (for example, with different voltages or frequencies or as backup power), the design shall be such that all of the following conditions are met:

– separate means of connection are provided for different circuits; and

– supply plug connections, if any, are not interchangeable if a hazard could be created by incorrect plugging; and

– bare parts of an ELV CIRCUIT or parts at HAZARDOUS VOLTAGES, such as plug contacts, are not accessible to an OPERATOR when one or more connectors are disconnected.

Compliance is checked by inspection and for accessibility, where necessary, by a test with the test finger, Figure 2A (see 2.1.1.1).

3.2.3 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.

PERMANENTLY CONNECTED EQUIPMENT having a set of terminals shall:

– permit the connection of the supply wires after the equipment has been fixed to its support; and

– 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 3A.

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 CLEARANCES and CREEPAGE DISTANCES below the values specified in 2.10 (or Annex G).

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

Table 3A – Sizes of cables and conduits for equipment having a rated current not exceeding 16 A

Number of conductors, including the PROTECTIVE EARTHING CONDUCTOR where provided	Overall diameter mm	
	Cable	Conduit
2	13,0	16,0 (22,2)
3	14,0	16,0 (22,2)
4	14,5	20,0 (27,8)
5	15,5	20,0 (27,8)
NOTE In Canada and the United States the dimensions in parentheses are the size of conduit opening required for terminating nominal 1/2 inch and 3/4 inch trade size conduits.		

3.2.4 Appliance inlets

Appliance inlets shall meet all of the following:

– be so located or enclosed that parts at HAZARDOUS VOLTAGE are not accessible during insertion or removal of the connector (appliance inlets complying with IEC 60309 or with IEC 60320 are considered to comply with this requirement); and

– be so located that the connector can be inserted without difficulty; and

– be so located that, after insertion of the connector, the equipment is not supported by the connector for any position of normal use on a flat surface.

Compliance is checked by inspection and, for accessibility, by means of the test finger, Figure 2A (see 2.1.1.1).

NOTE For Switzerland, see 3.2.1.1 Note.

3.2.5 Power supply cords

3.2.5.1 AC power supply cords

~~A power supply cord for connection to the AC MAINS SUPPLY shall~~ A MAINS SUPPLY cord shall be of the sheathed type and comply with the following as appropriate:

– if rubber ~~insulated~~ sheathed, be of synthetic rubber and not lighter than ordinary tough rubber-sheathed flexible cord according to IEC 60245-1 (designation 60245 IEC 53);

– if PVC ~~insulated~~ sheathed:

- for equipment provided with a NON-DETACHABLE POWER SUPPLY CORD and having a mass not exceeding 3 kg, be not lighter than light PVC sheathed flexible cord according to IEC 60227-1:2007 (designation 60227 IEC 52);
- for equipment provided with a NON-DETACHABLE POWER SUPPLY CORD and having a mass exceeding 3 kg, be not lighter than ordinary PVC sheathed flexible cord according to IEC 60227-1:2007 (designation 60227 IEC 53);

NOTE 1 There is no limit on the mass of the equipment if the equipment is intended for use with a DETACHABLE POWER SUPPLY CORD.

- for equipment provided with a detachable power supply cord, be not lighter than light PVC sheathed flexible cord according to IEC 60227-1:2007 (designation 60227 IEC 52);

~~NOTE 1 There is no limit on the mass of the equipment if the equipment is intended for use with a DETACHABLE POWER SUPPLY CORD.~~

- ~~include, for equipment required to have protective earthing, a PROTECTIVE EARTHING CONDUCTOR having green-and-yellow insulation; and~~

- ~~have conductors with cross-sectional areas not less than those specified in Table 3B.~~

~~NOTE 2 In Australia and New Zealand, conductor sizes for some current ranges are different from those specified in Table 3B.~~

~~*Compliance is checked by inspection and by measurement. In addition, for screened cords, compliance is checked by the tests of IEC 60227 (all parts). However, flexing tests need be applied only to screened power supply cords for MOVABLE EQUIPMENT.*~~

~~NOTE 3 Although screened cords are not covered in the Scope of IEC 60227, the relevant tests of IEC 60227 are used.~~

- for screened cords of moveable equipment, the flexing test of 3.1 of IEC 60227-2:1997;

NOTE 2 Although screened cords are not covered in the scope of IEC 60227-2, the relevant flexing tests of IEC 60227-2 are used.

– other types of cords may be used if they have similar or better electro-mechanical and fire safety properties as above.

NOTE 3 Where national or regional standards exist, they can be used to show compliance with the above paragraph.

For equipment required to have protective earthing, a PROTECTIVE EARTHING CONDUCTOR shall be included in the MAINS SUPPLY cord.

A MAINS SUPPLY cord shall have conductors with a cross-sectional area not less than those specified in Table 3B.

Compliance is checked by inspection. For screened cords, damage to the screen is acceptable provided that:

– *during the flexing test the screen does not make contact with any conductor, and*

– *after the flexing test, the sample withstands the appropriate electric strength test between the screen and all other conductors.*

Table 3B – Sizes of conductors

RATED CURRENT of equipment A	Minimum conductor sizes	
	Nominal cross-sectional area mm²	AWG or kcmil [cross-sectional area in mm²] see Note 2
Up to and including 6	0,75 [a]	18 [0,8]
Over 6 up to and including 10	(0,75) [b] 1,00	16 [1,3]
Over 10 up to and including 13	(1,0) [c] 1,25	16 [1,3]
Over 13 up to and including 16	(1,0) [c] 1,5	14 [2]
Over 16 up to and including 25	2,5	12 [3]
Over 25 up to and including 32	4	10 [5]
Over 32 up to and including 40	6	8 [8]
Over 40 up to and including 63	10	6 [13]
Over 63 up to and including 80	16	4 [21]
Over 80 up to and including 100	25	2 [33]
Over 100 up to and including 125	35	1 [42]
Over 125 up to and including 160	50	0 [53]
Over 160 up to and including 190	70	000 [85]
Over 190 up to and including 230	95	0000 [107]
Over 230 up to and including 260	120	250 kcmil [126]
Over 260 up to and including 300	150	300 kcmil [152]
Over 300 up to and including 340	185	400 kcmil [202]
Over 340 up to and including 400	240	500 kcmil [253]
Over 400 up to and including 460	300	600 kcmil [304]

NOTE 1 IEC 60320 specifies acceptable combinations of appliance couplers and flexible cords, including those covered by Footnotes a, b and c above. However, several countries have indicated that they do not accept all of the values listed in Table 3B, particularly those covered by Footnotes a, b and c above.

NOTE 2 AWG and kcmil sizes are provided for information only. The associated cross-sectional areas, in square brackets, have been rounded to show significant figures only. AWG refers to the American Wire Gage and the term "cmil" refers to circular mils where 1 cmil is the area of a circle having a diameter of 1 mil (one thousandth of an inch). These terms are commonly used to designate wire sizes in North America.

[a] 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.

[b] The value in parentheses applies to DETACHABLE POWER SUPPLY CORDS fitted with the connectors rated 10 A in accordance with IEC 60320 (types C13, C15, C15A and C17) provided that the length of the cord does not exceed 2 m.

[c] The value in parentheses applies to DETACHABLE POWER SUPPLY CORDS fitted with the connectors rated 16 A in accordance with IEC 60320 (types C19, C21 and C23) provided that the length of the cord does not exceed 2 m.

3.2.5.2 DC power supply cords

A power supply cord for connection to the DC MAINS SUPPLY shall be suitable for the voltage, current and the physical abuses it is likely to encounter.

Compliance is checked by inspection.

3.2.6 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, and

– the outer covering of the cord is protected from abrasion.

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.

For NON-DETACHABLE POWER SUPPLY CORDS containing a PROTECTIVE EARTHING CONDUCTOR, the construction shall be such that if the 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; and

– for ordinary replacement cords, it is clear how relief from strain is to be obtained; and

– the cord is not clamped by a screw that bears directly on the cord, unless the cord anchorage, including the screw, is made of insulating material and the screw is of comparable size to the diameter of the cord being clamped; and

– methods such as tying the cord into a knot or tying the cord with string are not used; and

– 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 that are made with the type of power supply cord supplied with the equipment.

The cord is subjected to a steady pull of the value shown in Table 3C, applied in the most unfavourable direction. The test is conducted 25 times, each time for a duration of 1 s.

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, and CLEARANCES and CREEPAGE DISTANCES shall not be reduced below the values specified in 2.10 (or Annex G).

Table 3C – Physical tests on power supply cords

Mass (M) of the equipment kg	**Pull** N
Up to and including 1	30
Over 1 up to and including 4	60
Over 4	100

3.2.7 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, and

– not be removable without the use of a TOOL.

A metallic inlet bushing shall not be used in a non-metallic ENCLOSURE.

An inlet bushing or cord guard secured to a conductive part that is not protectively earthed shall meet the requirements for SUPPLEMENTARY INSULATION.

Compliance is checked by inspection and measurement.

3.2.8 Cord guards

A cord guard shall be provided at the power supply cord inlet opening of equipment that has a NON-DETACHABLE POWER SUPPLY CORD, and which is HAND-HELD EQUIPMENT or is 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 150 % of 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, and

– 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 with the cord as delivered with the equipment.

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 $10 \times D^2$ *g is then attached to the free end of the cord, where D is the overall diameter of, or for flat cords, the minor overall dimension of the cord, in millimetres.*

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.

3.2.9 Supply wiring space

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

– to allow the conductors to be introduced and connected easily; and

– so that the uninsulated end of a conductor is unlikely to become free from its terminal, or, should it do so, cannot come into contact with:
  - an accessible conductive part that is not protectively earthed; or
  - an accessible conductive part of HAND-HELD EQUIPMENT; and
– to permit checking before fitting the cover, if any, that the conductors are correctly connected and positioned; and
– so that covers, if any, can be fitted without risk of damage to the supply conductors or their insulation; and
– 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 3.3.4.

3.3 Wiring terminals for connection of external conductors

3.3.1 Wiring 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 (see also 2.6.4).

Compliance is checked by inspection.

3.3.2 Connection of 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 while the equipment is operated under NORMAL LOAD (see also 3.1.9).

Compliance is checked by inspection and by measuring the temperature of the connection which shall not exceed the values of 4.5.3, Table 4B.

3.3.3 Screw terminals

Screws and nuts that clamp external MAINS SUPPLY conductors shall have a thread conforming to ISO 261 or ISO 262, or a thread comparable in pitch and mechanical strength (for example, 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. For protective earthing terminals and protective bonding terminals, see also 2.6.4.2.

The terminals of a component (for example, a switch) built into the equipment are permitted for use as terminals for external MAINS SUPPLY conductors, provided that they comply with the requirements of 3.3.

Compliance is checked by inspection.

3.3.4 Conductor sizes to be connected

Terminals shall allow the connection of conductors having nominal cross-sectional areas as shown in Table 3D.

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 3D.

Table 3D – Range of conductor sizes to be accepted by terminals

RATED CURRENT of equipment A	Nominal cross-sectional area mm²	
	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

3.3.5 Wiring terminal sizes

Pillar, stud or screw type terminals shall comply with the minimum sizes in Table 3E.

Compliance is checked by inspection and measurement.

Table 3E – Sizes of terminals for mains supply conductors and protective earthing conductors [a]

~~RATED CURRENT of equipment~~ ~~A~~	~~Minimum nominal thread diameter~~ ~~mm~~	
	~~Pillar type or stud type~~	~~Screw type~~ [b]
~~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~~

~~a This table is also used for the sizes of terminals for PROTECTIVE BONDING CONDUCTORS if specified in 2.6.4.2.~~

~~b "Screw type" refers to a terminal that clamps the conductor under the head of a screw, with or without a washer.~~

RATED CURRENT A up to and including	Conductor size mm²	Minimum nominal thread diameter mm		Area of cross section mm²	
		Pillar type or stud type	Screw type [b]	Pillar type or stud type	Screw type [b]
10	1	3,0	3,5	7	9,6
16	1,5	3,5	4,0	9,6	12,6
25	2,5	4,0	5,0	12,6	19,6
32	4	4,0	5,0	12,6	19,6
40	6	5,0	5,0	19,6	19,6
63	10 [c]	6,0	6,0	28	28
80	16 [c]	7,9	7,9	49	49

[a] This table is also used for the sizes of terminals for PROTECTIVE BONDING CONDUCTORS if specified in 2.6.4.2.

[b] "Screw type" refers to a terminal that clamps the conductor under the head of a screw, with or without a washer.

[c] As an alternative to the requirements of this table, the protective earthing conductor may be attached to special connectors, or suitable clamping means (for example, an upturned spade or closed loop pressure type; clamping unit type; saddle clamping unit type; mantle clamping unit type; etc.) that is secured by a screw and nut mechanism to the metal chassis of the equipment. The sum of the cross-sectional areas of the screw and the nut shall not be less than three times the cross-sectional area of the conductor size in Table 2D or Table 3B as applicable. The terminals shall comply with IEC 60998-1 and IEC 60999-1 or IEC 60999-2.

3.3.6 Wiring terminal design

Wiring terminals shall be so designed that they clamp the conductor between metal surfaces with sufficient contact pressure and without damage to the conductor.

Terminals shall be so designed or located that the conductor cannot slip out when the clamping screws or nuts are tightened.

Terminals shall be provided with appropriate fixing hardware for the conductors (for example, nuts and washers).

Terminals shall be so fixed that, when the means of clamping the conductor is tightened or loosened, all of the following apply:

– the terminal itself does not work loose;

– internal wiring is not subjected to stress; and

– CLEARANCES and CREEPAGE DISTANCES are not reduced below the values specified in 2.10 (or Annex G).

Compliance is checked by inspection and measurement.

3.3.7 Grouping of wiring terminals

For ordinary NON-DETACHABLE POWER SUPPLY CORDS and for PERMANENTLY CONNECTED EQUIPMENT, all associated AC MAINS SUPPLY terminals shall be located in proximity to each other and to the main protective earthing terminal, if any.

For ordinary NON-DETACHABLE POWER SUPPLY CORDS and for PERMANENTLY CONNECTED EQUIPMENT, all associated DC MAINS SUPPLY terminals shall be located in proximity to each other. They need not be located in proximity to the main protective earthing terminal, if any, provided the installation instructions detail the proper earthing of the system.

Compliance is checked by inspection.

3.3.8 Stranded wire

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 reduce the likelihood 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.

Terminals shall be located, guarded or insulated so that, should a strand of a flexible conductor escape when the conductor is fitted, there is no likelihood 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.

A piece of insulation approximately 8 mm long 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 around the guard.

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

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

3.4 Disconnection from the mains supply

3.4.1 General requirement

A disconnect device or devices shall be provided to disconnect the equipment from the MAINS SUPPLY for servicing.

NOTE Instructions may be provided to allow servicing parts of the equipment with or without opening the disconnect device.

Compliance is checked by inspection.

3.4.2 Disconnect devices

For equipment intended to be powered from an AC MAINS SUPPLY that is Overvoltage Category I, Overvoltage Category II or Overvoltage Category III, or from a DC MAINS SUPPLY that is at a HAZARDOUS VOLTAGE, a disconnect device shall have a contact separation of at least 3 mm. For an AC MAINS SUPPLY that is Overvoltage Category IV, refer to IEC 60947-1.

For equipment intended to be powered from a DC MAINS SUPPLY that is not at a HAZARDOUS VOLTAGE, a disconnect device shall have a contact separation at least equal to the minimum CLEARANCE for BASIC INSULATION.

NOTE For a DC MAINS SUPPLY, additional measures may be necessary to prevent arcing in the disconnect device, depending on the circuit.

If a disconnect device is incorporated in the equipment, it shall be connected as closely as practicable to the incoming supply.

Functional switches are permitted 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 MAINS SUPPLY plug on the power supply cord;
– a MAINS SUPPLY plug that is part of DIRECT PLUG-IN EQUIPMENT;
– an appliance coupler;
– an isolating switch;
– a circuit-breaker;
– for a DC MAINS SUPPLY that is not at a HAZARDOUS VOLTAGE, a removable fuse, provided that it is accessible only to a SERVICE PERSON;
– any equivalent device.

Compliance is checked by inspection.

3.4.3 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 1.7.2.1, stating that an appropriate disconnect device shall be provided external to the equipment.

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

Compliance is checked by inspection.

3.4.4 Parts which remain energized

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

Compliance is checked by inspection.

3.4.5 Switches in flexible cords

Isolating switches shall not be fitted in flexible cords.

Compliance is checked by inspection.

3.4.6 Number of poles - single-phase and d.c. equipment

A disconnect device, if provided in or as part of the equipment, shall disconnect both poles simultaneously, except that

– if it is possible to rely on the identification of the earthed conductor in the DC MAINS SUPPLY, or an earthed neutral in an AC MAINS SUPPLY, it is permitted to use a single-pole disconnect device that disconnects the unearthed (line) conductor, or

– if it is not possible to rely on the identification of the earthed conductor in the DC MAINS SUPPLY, or an earthed neutral in an AC MAINS SUPPLY, and the equipment is not provided with a two-pole disconnect device, the installation instructions shall specify that a two-pole disconnect device is to be provided external to the equipment.

NOTE Some examples of cases where a two-pole disconnect device is required (because identification of an earthed conductor in the MAINS SUPPLY is not possible) 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 unidentified or indeterminate polarity.

Compliance is checked by inspection.

3.4.7 Number of poles – three-phase equipment

For three-phase equipment, the disconnect device shall disconnect simultaneously all line conductors of the AC MAINS SUPPLY.

For equipment requiring a neutral connection to an IT power distribution system, the disconnect device shall be a four-pole device and shall disconnect all line conductors and the neutral conductor. If this four-pole device is not provided in the equipment, the installation instructions shall specify the need for the provision of the device external to the equipment.

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

Compliance is checked by inspection.

3.4.8 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.

3.4.9 Plugs as disconnect devices

Where a plug on the power supply cord is used as the disconnect device, the installation instructions shall comply with 1.7.2.1.

Compliance is checked by inspection.

3.4.10 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 such power from the unit.

Compliance is checked by inspection.

3.4.11 Multiple power sources

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

If the disconnect device is not in the equipment, the marking shall be on the equipment and located close to the MAINS input terminals.

Compliance is checked by inspection.

3.5 Interconnection of equipment

3.5.1 General requirements

Where an equipment is intended to be electrically connected to another equipment, to an accessory or to a TELECOMMUNICATION NETWORK, interconnection circuits shall be selected to provide continued conformance to the requirements of 2.2 for SELV CIRCUITS, and with the requirements of 2.3 for TNV CIRCUITS, after making connections.

NOTE 1 This is normally achieved by connecting SELV CIRCUITS to SELV CIRCUITS, and TNV CIRCUITS to TNV CIRCUITS.

Additionally, SELV CIRCUITS of data ports for connection to other equipment or accessories shall limit the risk of fire in the connected equipment as specified in 3.5.4.

NOTE 2 It is permitted for an INTERCONNECTING CABLE to contain more than one type of circuit (for example, SELV CIRCUIT, LIMITED CURRENT CIRCUIT, TNV CIRCUIT, ELV CIRCUIT or HAZARDOUS VOLTAGE circuit) provided that they are separated as required by this standard.

Compliance is checked by inspection.

3.5.2 Types of interconnection circuits

Each interconnection circuit shall be one of the following types:

– an SELV CIRCUIT or a LIMITED CURRENT CIRCUIT; or
– a TNV-1 CIRCUIT, TNV-2 CIRCUIT or TNV-3 CIRCUIT; or
– a HAZARDOUS VOLTAGE circuit.

Except as permitted in 3.5.3, interconnection circuits shall not be ELV CIRCUITS.

Compliance is checked by inspection.

3.5.3 ELV circuits as interconnection circuits

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

Compliance is checked by inspection.

3.5.4 Data ports for additional equipment

To limit the risk of fire in an additional equipment or accessory (for example, a scanner, mouse, keyboard, DVD drive, CD ROM drive or joystick), SELV CIRCUITS of a data port for connection of such equipment shall be supplied by a limited power source that complies with 2.5. This requirement does not apply if it is known that the additional equipment complies with 4.7.

NOTE It is recommended that manufacturers of accessories and their INTERCONNECTING CABLES include protection against fault currents up to 8 A at 100 VA, the maximum available from a limited power source in compliance with Table 2B.

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

4 Physical requirements

4.1 Stability

Under conditions of normal use, units and equipment shall not become physically unstable to the degree that they could become a hazard to an OPERATOR or to a SERVICE PERSON.

If units are designed to be fixed together on site and not used individually, the stability of each individual unit is exempt from the requirements of 4.1.

The requirements of 4.1 are not applicable if the installation instructions for a unit specify that the equipment is to be secured to the building structure before operation.

Under conditions of OPERATOR use, a stabilizing means, if needed, shall be automatic in operation when drawers, doors, etc., are opened.

During operations performed by a SERVICE PERSON, the stabilizing means, if needed, shall either be automatic in operation, or a marking shall be provided to instruct the SERVICE PERSON to deploy the stabilizing means.

Compliance is checked by the following tests, where relevant. Each test is conducted separately. During the tests, 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 the installation instructions require jacks to be lowered after installation, 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 having a mass of 7 kg or more shall not fall over when tilted to an angle of 10° from its normal upright position. Doors, drawers, etc., are closed during this test. A unit provided with multi-positional features shall be tested in the least favourable position permitted by the construction. Alternatively, the unit is placed in its intended position of use on a plane, inclined at an angle of 10° to the horizontal, and then rotated slowly through an angle of 360° about its normal vertical axis.*

  NOTE It could be the plane being turned around or the plane could be stationary and the equipment is rotated.

– *A floor-standing unit having a mass of 25 kg or more shall not fall 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 the OPERATOR or by a SERVICE PERSON, are placed in their most unfavourable position, consistent with the installation instructions.*

– *A floor-standing unit shall not fall over when a constant downward force of 800 N is applied at the point of maximum moment to any horizontal surface of at least 125 mm by at least 200 mm, at a height up to 1 m from the floor. Doors, drawers, etc., are closed during this test. The 800 N force is applied by means of a suitable test tool having a flat surface of approximately 125 mm by 200 mm. The downward force is applied with the complete flat surface of the test tool in contact with the EUT; the test tool need not be in full contact with uneven surfaces (for example, corrugated or curved surfaces).*

4.2 Mechanical strength

4.2.1 General

Equipment shall have adequate mechanical strength and shall be so constructed that no hazard is created in the meaning of this standard when subjected to handling as may be expected. For additional requirements for rack-mounted equipment, see Annex DD.

Mechanical strength tests are not required on an internal barrier, screen or the like, provided to meet the requirements of 4.6.2, if the ENCLOSURE provides mechanical protection.

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.

~~NOTE Examples of equipment where such precautions may be necessary include CD-ROM or DVD drives whose rotational speed is greater than 8 000 r.p.m.~~

Compliance is checked by inspection of the construction and available data and, where necessary, by the relevant tests of 4.2.2 to 4.2.7 as specified.

The tests are not applied to handles, levers, knobs, the face of cathode ray tubes (see 4.2.8) or to transparent or translucent covers of indicating or measuring devices, unless parts at HAZARDOUS VOLTAGE are accessible by means of the test finger, Figure 2A (see 2.1.1.1), if the handle, lever, knob or cover is removed.

During the tests of 4.2.2, 4.2.3 and 4.2.4, earthed or unearthed conductive ENCLOSURES shall not bridge parts between which a HAZARDOUS ENERGY LEVEL exists and shall not contact a bare part at HAZARDOUS VOLTAGE. For voltages exceeding 1 000 V a.c. or 1 500 V d.c., contact is not permitted and there shall be an air gap between the part at HAZARDOUS VOLTAGE and the ENCLOSURE. This air gap shall either have a minimum length equal to the minimum CLEARANCE specified in 2.10.3 (or Annex G) for BASIC INSULATION or withstand the relevant electric strength test in 5.2.2.

After the tests of 4.2.2 to 4.2.7, the sample shall continue to comply with the requirements of 2.1.1, 2.6.1, 2.10, 3.2.6 and 4.4.1. It 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 INSULATION or REINFORCED INSULATION is subjected to an electric strength test as specified in 5.2.2.

Damage to finish, cracks, dents and chips are disregarded if they do not adversely affect safety.

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.

4.2.2 Steady force test, 10 N

Components and parts, other than parts serving as an ENCLOSURE (see 4.2.3 and 4.2.4), are subjected to a steady force of 10 N ± 1 N.

Compliance criteria are in 4.2.1.

4.2.3 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 4.2.4, are subjected to a steady force of 30 N ± 3 N for a period of 5 s, applied by means of a straight unjointed version of the test finger, Figure 2A (see 2.1.1.1), to the part on or within the equipment.

Compliance criteria are in 4.2.1.

4.2.4 Steady force test, 250 N

External ENCLOSURES are subjected to a steady force of 250 N ± 10 N for a period of 5 s, applied in turn to the top, bottom and sides of the ENCLOSURE fitted to the equipment, by means of a suitable test tool providing contact over a circular plane surface 30 mm in diameter. However, this test is not applied to the bottom of an ENCLOSURE of equipment having a mass of more than 18 kg.

Compliance criteria are in 4.2.1.

4.2.5 Impact test

Except for equipment identified in 4.2.6, external surfaces of ENCLOSURES, the failure of which would give access to hazardous parts, are tested as follows.

A sample consisting of the complete ENCLOSURE, or a portion thereof representing the largest unreinforced area, is supported in its normal position. A solid smooth steel ball, approximately 50 mm in diameter and with a mass of 500 g ± 25 g, is permitted to fall freely from rest through a vertical distance (H) of 1,3 m (see Figure 4A) onto the sample. (Vertical surfaces are exempt from this test.)

In addition, the steel ball is suspended by a cord and swung as a pendulum in order to apply a horizontal impact, dropping through a vertical distance (H) of 1,3 m (see Figure 4A) onto the sample. (Horizontal surfaces are exempt from this test.) Alternatively, the sample is rotated 90° about each of its horizontal axes and the ball dropped as in the vertical impact test.

The bottoms of ENCLOSURES are also tested if the operating instructions permit an orientation in which the bottom of the ENCLOSURE becomes the top or a side of the ENCLOSURE.

~~*The test is not applied to the following:*~~

~~– a flat panel display;~~

~~– the face of a cathode ray tube (see 4.2.8);~~

~~– the platen glass of equipment (for example, on a copying machine);~~

~~– *the surface of the ENCLOSURE of STATIONARY EQUIPMENT, including EQUIPMENT FOR BUILDING-IN, which is inaccessible and protected after installation.*~~

The impact test is not applied to the following:

- *the face of a cathode ray tube (see 4.2.8);*
- *the platen glass of equipment (for example, on a copying machine);*
- *the surface of the ENCLOSURE of STATIONARY EQUIPMENT, including EQUIPMENT FOR BUILDING-IN, that is inaccessible and protected after installation;*
- *a flat panel display*
  - *having a surface area of glass not exceeding 0,1 m^2 or with a major dimension not exceeding 450 mm; or*
  - *made of laminated glass; or*

  NOTE Laminated glass includes constructions such as plastic film affixed to a single side of the glass.

  - *that has been evaluated and complies with 19.5 of IEC 60065.*

Compliance criteria are in 4.2.1.

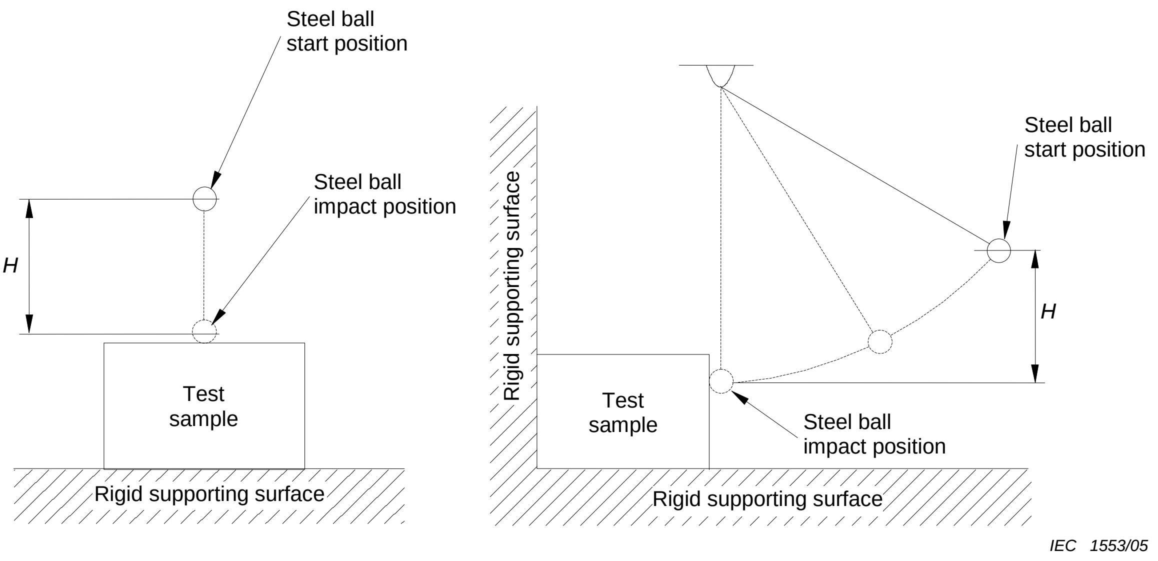


Figure 4A – Impact test using a steel ball

4.2.6 Drop test

The following equipment is subjected to a drop test:

– HAND-HELD EQUIPMENT;

– DIRECT PLUG-IN EQUIPMENT;

– TRANSPORTABLE EQUIPMENT;

– desk-top equipment having a mass of 5 kg or less that is intended for use with any one of the following:

- a cord-connected telephone handset, or
- another cord-connected hand-held accessory with an acoustic function, or
- a headset;

– MOVABLE EQUIPMENT requiring lifting or handling by the USER as part of its intended use.

NOTE An example of such equipment is a paper shredder that rests on a waste container, requiring its removal to empty the container.

To determine compliance, a sample of the complete equipment is subjected to three impacts that result from being dropped onto a horizontal surface in positions likely to produce the most adverse results.

The height of the drop shall be:

– *750 mm ± 10 mm for desk-top equipment as described above;*

– *750 mm ± 10 mm for MOVABLE EQUIPMENT as described above;*

– *1 000 mm ± 10 mm for HAND-HELD EQUIPMENT, DIRECT PLUG-IN EQUIPMENT and TRANSPORTABLE EQUIPMENT.*

The horizontal surface consists of hardwood at least 13 mm thick, mounted on two layers of plywood each ~~19 mm to 20 mm~~ 18 mm ± 2 mm thick, all supported on a concrete or equivalent non-resilient floor.

Compliance criteria are in 4.2.1.

4.2.7 Stress relief test

ENCLOSURES of moulded or formed thermoplastic materials shall be so constructed that any shrinkage or distortion of the material due to release of internal stresses caused by the moulding or forming operation does not result in the exposure of hazardous parts or in the reduction of CLEARANCES or CREEPAGE DISTANCES below the values specified in 2.10 (or Annex G).

Compliance is checked by the mould stress relief test of IEC 60695-10-3, or by the test procedure described below, or by the inspection of the construction and the available data where appropriate.

One sample consisting of the complete equipment, or of the complete ENCLOSURE together with any supporting framework, is placed in a circulating air oven ~~(according to IEC 60216-4-1)~~ at a temperature 10 K higher than the maximum temperature observed on the ENCLOSURE during the test of 4.5.2, but not less than 70 °C, for a period of 7 h, then permitted to cool to room temperature.

With the concurrence of the manufacturer, it is permitted to increase the above time duration.

For large equipment where it is impractical to condition a complete ENCLOSURE, it is permitted to use a portion of the ENCLOSURE representative of the complete assembly with regard to thickness and shape, including any mechanical support members.

NOTE Relative humidity need not be maintained at a specific value during this test.

If the above test is conducted, the compliance criteria of 4.2.1 apply.

4.2.8 Cathode ray tubes

If a cathode ray tube having a maximum face dimension exceeding 160 mm is included in the equipment, either the cathode ray tube or the ENCLOSURE with the cathode ray tube correctly installed shall comply with the requirements of Clause 18 of IEC 60065 for mechanical strength of cathode ray tubes.

NOTE Clause 18 of IEC 60065 requires cathode ray tubes either to pass the tests specified in 18.1 or to comply with IEC 61965. In the future amendment 2 to IEC 60065:2001, anticipated for 2006 at the earliest, it is intended that intrinsically-protected cathode ray tubes will be required to comply with IEC 61965, with no option as presently permitted in the seventh edition. The test now in 18.3 of IEC 60065 will continue to apply to non-intrinsically-protected tubes, which are not in the Scope of IEC 61965.

Compliance is checked by inspection, by measurement and, if necessary, by the relevant requirements and tests of Clause 18 of IEC 60065.

4.2.9 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 reduce the likelihood of harm 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.

NOTE 2.10.3.5 may also apply in some cases.

4.2.10 Wall or ceiling mounted equipment

The mounting means of equipment intended for wall or ceiling mounting shall be adequate.

Compliance is checked by inspection of the construction and of available data, or where necessary, by the following test.

The equipment is mounted in accordance with the installation instructions. A force, in addition to the weight of the equipment, is applied downwards through the centre of gravity of the equipment, for 1 min. The additional force shall be equal to three times the weight of the equipment but not less than 50 N. The equipment and its associated mounting means shall remain secure during the test. After the test, the equipment, including any associated mounting plate, shall not be damaged.

4.3 Design and construction

4.3.1 Edges and corners

Where edges or corners could be hazardous to OPERATORS because of location or application in the equipment, they shall be rounded or smoothed.

This requirement does not apply to edges or corners that are required for proper functioning of the equipment.

Compliance is checked by inspection.

4.3.2 Handles and 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 create a hazard. Sealing compounds and the like, other than self-hardening resins, shall not be used to prevent loosening.

If handles, knobs and the like 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 create 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; and*

– *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; and*

– *50 N in other cases.*

4.3.3 Adjustable controls

Equipment shall be so constructed that manual adjustment of a control device, such as a device for selection of different AC MAINS SUPPLY voltages, requires the use of a TOOL if incorrect setting or inadvertent adjustment might create a hazard.

NOTE Marking requirements for supply voltage adjustment are in 1.7.4.

Compliance is checked by manual test.

4.3.4 Securing of parts

Screws, nuts, washers, springs or similar parts shall be secured so as to withstand mechanical stresses occurring in normal use if loosening would create a hazard, or if CLEARANCES or CREEPAGE DISTANCES for SUPPLEMENTARY INSULATION or REINFORCED INSULATION would be reduced below the values specified in 2.10 (or Annex G).

NOTE 1 Requirements regarding fixing of conductors are in 3.1.9.

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; and*

– *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.*

NOTE 2 Spring washers and the like can provide satisfactory locking.

4.3.5 Connection by plugs and sockets

Within a manufacturer's unit or system, plugs and sockets likely to be used by the OPERATOR or by a SERVICE PERSON shall not be employed in a manner likely to create a hazard due to misconnection. In particular, connectors complying with IEC 60083 or IEC 60320 shall not be used for SELV CIRCUITS or TNV CIRCUITS. Keying, location or, in the case of connectors accessible only to a SERVICE PERSON, clear markings are permitted to meet the requirement.

Compliance is checked by inspection.

4.3.6 Direct plug-in equipment

DIRECT PLUG-IN EQUIPMENT shall not impose undue stress on the socket-outlet. The mains plug part shall comply with the standard for the relevant mains plug.

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

The equipment is inserted, as in normal use, into a fixed socket-outlet of a configuration as intended by the manufacturer, which can be pivoted about a horizontal axis intersecting the centre lines of the contacts at a distance of 8 mm behind the engagement face of the socket-outlet. The additional torque that has to be applied to the socket-outlet to maintain the engagement face in the vertical plane shall not exceed 0,25 N · m.

NOTE 1 In Australia and New Zealand, compliance is checked in accordance with AS/NZS 3112.

NOTE 2 In the United Kingdom, the torque test is performed using a socket-outlet complying with BS 1363, and the plug part of DIRECT PLUG-IN EQUIPMENT shall be assessed to the relevant clauses of BS 1363.

4.3.7 Heating elements in earthed equipment

Heating elements in equipment that is earthed for safety purposes shall be protected so that, under earth fault conditions, a fire hazard due to overheating is prevented. In such equipment, temperature sensing devices, if provided, shall be located in all line conductors supplying the heating elements.

The temperature sensing devices shall also disconnect the neutral conductor for each of the following cases:

a) in equipment supplied from an IT power distribution system;

b) in PLUGGABLE EQUIPMENT supplied through a reversible appliance coupler or a reversible plug;

c) in 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.

It is not required to disconnect the conductors simultaneously.

Compliance is checked by inspection.

4.3.8 Batteries

NOTE 1 Requirements for markings or instructions are given in 1.7.13.

NOTE 2 Requirements for overcurrent protection are given in 3.1.1 and 5.3.1.

NOTE 3 Requirements for stationary batteries (such as large secondary batteries installed in a fixed installation and external to the equipment) are given in IEC 60896-21, IEC 60896-22 and EN 50272-2.

Portable secondary sealed cells and batteries (other than button) containing alkaline or other non-acid electrolyte shall comply with IEC 62133.

Equipment containing batteries shall be designed to reduce the risk of fire, explosion and chemical leaks under normal conditions and after a single fault in the equipment (see 1.4.14)~~, including a fault in circuitry within the equipment battery pack~~. For USER-replaceable batteries, the design shall reduce the likelihood of reverse polarity installation if this would create a hazard.

Battery circuits shall be designed so that:

– the output characteristics of a battery charging circuit are compatible with its rechargeable battery; and
– for non-rechargeable batteries, discharging at a rate exceeding the battery manufacturer's recommendations, and unintentional charging, are prevented; and
– for rechargeable batteries, charging and discharging at a rate exceeding the battery manufacturer's recommendations, and reversed charging, are prevented; and
– OPERATOR-replaceable batteries shall either:
  - have contacts that cannot be shorted with the test finger Figure 2A; or
  - be inherently protected to avoid creating a hazard within the meaning of the standard.

NOTE 4 Reverse charging of a rechargeable battery occurs when the polarity of the charging circuit is reversed, aiding the discharge of the battery.

If a battery contains liquid or gel electrolyte, a battery tray shall be provided that is capable of retaining any liquid that could leak as a result of internal pressure build-up in the battery. The requirement to provide a battery tray does not apply if the construction of the battery is such that leakage of the electrolyte from the battery is unlikely (see also 1.3.6).

NOTE 5 An example of a battery construction where leakage of the electrolyte is considered to be unlikely is the sealed cell valve-regulated type.

If a battery tray is required, its capacity shall be at least equal to the volume of electrolyte of all the cells of the battery, or the volume of a single cell if the design of the battery is such that simultaneous leakage from multiple cells is unlikely.

NOTE 6 If several cells (for example, the six cells in a 12 V lead-acid battery) are in a single casing, its fracture could lead to a greater volume of leakage than from a single cell.

Compliance is checked by inspection and by evaluation of the data provided by the equipment manufacturer and battery manufacturer.

When appropriate data is not available, compliance is checked by test. However, batteries that are inherently safe for the conditions given are not tested under those conditions. Consumer grade, non-rechargeable carbon-zinc or alkaline batteries are considered safe under short-circuiting conditions and therefore are not tested for discharge; nor are such batteries tested for leakage under storage conditions.

The battery used for the following tests is either a new non-rechargeable battery or a fully charged rechargeable battery as provided with, or recommended by the manufacturer for use with, the equipment.

– ~~***Overcharging of a rechargeable battery**. The battery is charged under each of the following conditions in turn.*~~

- ~~*The battery charging circuit is adjusted with the battery disconnected to give 106 % of the rated output voltage of the charger, or the maximum charging voltage available from the charger (without simulation of faults), whichever is the higher attainable value. The battery is then charged for 7 h.*~~

– ~~*The battery charging circuit is adjusted, with the battery disconnected, to 100 % of the rated output voltage of the charger. The battery is charged while briefly subjected to the simulation of any single component failure that is likely to occur in the charging circuit and that results in overcharging of the battery. To minimize testing time, the failure is chosen that causes the highest overcharging current. The battery is then charged for a single period of 7 h with that simulated failure in place.*~~

– ***Overcharging of a rechargeable battery.** The battery is charged while briefly subjected to the simulation of any SINGLE FAULT CONDITION that is likely to occur in the charging circuit and that results in overcharging of the battery. To minimize testing time, the failure is chosen that causes the worst-case overcharging condition. The battery is then charged for a single period of 7h with the simulated failure in place.*

– ***Unintentional charging of a non-rechargeable battery.** The battery is charged while briefly subjected to the simulation of any single component failure that is likely to occur in the charging circuit and that would result in unintentional charging of the battery. To minimize testing time, the failure is chosen that causes the highest charging current. The battery is then charged for a single period of 7 h with that simulated failure in place.*

– ***Reverse charging of a rechargeable battery**. The battery is reverse charged while briefly subjected to the simulation of any single component failure that is likely to occur in the charging circuit and that would result in reverse charging of the battery. To minimize testing time, the failure is chosen that causes the highest reverse charging current. The battery is then reverse charged for a single period of 7 h with that simulated failure in place.*

– ***Excessive discharging rate for any battery**. The battery is subjected to rapid discharge by open-circuiting or short-circuiting any current-limiting or voltage-limiting components in the load circuit of the battery under test.*

NOTE 7 Some of the tests specified can be hazardous to the persons carrying them out; all appropriate measures to protect personnel against possible chemical or explosion hazards should be taken.

These tests shall not result in any of the following:

– *chemical leaks caused by cracking, rupturing or bursting of the battery jacket, if such leakage could adversely affect required insulation; or*

– *spillage of liquid from any pressure relief device in the battery, unless such spillage is contained by the equipment without risk of damage to the insulation or harm to the USER; or*

– *explosion of the battery, if such explosion could result in injury to a USER; or*

– *emission of flame or expulsion of molten metal to the outside of the equipment ENCLOSURE.*

After completion of the tests, the equipment is subjected to the electric strength tests of 5.3.9.2.

4.3.9 Oil and grease

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, and by evaluation of the data for the insulating material.

4.3.10 Dust, powders, liquids and gases

Equipment producing dust (for example, paper dust) or using powders, liquids or gases shall be so constructed that it is unlikely that either a dangerous concentration of these materials or a hazard in the meaning of this standard will be created by condensation, vaporization, leakage, spillage or corrosion during normal operation, storage, filling or emptying. CLEARANCES and CREEPAGE DISTANCES shall not be reduced below the values specified in 2.10 (or Annex G).

Compliance is checked by inspection, measurement and, where spillage of liquid could affect electrical insulation during replenishment, by the following test and, for flammable liquids, by the tests of 4.3.12.

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

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 5.2.2 on any insulation on which spillage could have occurred and inspection shall show that the liquid has not created a hazard in 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.

4.3.11 Containers for liquids or gases

Equipment that, in normal use, contains liquids or gases shall incorporate adequate safeguards against build-up of excessive pressure.

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

4.3.12 Flammable liquids

If a 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 l. If, however, the usage of liquid is such that more than 5 l is consumed in 8 h, it is permitted to increase the quantity stored to that required for an 8 h operation.

Oil or equivalent liquids 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 liquid and shall incorporate means for pressure relief. This requirement is not applicable to lubricating oils that are applied to points of friction in quantities that 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 sufficient pressure to cause atomization.

Replenishable flammable liquids that have a flash point of less than 60 °C or that are under sufficient pressure to cause atomization are permitted provided inspection shows that there is no likelihood of liquid sprays or build-up of flammable vapour-air mixtures that could cause explosion or create a 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 that risk of fire or explosion is reduced, even under the test conditions specified in 4.2.5.

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

The equipment is operated in accordance with 4.5.2 until its temperature stabilizes. In this condition, the equipment is operated in a normal manner, as directed in the operating 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.

4.3.13 Radiation

4.3.13.1 General

Equipment shall be so designed that the risk of harmful effects of radiation to persons, and damage to materials affecting safety, is reduced.

Compliance is checked by inspection and as detailed in 4.3.13.2, 4.3.13.3, 4.3.13.4, 4.3.13.5 and 4.3.13.6 as appropriate.

4.3.13.2 Ionizing radiation

For equipment that generates ionizing radiation, compliance is checked by the test in Annex H.

4.3.13.3 Effect of ultraviolet (UV) radiation on materials

The following requirements apply only to equipment containing lamps that produce significant UV radiation, that is, having emission predominantly in the spectrum 180 nm to 400 nm, as specified by the lamp manufacturer.

NOTE General-purpose incandescent and fluorescent lamps, with ordinary glass envelopes, are not considered to emit significant UV radiation. A lamp that has UV in the spectrum from 180 nm to 400 nm as its predominant radiation emission (as specified by the lamp manufacturer), and emits higher than 0,001 W/m^2 irradiance, is considered to produce "significant" radiation.

Non-metallic parts (for example, non-metallic ENCLOSURES and internal materials including wire and cable insulation) that are exposed to UV radiation from a lamp in the equipment, shall be sufficiently resistant to degradation to the extent that safety is not affected.

Table 4A – Minimum property retention limits after UV exposure

Parts to be tested	Property	Standard for the test method	Minimum retention after test
Parts providing mechanical support	Tensile strength [a] or Flexural strength [a b]	ISO 527	70 %
		ISO 178	70 %
Parts providing impact resistance	Charpy impact [c] or Izod impact [c] or Tensile impact [c]	ISO 179	70 %
		ISO 180	70 %
		ISO 8256	70 %
All parts	Flammability classification	See 1.2.12 and Annex A	See [d]

[a] Tensile strength and flexural strength tests are to be conducted on specimens no thicker than the actual thicknesses.

[b] The side of the sample exposed to UV radiation is to be in contact with the two loading points when using the three point loading method.

[c] Tests conducted on 3,0 mm thick specimens for Izod impact and Tensile impact tests and 4,0 mm thick specimens for Charpy impact tests are considered representative of other thicknesses, down to 0,8 mm.

[d] The flammability classification may change as long as it does not fall below that specified in Clause 4.

Compliance is checked by examination of the construction and of available data regarding the UV resistance characteristics of the parts exposed to UV radiation in the equipment. If such data is not available, the tests in Table 4A are conducted on the parts.

Samples taken from the parts, or consisting of identical material, are prepared according to the standard for the test to be conducted. They are then conditioned according to Annex Y. After conditioning, the samples shall show no signs of significant deterioration, such as crazing or cracking. They are then kept at room ambient conditions for not less than 16 h and not more than 96 h, after which they are tested according to the standard for the relevant test.

In order to evaluate the percent retention of properties after test, samples that have not been conditioned according to Annex Y are tested at the same time as the conditioned samples. The retention shall be as specified in Table 4A.

4.3.13.4 Human exposure to ultraviolet (UV) radiation

The following requirements apply only to equipment containing lamps that produce significant UV radiation, that is having emission predominantly in the spectrum 180 nm to 400 nm as specified by the lamp manufacturer.

NOTE 1 General purpose incandescent and fluorescent lamps, with ordinary glass envelopes, are not considered to emit significant UV radiation. A lamp that has UV in the spectrum from 180 nm to 400 nm as its predominant radiation emission (as specified by the lamp manufacturer), and emits higher than 0,001 W/m^2 irradiance, is considered to produce "significant" radiation.

Equipment that produces a combination of visible light and UV light that is only emitted through a glass focusing lens having a 90 % UV attenuation up to 400 nm is exempt if there are no other openings through which visible radiation is emitted.

NOTE 2 Glass with a thickness of 2 mm usually complies with this requirement.

Equipment shall not emit excessive UV radiation.

UV radiation shall either

– be adequately contained by the ENCLOSURE of the UV lamp or the ENCLOSURE of the equipment, or

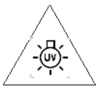
– not exceed the relevant limits given in IEC 60825-9.

During normal operation, the relevant limit is that for 8 h exposure.

Higher limits are permitted for limited periods of time for maintenance and cleaning operations, if it is necessary for the UV lamp to be on during these operations. The relevant limits are those for the expected time intervals for these operations, which shall be stated in the USER and servicing instructions.

All USER access doors and covers that, if opened, would allow access to higher emissions than those permitted above shall be marked with one of the following (see also 1.7.12):

– "WARNING: TURN OFF THE UV LAMP BEFORE OPENING", or equivalent; or

– the symbol  or equivalent.

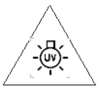
It is permitted for the above marking to be beside a door or cover, or on a door provided that the door is secured to the equipment.

The above marking is not required for a door or cover that is provided with a SAFETY INTERLOCK switch (see 2.8) that disconnects power to the UV lamp when the door or cover is opened, or any other mechanism that prevents UV radiation.

If the UV radiation symbol is used on the equipment, both the symbol and a warning similar to the above marking shall appear together in the USER and servicing instructions.

If higher emissions than those permitted above are accessible in a SERVICE ACCESS AREA, and it is necessary for the equipment to remain energized while being serviced, the equipment shall be marked with one of the following:

– "WARNING: USE UV RADIATION EYE AND SKIN PROTECTION DURING SERVICING", or equivalent; or

– the symbol  or equivalent.

The marking shall be located where readily visible during the servicing operation (see also 1.7.12).

If the UV radiation symbol is used on the equipment, both the symbol and a warning similar to the above marking shall appear together in the servicing instructions.

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

UV radiation is measured using a scanning spectrograph or a specific detector having a spectral response equal to the relative spectral effectiveness for the UV range.

The UV radiation exposure and effective irradiance during normal operation shall not exceed the limits given in IEC 60825-9 for an 8 h exposure.

The UV radiation exposure and effective irradiance during maintenance and cleaning operations shall not exceed the limits in IEC 60825-9 corresponding to the exposure times stated for these operations in the relevant instructions. The maximum permitted radiation is that for 30 min exposure.

NOTE ~~2~~ 3 The permitted radiation is increased as the exposure time is reduced.

All USER access doors and covers, and parts such as lenses, filters and the like, if their opening or removal could result in an increase in the UV radiation, shall be opened or removed during measurements, unless provided with a SAFETY INTERLOCK switch that disconnects the power to the UV lamp, or any other mechanism that prevents UV radiation.

NOTE ~~3~~ 4 For guidance on measuring techniques, see CIE Publication 63.

4.3.13.5 Lasers ~~(including LEDs)~~ (including laser diodes) and LEDs

4.3.13.5.1 Lasers (including laser diodes)

Except as permitted below, equipment shall be classified and labelled according to IEC 60825-1, IEC 60825-2 and IEC 60825-12, as applicable.

Equipment that is inherently a Class I laser product, ~~that is~~ which means the equipment contains no laser or ~~light emitting diode (LED)~~ laser diode of a higher class number, is not required to have a laser warning label or other laser statement.

The data for a laser or ~~LED components~~ a laser diode shall confirm that these components comply with the Accessible Emission Limit for Class I when measured according to IEC 60825-1, for the above exception to apply. The data may be obtained from the component manufacturer (see 1.4.15) and can relate to the component alone or to the component in its intended application in the equipment. The lasers or ~~LEDs~~ laser diodes shall produce radiation only in the wavelength range of 180 nm to 1 mm.

Compliance is checked by inspection, by evaluation of the data provided by the manufacturer and, if necessary, by testing according to IEC 60825-1.

4.3.13.5.2 Light emitting diodes (LEDs)

Equipment containing LEDs that produce optical radiation in excess of the limits specified in IEC 62471 in the wavelength range 200 nm to 3 000 nm, as specified by the lamp manufacturer, shall be provided with means (such as an interlock, barriers, guards or the equivalent) to reduce the likelihood of optical radiation exceeding the limits specified in IEC 62471 from appearing in USER accessible areas. Low power applications of LEDs need not comply with IEC 62471.

NOTE 1 Some examples of low power applications of LEDs that will normally comply are those used as:

– indicating lights;
– infra-red devices such as are used in home entertainment devices;
– infra-red devices for data transmission, such as are used between computers and computer peripherals;
– optocouplers; and
– other similar low power devices.

Compliance is checked by evaluation of available data sheets, by inspection and, if necessary, by measurement.

NOTE 2 For guidance on measuring techniques, see IEC 62471.

NOTE 3 If optical radiation is broadband visible and IR-A radiation and the luminance of the source does not exceed 10^4 cd/m^2, it is expected that the radiation does not exceed the exposure limits given in 4.3 of IEC 62471:2006 (see 4.1 of IEC 62471:2006).

4.3.13.6 Other types

For other types of radiation, compliance is checked by inspection.

4.4 Protection against hazardous moving parts

4.4.1 General

Except for moving fan blades, hazardous moving parts of the equipment (~~that is~~ which means moving parts that have the potential to cause injury) shall be so arranged, enclosed or guarded as to reduce the risk of injury to persons. Moving fan blades are evaluated in accordance with 4.4.5.

AUTOMATIC RESET THERMAL CUT-OUTS or overcurrent protection devices, automatic timer starting, etc., shall not be incorporated if unexpected resetting might create a hazard.

Compliance is checked by inspection and as detailed in 4.4.2, 4.4.3 and 4.4.4.

4.4.2 Protection in operator access areas

In an OPERATOR ACCESS AREA, protection shall be provided by a suitable construction reducing the likelihood of access to hazardous moving parts, or by locating the moving parts in an ENCLOSURE provided with mechanical or electrical SAFETY INTERLOCKS that remove the hazard when access is gained. HOUSEHOLD AND HOME/OFFICE DOCUMENT/MEDIA SHREDDERS shall also comply with Annex EE.

Where it is not possible to comply fully with the above access requirements and also allow the equipment to function as intended, access is permitted provided that:

– the hazardous moving part concerned is directly involved in the process (for example, moving parts of a paper cutter); and
– the hazard associated with the part is obvious to the OPERATOR; and
– additional measures are taken as follows:
  - a statement shall be provided in the operating instructions and a marking shall be fixed to the equipment, each containing the following or a similar appropriate wording;

WARNING
HAZARDOUS MOVING PARTS
KEEP FINGERS AND OTHER BODY PARTS AWAY

  - where the possibility exists that fingers, jewellery, clothing, etc., can be drawn into the moving parts, means shall be provided to enable the OPERATOR to stop the moving part.

The above warning notice 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 greatest.

Compliance is checked by inspection and where necessary by a test with the test finger, Figure 2A (see 2.1.1.1), after removal of OPERATOR-detachable parts, and with OPERATOR access doors and covers open.

Unless additional measures have been taken as specified above, it shall not be possible to touch hazardous moving parts with the test finger, applied without appreciable force in every possible position.

Openings preventing the entry of the test finger, Figure 2A (see 2.1.1.1), 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 2A (see 2.1.1.1), is repeated, except that the finger is pushed through the opening using any necessary force up to 30 N.

4.4.3 Protection in restricted access locations

For equipment to be installed in a RESTRICTED ACCESS LOCATION, the requirements and compliance criteria in 4.4.2 for OPERATOR ACCESS AREAS apply.

4.4.4 Protection in service access areas

In a SERVICE ACCESS AREA, protection shall be provided such that unintentional contact with hazardous moving parts is unlikely during servicing operations involving other parts of the equipment.

Compliance is checked by inspection.

4.4.5 Protection against moving fan blades

4.4.5.1 General

Equipment shall be so constructed that the likelihood of injury from moving fan blades has been minimized.

The likelihood of injury from moving fan blades is determined by calculating the *K* factor for each fan blade, where the *K* factor is equal to:

$$K = 6 \times 10^{-7} (m\, r^{2} N^{2})$$

Where:

- m is the mass (kg) of the moving part of the fan assembly (blade, shaft and rotor);
- r is the radius (mm) of the fan blade from the centre line of the motor (shaft) to the tip of the outer area likely to be contacted;
- N is the rotational speed (r/min) of the fan blade.

The classification of moving fan blades relative to their ability to cause injury is as follows:

a) a moving fan blade is not considered likely to cause pain or injury if

$$\frac{r\ /\mathrm{min}}{15000} + \frac{K\ \mathrm{factor}}{2\,400} \le 1$$

b) a moving fan blade is considered likely to cause pain, but is not considered likely to cause injury if

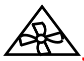
$$\frac{r\ /\mathrm{min}}{22000} + \frac{K\ \mathrm{factor}}{3\,600} \le 1$$

c) a moving fan blade that does not comply with a) or b) above is considered likely to cause injury.

4.4.5.2 Protection for users

A moving fan blade classified as 4.4.5.1 a) may be located in an OPERATOR ACCESS AREA. Under a single fault condition, a moving fan blade classified as 4.4.5.1 a) may reach the limits permitted for a moving fan blade classified as 4.4.5.1 b).

A moving fan blade classified as 4.4.5.1 b) shall not be located in an OPERATOR ACCESS AREA during normal operation. Under a single fault condition, a moving fan blade classified as 4.4.5.1 b) shall remain within the limits of 4.4.5.1 b). If such a moving fan blade is accessible only during USER servicing, then a warning in accordance with the following shall be provided.

Either the symbol , or a similar symbol combined with the triangle shaped warning sign from ISO 3864-2, or the following statement or equivalent text shall be used:

WARNING Hazardous moving parts Keep away from moving fan blades

A moving fan blade classified as 4.4.5.1 c) that is arranged, located, enclosed or guarded so that the possibility of contact with the moving parts of the fan is unlikely by a USER during USER servicing, shall be provided with a warning as specified above.

During USER servicing conditions, where the equipment protection against access to a moving fan blade classified as 4.4.5.1 b) or 4.4.5.1 c) must be defeated or bypassed to perform the servicing, an instruction shall be provided to disconnect the power source prior to defeating or bypassing the equipment protection means, and to restore the equipment protection means before restoring power.

4.4.5.3 Protection for service persons

No equipment protection from moving fan blades is required for the protection for SERVICE PERSONS.

During servicing in areas where inadvertent contact with a moving fan blade classified as 4.4.5.1 c) is possible by a SERVICE PERSON, a marking in accordance with 4.4.5.2 shall be provided to identify the location of the moving fan blade along with any necessary instructions required for the SERVICE PERSON to avoid contacting the moving fan blade.

4.5 Thermal requirements

4.5.1 General

Subclause 4.5 specifies requirements intended to prevent:

– touchable parts from exceeding certain temperatures; and

– components, parts, insulation and plastic materials from exceeding temperatures that may degrade electrical, mechanical, or other properties during normal use over the expected life of the equipment.

Consideration shall be given to the fact that, on a long-term basis, the electrical and mechanical properties of certain insulating materials (see 2.9.1) may be adversely affected (for example, by softeners evaporating at temperatures below the normal softening temperatures of the materials).

During the tests of 4.5.2, audio amplifiers are operated in accordance with 4.2.4 of IEC 60065.

4.5.2 Temperature tests

Materials used in components and in the construction of the equipment shall be selected so that under NORMAL LOAD, temperatures do not exceed safe values in the meaning of this standard.

Components working at high temperature shall be effectively shielded or separated to avoid overheating of their adjacent materials and components.

Compliance is checked by inspection of material data sheets and by determining and recording the temperatures. The equipment or parts of the equipment are operated in accordance with 1.4.5 under NORMAL LOAD until the temperature has stabilized. For temperature limits, see 4.5.3 and 4.5.4.

NOTE See also 1.4.4, 1.4.10, 1.4.12 and 1.4.13.

It is permitted to test components and other parts independently provided that the test conditions applicable to the equipment are followed.

Equipment intended for building-in or rack-mounting, or for incorporation in larger equipment, is tested under the most adverse actual or simulated conditions permitted in the installation instructions.

The temperature of electrical insulation (other than that of windings, see 1.4.13), the failure of which could create a hazard, is measured on the surface of the insulation at a point close to the heat source (see Footnote a in Table 4B). During the test:

- *THERMAL CUT-OUTS and overcurrent protection devices shall not operate;*
- *THERMOSTATS are permitted to operate, provided that they do not interrupt the normal operation of the equipment;*
- *TEMPERATURE LIMITERS are permitted to operate;*
- *sealing compounds, if any, shall not flow out.*

4.5.3 Temperature limits for materials

The temperature of materials and components shall not exceed the values shown in Table 4B.

Table 4B – Temperature limits, materials and components

Part	Maximum temperature (T_{max}) °C
Insulation, including winding insulation: – of Class 105 material (A) – of Class 120 material (E) – of Class 130 material (B) – of Class 155 material (F) – of Class 180 material (H) – of Class 200 material – of Class 220 material – of Class 250 material	 100 [a b c] 115 [a b c] 120 [a b c] 140 [a b c] 165 [a b c] 180 [a b] 200 [a b] 225 [a b]
Rubber or PVC insulation of internal and external wiring, including power supply cords: – without temperature marking – with temperature marking	 75 [d] Temperature marking
Other thermoplastic insulation	See [e]
Terminals, including earthing terminals for external earthing conductors of STATIONARY EQUIPMENT, unless provided with a NON-DETACHABLE POWER SUPPLY CORD	85
Parts in contact with a flammable liquid	See 4.3.12
Components	See 1.5.1

[a] If the temperature of a winding is determined by thermocouples, these values are reduced by 10 °C, except in the case of

– a motor, or

– a winding with embedded thermocouples.

[b] For each material, account shall be taken of the data for that material to determine the appropriate maximum temperature.

[c] The designations A to H, formerly assigned in IEC 60085 to thermal classes 105 to 180, are given in parentheses.

[d] If there is no marking on the wire, the marking on the wire spool or the temperature rating assigned by the wire manufacturer is considered acceptable.

[e] It is not possible to specify maximum permitted temperatures for thermoplastic materials, due to their wide variety. These shall pass the tests specified in 4.5.5.

4.5.4 Touch temperature limits

The temperatures of accessible parts in OPERATOR ACCESS AREAS shall not exceed the values shown in Table 4C.

Table 4C – Touch temperature limits

Parts in OPERATOR ACCESS AREAS	Maximum temperature (T_{max}) °C		
	Metal	**Glass, porcelain and vitreous material**	**Plastic and rubber** [b]
Handles, knobs, grips, etc., held or touched for short periods only	60	70	85
Handles, knobs, grips, etc., continuously held in normal use	55	65	75
External surfaces of equipment that may be touched [a]	70	80	95
Parts inside the equipment that may be touched [c]	70	80	95

[a] Temperatures up to 100 °C are permitted on the following parts:

– areas on the external surface of equipment that have no dimension exceeding 50 mm, and that are not likely to be touched in normal use; and

– a part of equipment requiring heat for the intended function (for example, a document laminator), provided that this condition is obvious to the USER. A warning shall be marked on the equipment in a prominent position adjacent to the hot part.

The warning shall be either

- the symbol (IEC 60417-5041 (DB:2002-10)): 
- or the following or similar wording

WARNING
HOT SURFACE
DO NOT TOUCH

[b] For each material, account shall be taken of the data for that material to determine the appropriate maximum temperature.

[c] Temperatures exceeding the limits are permitted provided that the following conditions are met:

– unintentional contact with such a part is unlikely; and

– the part has a marking indicating that this part is hot. It is permitted to use the following symbol (IEC 60417-5041 (DB:2002-10)) to provide this information.

For equipment intended for installation in a RESTRICTED ACCESS LOCATION, the temperature limits in Table 4C apply, except that for external metal parts that are evidently designed as heat sinks or that have a visible warning, a temperature of 90 °C is permitted.

4.5.5 Resistance to abnormal heat

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 ball pressure test according to IEC 60695-10-2. 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 this test.

The test is made in a heating cabinet at a temperature of $(T – T_{amb} + T_{ma} + 15\ °C) \pm 2\ °C$.

However, a thermoplastic part supporting parts in a PRIMARY CIRCUIT is tested at a minimum of 125 °C.

The significances of T, T_{ma} *and* T_{amb} *are as given in 1.4.12.1.*

4.6 Openings in enclosures

NOTE 1 Subclauses 4.6.1 and 4.6.2 do not apply to TRANSPORTABLE EQUIPMENT. Subclause 4.6.4 applies to TRANSPORTABLE EQUIPMENT only.

NOTE 2 Additional requirements concerning openings in ENCLOSURES are in 2.1.1.

4.6.1 Top and side openings

For equipment that is intended to be used in more than one orientation (see 1.3.6), the requirements of 4.6.1 apply in each appropriate orientation.

Openings in the top and sides of ENCLOSURES, except for ENCLOSURES of TRANSPORTABLE EQUIPMENT (see 4.6.4), shall be so located or constructed that it is unlikely that objects will enter the openings and create hazards by contacting bare conductive parts.

NOTE 1 Hazards include energy hazards, and those created by bridging of insulation or by OPERATOR access to parts at HAZARDOUS VOLTAGE (for example, via metal jewellery).

Openings, located behind doors, panels, covers, etc., that can be opened or removed by an OPERATOR, are not required to comply provided that the equipment openings comply with the doors, panels and covers closed or in place.

Where a portion of the side of a FIRE ENCLOSURE falls within the area traced out by the 5° angle in Figure 4E, the limitations in 4.6.2 on sizes of openings in bottoms of FIRE ENCLOSURES also apply to this portion of the side.

Compliance is checked by inspection and measurement. Except for that portion of the side of a FIRE ENCLOSURE that is subject to the requirements of 4.6.2 (see above paragraph), any one of the following is considered to satisfy the requirements (other constructions are not excluded):

– *openings that do not exceed 5 mm in any dimension;*
– *openings that do not exceed 1 mm in width regardless of length;*
– *top openings in which vertical entry is prevented (see Figure 4B for examples);*
– *side openings provided with louvres that are shaped to deflect outwards an external vertically falling object (see Figure 4C for examples);*
– *top or side openings, as shown in Figure 4D, that are not located vertically, or within a volume V bounded by a 5° vertical projection up to the size of opening L, above bare conductive parts:*
  - *at HAZARDOUS VOLTAGE, or*
  - *that present an energy hazard within the meaning of 2.1.1.5.*

NOTE 2 The examples of Figures 4B, 4C, 4D and 4E are not intended to be used as engineering drawings but are only shown to illustrate the intent of these requirements.

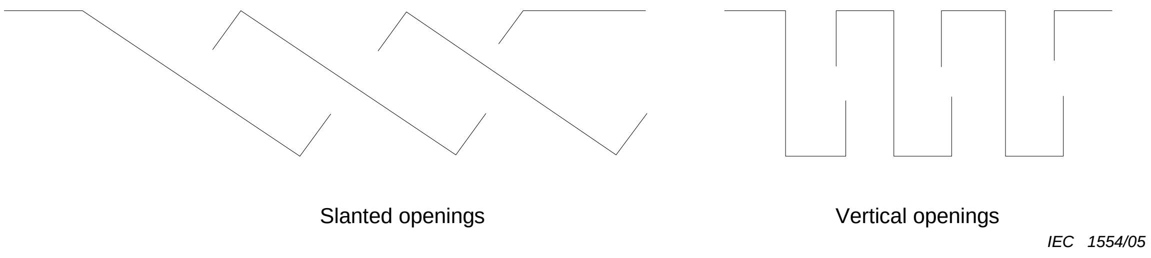


Figure 4B – Examples of cross-sections of designs of openings preventing vertical access

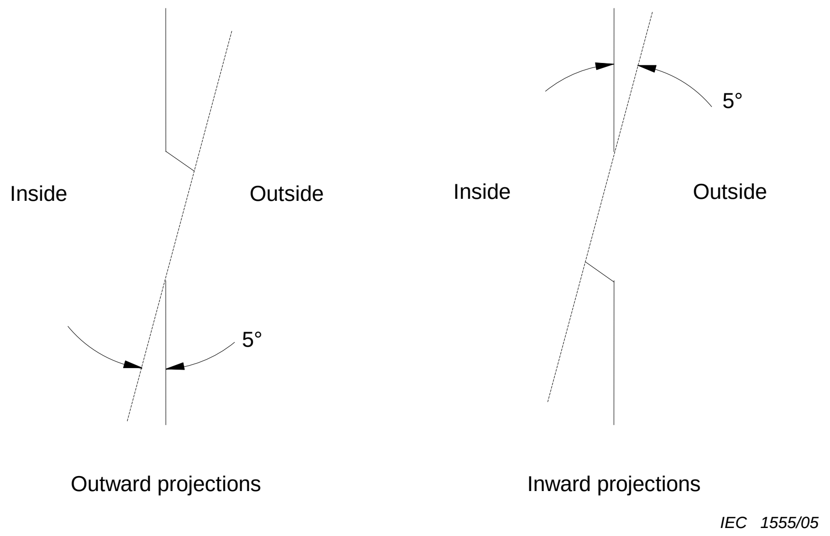
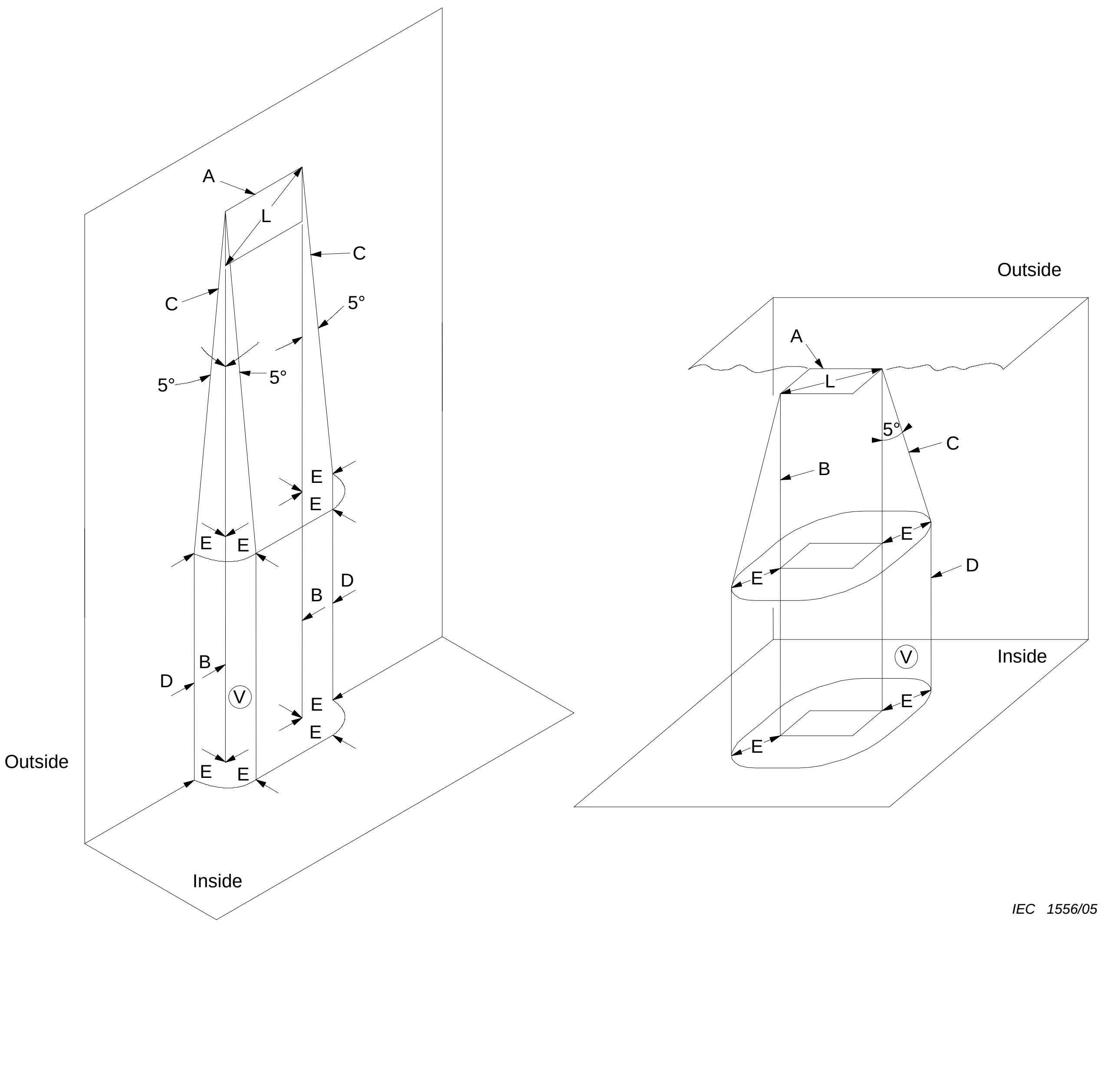


Figure 4C – Examples of louvre design



A ENCLOSURE opening.

B Vertical projection of the outer edges of the opening.

C Inclined lines that project at a 5° angle from the edges of the opening to points located E distance from B.

D Line that is projected straight downward in the same plane as the ENCLOSURE side wall.

E Projection of the outer edge of the opening (B) and the inclined line (C) (not to be greater than L).

L Maximum dimension of the ENCLOSURE opening.

V Volume in which bare parts at HAZARDOUS VOLTAGE, or which are energy hazards (see 4.6.1), are not located.

Figure 4D – Enclosure openings

4.6.2 Bottoms of fire enclosures

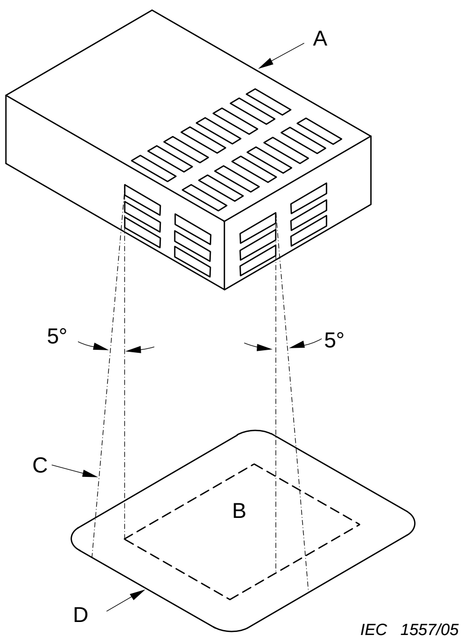
For equipment that is intended to be used in more than one orientation (see 1.3.6), the requirements of 4.6.2 apply in each appropriate orientation.

The bottom of a FIRE ENCLOSURE (except for the FIRE ENCLOSURE of a TRANSPORTABLE EQUIPMENT) 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.

NOTE See 4.7.2.2 for parts that do not require a FIRE ENCLOSURE.

The bottom or barrier shall be located as, and no smaller in area than, indicated in Figure 4E and be horizontal, lipped or otherwise shaped to provide equivalent protection.

An opening in the bottom shall be protected by a baffle, screen or other means so that molten metal and burning material are unlikely to fall outside the FIRE ENCLOSURE.



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 round 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 that is within the area traced out by the 5° angle is also considered to be part of the bottom of the FIRE ENCLOSURE.

Figure 4E – Typical bottom of a fire enclosure for partially enclosed component or assembly

The requirements of 4.6.2 do not apply to STATIONARY EQUIPMENT intended only for use in a RESTRICTED ACCESS LOCATION and to be mounted on a concrete floor or other non-combustible surface. Such equipment shall be marked as follows:

SUITABLE FOR MOUNTING ON CONCRETE OR OTHER NON-COMBUSTIBLE SURFACE ONLY

Compliance is checked by inspection and, where necessary, by the test of Clause A.3.

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 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 and parts meeting the requirements for V-1 CLASS MATERIAL, or HF-1 CLASS FOAMED MATERIAL or under small components that pass the needle-flame test of IEC 60695-11-5 using a 30 s flame application;*
- *baffle plate construction as illustrated in Figure 4F;*
- *metal bottoms of FIRE ENCLOSURES conforming to the dimensional limits of any line in Table 4D;*
- *metal bottom screens having a mesh with nominal openings not greater than 2 mm between centre lines and with wire diameters of not less than 0,45 mm.*

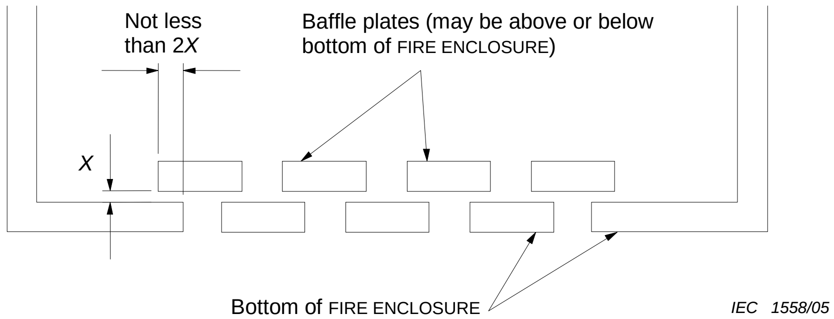


Figure 4F – Baffle plate construction

Table 4D – Size and spacing of openings in metal bottoms of fire enclosures

Applicable to circular holes			Applicable to other shaped openings	
Metal bottom minimum thickness mm	**Maximum diameter of holes** mm	**Minimum spacing of holes centre to centre** mm	**Maximum area** mm²	**Minimum spacing of openings border to border** mm
0,66	1,1	1,7	1,1	0,56
0,66	1,2	2,3	1,2	1,1
0,76	1,1	1,7	1,1	0,55
0,76	1,2	2,3	1,2	1,1
0,81	1,9	3,1	2,9	1,1
0,89	1,9	3,1	2,9	1,2
0,91	1,6	2,7	2,1	1,1
0,91	2,0	3,1	3,1	1,2

1,0	1,6	2,7	2,1	1,1
1,0	2,0	3,0	3,2	1,0

4.6.3 Doors or covers in fire enclosures

If part of a FIRE ENCLOSURE consists of a door or cover leading to an OPERATOR ACCESS AREA, it shall comply with one of the following requirements:

– 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 other parts of the FIRE ENCLOSURE by the OPERATOR; and

  • 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, is permitted to be removable provided that the operating instructions include directions for correct removal and reinstallation of the door or cover.

Compliance is checked by inspection.

4.6.4 Openings in transportable equipment

The risk of ignition caused by small metallic objects, such as paper clips or staples, moving around inside TRANSPORTABLE EQUIPMENT during transportation shall be reduced by measures to minimize the likelihood of such objects entering the equipment and bridging bare conductive parts that may result in a fire hazard. Except as required in 4.6.4.3, provision of such measures is not required for bare conductive parts between which the power is limited in accordance with 2.5.

NOTE The above requirement only applies to bare conductive parts. Conductive parts covered with conformal or other coatings are not considered to be bare conductive parts.

Compliance is checked according to 4.6.4.1, 4.6.4.2 and 4.6.4.3 as appropriate. During the inspection and tests, all doors or covers are closed or in place and peripheral devices or assemblies, such as disk drives, batteries, etc., are installed as intended.

4.6.4.1 Constructional design measures

Examples of acceptable constructional design measures are:

– providing openings that do not exceed 1 mm in width regardless of length; or

– providing a screen having a mesh with openings not greater than 2 mm between centre lines and constructed with a thread or wire diameter of not less than 0,45 mm; or

– providing internal barriers; or

– other equivalent constructional means.

NOTE Screens provided to limit the entry of small objects form part of the ENCLOSURE and the requirements in 4.7 for FIRE ENCLOSURES may apply, see also 1.3.6.

Compliance is checked by inspection and measurement and, if necessary, by simulating the entry of objects that could bridge bare conductive parts.

4.6.4.2 Evaluation measures for larger openings

Openings larger than specified in 4.6.4.1 are permitted (see also 2.1.1.1), provided that fault testing is conducted to simulate bridging along a direct straight path between bare conductive parts (for metallized parts, see 4.6.4.3) located less than 13 mm away from each other in all areas within the equipment that do not meet the criteria of 4.6.4.1.

Compliance is checked by inspection and measurement and by simulated fault testing. Bridging is considered to exist between bare conductive parts that can be contacted simultaneously using a straight metal object, 1 mm in diameter and having any length up to 13 mm, applied without appreciable force. During the fault tests, there shall be no ignition of any non-metallic materials and no emission of molten metal.

4.6.4.3 Use of metallized parts

Where metallized parts of a plastic barrier or ENCLOSURE are within 13 mm of parts of circuits where the available power is greater than 15 VA, one of the following requirements a) or b) or c) applies:

a) access by a foreign metallic object shall be limited in accordance with 4.6.4.1, whether or not the available power meets the limits of 2.5; or

b) there shall be a barrier between the bare conductive parts and the metallized barrier or ENCLOSURE; or

c) fault testing shall be conducted to simulate bridging along a direct path between a bare conductive part and the nearest metallized part of a barrier or ENCLOSURE that is within 13 mm of the bare conductive part.

NOTE Examples of metallized plastic barriers or ENCLOSURES include those made of conductive composite materials or that are electroplated, vacuum-deposited, painted or foil lined.

Compliance is checked by inspection and measurement and, where appropriate, by test. If simulated fault testing is conducted, no ignition of the metallized barrier or ENCLOSURE shall occur.

4.6.5 Adhesives for constructional purposes

If a barrier or screen provided to comply with 4.6.1, 4.6.2 or 4.6.4 is secured with adhesive to the inside of the ENCLOSURE or to other parts inside the ENCLOSURE, the adhesive shall have adequate bonding properties throughout the life of the equipment.

Compliance is checked by examination of the construction and of the available data. If such data is not available, compliance is checked by the following tests.

A sample of the equipment or a part of the ENCLOSURE with the barrier or screen attached is evaluated with the sample placed with the barrier or screen on the underside.

Condition the sample in an oven at one of the following temperatures for the time durations specified:

100 °C ± 2 °C for one week; or

90 °C ± 2 °C for three weeks; or

82 °C ± 2 °C for eight weeks.

Upon completion of the temperature conditioning, subject the sample to the following:

– *remove the sample from oven and leave it at any convenient temperature between 20 °C and 30 °C for 1 h;*

– *place the sample in a freezer at -40 °C ± 2 °C for 4 h;*

– *remove and allow the sample to come to any convenient temperature between 20 °C and 30 °C for 8 h;*

– *place the sample in a cabinet at 91 % to 95 % relative humidity for 72 h;*

– *remove the sample and leave it at any convenient temperature between 20 °C and 30 °C for 1 h;*

– *place the sample in an oven at the temperature used for the temperature conditioning for 4 h;*

– *remove the sample and allow it to reach any convenient temperature between 20 °C; and 30 °C for 8 h.*

The sample is then immediately subjected to the tests of 4.2 as applicable. The barrier or screen shall not fall off or partly dislodge as a result of these tests.

With the concurrence of the manufacturer, it is permitted to increase any of the above time durations.

4.7 Resistance to fire

This subclause specifies requirements intended to reduce the risk of ignition and the spread of flame, both within the equipment and to the outside, by the appropriate use of materials and components and by suitable construction.

NOTE 1 The risk of ignition is reduced by limiting the maximum temperature of components under normal operating conditions and after a single fault (see 1.4.14), or by limiting the power available in a circuit.

NOTE 2 The spread of flame in the event of ignition is reduced by the use of flame retardant materials and insulation, or by providing adequate separation.

NOTE 3 For a ranking of materials with respect to flammability, refer to the notes in 1.2.12.1.

NOTE 4 In Australia and New Zealand, an alternative set of fire tests is also accepted.

Metals, ceramic materials and glass shall be considered to comply without test.

4.7.1 Reducing the risk of ignition and spread of flame

For equipment or a portion of equipment, there are two alternative methods of providing protection against ignition and spread of flame that could affect materials, wiring, wound components and electronic components such as integrated circuits, transistors, thyristors, diodes, resistors and capacitors.

Method 1 – Selection and application of components, wiring and materials that reduce the possibility of ignition and spread of flame and, where necessary, by the use of a FIRE ENCLOSURE. The appropriate requirements are detailed in 4.7.2 and 4.7.3. In addition, the simulated faults of 5.3.7 are applied, except for 5.3.7 c), when using this method.

NOTE 1 Method 1 may be preferred for equipment or that portion of equipment with a large number of electronic components.

Method 2 – Application of all of the simulated fault tests in 5.3.7. A FIRE ENCLOSURE is not required for equipment or that portion of equipment for which only Method 2 is used. In particular, 5.3.7 c) applies, which includes testing all relevant components in both PRIMARY CIRCUITS and SECONDARY CIRCUITS.

NOTE 2 Method 2 may be preferred for equipment or that portion of equipment with a small number of electronic components.

4.7.2 Conditions for a fire enclosure

A FIRE ENCLOSURE is required when temperatures of parts under fault conditions could be sufficient for ignition.

4.7.2.1 Parts requiring a fire enclosure

Except where Method 2 of 4.7.1 is used, or as permitted in 4.7.2.2, the following are considered to have a risk of ignition and, therefore, require a FIRE ENCLOSURE:

– components in PRIMARY CIRCUITS;

- components in SECONDARY CIRCUITS supplied by power sources that exceed the limits specified in 2.5;
- components in SECONDARY CIRCUITS supplied by limited power sources as specified in 2.5, but not mounted on V-1 CLASS MATERIAL;
- components within a power supply unit or assembly having a limited power output as specified in 2.5, including overcurrent protective devices, limiting impedances, regulating networks and wiring, up to the point where the limited power source output criteria are met;
- components having unenclosed arcing parts, such as open switch and relay contacts and commutators, in a circuit at HAZARDOUS VOLTAGE or at a HAZARDOUS ENERGY LEVEL; and
- insulated wiring.

4.7.2.2 Parts not requiring a fire enclosure

The following do not require a FIRE ENCLOSURE:

- motors;
- transformers;
- electromechanical components complying with 5.3.5;
- wiring and cables insulated with PVC, TFE, PTFE, FEP, polychloroprene or polyimide;
- plugs and connectors forming part of a power supply cord or INTERCONNECTING CABLE;
- components, including connectors, meeting the requirements of 4.7.3.2, which fill an opening in a FIRE ENCLOSURE;
- connectors in SECONDARY CIRCUITS supplied by power sources that are limited to a maximum of 15 VA (see 1.4.11) under normal operating conditions and after a single fault in the equipment (see 1.4.14);
- connectors in SECONDARY CIRCUITS supplied by limited power sources complying with 2.5;
- other components in SECONDARY CIRCUITS:
  - supplied by limited power sources complying with 2.5 and mounted on V-1 CLASS MATERIAL;
  - supplied by internal or external power sources that are limited to a maximum of 15 VA (see 1.4.11) under normal operating conditions and after a single fault in the equipment (see 1.4.14) and mounted on HB75 CLASS MATERIA,L if the thinnest significant thickness of this material is < 3 mm, or HB40 CLASS MATERIAL, if the thinnest significant thickness of this material is ≥ 3 mm;

NOTE In Canada and the United States, additional requirements may apply, see Clause 6, Note 5.

  - complying with Method 2 of 4.7.1;
- equipment, or a part of the equipment, having a momentary contact switch that the USER has to activate continuously, and the release of which removes all power from the equipment or part.

Compliance with 4.7.2.1 and 4.7.2.2 is checked by inspection and by evaluation of the data provided by the manufacturer. In the case where no data is provided, compliance is determined by tests.

4.7.3 Materials

4.7.3.1 General

ENCLOSURES, components and other parts shall be so constructed, or shall make use of such materials, that the propagation of fire is limited.

VTM-0 CLASS MATERIAL, VTM-1 CLASS MATERIAL and VTM-2 CLASS MATERIAL are considered to be equivalent to V-0 CLASS MATERIAL, V-1 CLASS MATERIAL and V-2 CLASS MATERIAL, respectively, for their flammability properties. Their electrical and mechanical properties are not necessarily equivalent.

Where HB40 CLASS MATERIAL, HB75 CLASS MATERIAL or HBF CLASS FOAMED MATERIAL, is required, material passing the glow-wire test at 550 °C according to IEC 60695-2-11 is acceptable as an alternative.

Where it is not practical to protect components against overheating under fault conditions, the components shall be mounted on V-1 CLASS MATERIAL. Additionally, such components shall be separated from material of a class lower than V-1 CLASS MATERIAL (see 1.2.12.1, Note 2) by at least 13 mm of air, or by a solid barrier of V-1 CLASS MATERIAL.

NOTE 1 See also 4.7.3.5.

NOTE 2 In Canada and the United States, requirements in addition to 4.7.3.2 and 4.7.3.3 apply to ENCLOSURES and DECORATIVE PARTS having an external surface with an exposed area of greater than 0,9 m^2 or a single dimension greater than 1,8 m.

NOTE 3 In considering how to limit propagation of fire, and what are "small parts", account should 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.

NOTE 4 The material flammability requirements in 4.7.3 are summarized in Table 4E.

Compliance is checked by inspection and by evaluation of relevant data provided by the manufacturer.

4.7.3.2 Materials for fire enclosures

The following requirements apply as appropriate.

The 18 kg mass criterion applies to individual complete equipments, even if they are used in close proximity to each other (for example, one on top of another). However, if a part of the FIRE ENCLOSURE is removed in such a situation (in the same example, the bottom cover of the top equipment), the combined mass of the equipment applies. In determining the total mass of equipment, supplies, consumable materials, media and recording materials used with the equipment shall not be taken into account.

For MOVABLE EQUIPMENT having a total mass not exceeding 18 kg, the material of a FIRE ENCLOSURE, in the thinnest significant wall thickness used, shall be of V-1 CLASS MATERIAL or shall pass the test of Clause A.2.

For MOVABLE EQUIPMENT having a total mass exceeding 18 kg and for all STATIONARY EQUIPMENT, the material of a FIRE ENCLOSURE, in the thinnest significant wall thickness used, shall be of 5VB CLASS MATERIAL or shall pass the test of Clause A.1.

Materials for components that fill an opening in a FIRE ENCLOSURE, and that are intended to be mounted in this opening shall:

– be of V-1 CLASS MATERIAL; or
– pass the tests of Clause A.2; or
– comply with the flammability requirements of the relevant IEC component standard.

NOTE Examples of these components are fuseholders, switches, pilot lights, connectors and appliance inlets.

Plastic materials of a FIRE ENCLOSURE shall be located more than 13 mm through air from arcing parts such as unenclosed commutators and unenclosed switch contacts.

Plastic materials of a FIRE ENCLOSURE located less than 13 mm through air from non-arcing parts which, under any condition of normal or abnormal operation, could attain a temperature sufficient to ignite the material, shall be capable of passing the test of IEC 60695-2-20. The average time to ignition of the samples shall be not less than 15 s. If a sample melts through without igniting, the time at which this occurs is not considered to be the time to ignition.

Compliance is checked by inspection of the equipment and material data sheets and, if necessary, by the appropriate test or tests in Annex A or IEC 60695-2-20.

4.7.3.3 Materials for components and other parts outside fire enclosures

Except as otherwise noted below, materials for components and other parts (including MECHANICAL ENCLOSURES, ELECTRICAL ENCLOSURES and DECORATIVE PARTS), located outside FIRE ENCLOSURES, shall be of

– HB75 CLASS MATERIAL if the thinnest significant thickness of this material is < 3 mm, or

– HB40 CLASS MATERIAL if the thinnest significant thickness of this material is ≥ 3 mm, or

– HBF CLASS FOAMED MATERIAL.

NOTE Where a MECHANICAL ENCLOSURE or an ELECTRICAL ENCLOSURE also serves as a FIRE ENCLOSURE, the requirements for FIRE ENCLOSURES apply.

Requirements for materials in air filter assemblies are in 4.7.3.5 and for materials in high-voltage components in 4.7.3.6.

Connectors shall comply with one of the following:

– be made of V-2 CLASS MATERIAL; or

– pass the tests of Clause A.2; or

– comply with the flammability requirements of the relevant IEC component standard; or

– be mounted on V-1 CLASS MATERIAL and be of a small size; or

– be located in a SECONDARY CIRCUIT supplied by a power source that is limited to a maximum of 15 VA (see 1.4.11) under normal operating conditions and after a single fault in the equipment (see 1.4.14).

The requirement for materials for components and other parts to be of HB40 CLASS MATERIAL, HB75 CLASS MATERIAL, or HBF CLASS FOAMED MATERIAL, does not apply to any of the following:

– electrical components that do not present a fire hazard under abnormal operating conditions when tested according to 5.3.7;

– materials and components within an ENCLOSURE of 0,06 m^3 or less, consisting totally of metal and having no ventilation openings, or within a sealed unit containing an inert gas;

– meter cases (if otherwise determined to be suitable for mounting of parts at HAZARDOUS VOLTAGE), meter faces and indicator lamps or their jewels;

– components meeting the flammability requirements of a relevant IEC component standard that includes such requirements;

– electronic components, such as integrated circuit packages, optocoupler packages, capacitors and other small parts that are:

  - mounted on V-1 CLASS MATERIAL; or
  - supplied from a power source of no more than 15 VA (see 1.4.11) under normal operating conditions or after a single fault in the equipment (see 1.4.14) and mounted on HB75 CLASS MATERIAL if the thinnest significant thickness of this material is < 3 mm, or HB40 CLASS MATERIAL if the thinnest significant thickness of this material is ≥ 3 mm;

– wiring, cables and connectors insulated with PVC, TFE, PTFE, FEP, polychloroprene or polyimide;

– individual clamps (not including helical wraps or other continuous forms), lacing tape, twine and cable ties used with wiring harnesses;

– gears, cams, belts, bearings and other small parts that would contribute negligible fuel to a fire, including DECORATIVE PARTS, labels, mounting feet, key caps, knobs and the like;

– supplies, consumable materials, media and recording materials;

– parts that 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.

Compliance is checked by inspection of the equipment and material data sheets and, if necessary, by the appropriate test or tests in Annex A.

4.7.3.4 Materials for components and other parts inside fire enclosures

Requirements for materials in air filter assemblies are in 4.7.3.5 and requirements for materials in high-voltage components in 4.7.3.6. Requirements for voltage dependent resistors (VDR's) are in Annex Q.

Inside FIRE ENCLOSURES, materials for components and other parts, (including MECHANICAL ENCLOSURES and ELECTRICAL ENCLOSURES located inside FIRE ENCLOSURES), shall comply with one of the following:

– be of V-2 CLASS MATERIAL or HF-2 CLASS FOAMED MATERIAL; or

– pass the flammability test described in Clause A.2; or

– meet the flammability requirements of a relevant IEC component standard that includes such requirements.

The above requirement does not apply to any of the following:

– electrical components that do not present a fire hazard under abnormal operating conditions when tested according to 5.3.7;

– materials and components within an ENCLOSURE of 0,06 m^3 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 V-2 CLASS MATERIAL, or HF-2 CLASS FOAMED MATERIAL;

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 4.6.2 continue to apply to the FIRE ENCLOSURE.

– meter cases (if otherwise determined to be suitable for mounting of parts at HAZARDOUS VOLTAGE), meter faces and indicator lamps or their jewels;

– electronic components, such as integrated circuit packages, optocoupler packages, capacitors and other small parts that are mounted on V-1 CLASS MATERIAL;

– wiring, cables and connectors insulated with PVC, TFE, PTFE, FEP, polychloroprene or polyimide;

– individual clamps (not including helical wraps or other continuous forms), lacing tape, twine and cable ties used with wiring harnesses;

– 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 V-1 CLASS MATERIAL:

  • gears, cams, belts, bearings and other small parts that would contribute negligible fuel to a fire, including, labels, mounting feet, key caps, knobs and the like;

- supplies, consumable materials, media and recording materials;
- parts that 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;
- tubing for air or any fluid systems, containers for powders or liquids and foamed plastic parts, provided that they are of HB75 CLASS MATERIAL if the thinnest significant thickness of the material is < 3 mm, or HB40 CLASS MATERIAL if the thinnest significant thickness of the material is ≥ 3 mm, or HBF CLASS FOAMED MATERIAL.

Compliance is checked by inspection of the equipment and material data sheets and, if necessary, by the appropriate test or tests of Annex A.

4.7.3.5 Materials for air filter assemblies

Air filter assemblies shall be constructed of V-2 CLASS MATERIAL, or HF-2 CLASS FOAMED MATERIAL.

This requirement does not apply to the following constructions:

– air filter assemblies in air circulating systems, whether or not airtight, that are not intended to be vented outside the FIRE ENCLOSURE;

– 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 4.6.2 for the bottoms of FIRE ENCLOSURES;

– air filter assemblies constructed of

- HB75 CLASS MATERIAL if the thinnest significant thickness of this material is < 3 mm, or
- HB40 CLASS MATERIAL if the thinnest significant thickness of this material is ≥ 3 mm, or
- HBF CLASS FOAMED MATERIAL,

provided that they are separated by at least 13 mm of air, or by a solid barrier of V-1 CLASS MATERIAL, from electrical parts (other than insulated wires and cables) which under fault conditions are likely to produce a temperature that could cause ignition.

Compliance is checked by inspection of the equipment and material data sheets and, if necessary, by appropriate tests.

4.7.3.6 Materials used in high-voltage components

High-voltage components operating at peak-to-peak voltages exceeding 4 kV shall either be of V-2 CLASS MATERIAL, or HF-2 CLASS FOAMED MATERIAL, or comply with 14.4 of IEC 60065 or pass the needle flame test according to IEC 60695-11-5.

Compliance is checked by inspection of the equipment and material data sheets and, if necessary, by

– *the tests for V-2 CLASS MATERIAL or HF-2 CLASS FOAMED MATERIAL; or*

– *the test described in 14.4 of IEC 60065; or*

– *the needle flame test according to IEC 60695-11-5.*

In addition, the following details apply, referring to clauses of IEC 60695-11-5:

Clause 7 – Severities

The test flame is applied for 10 s. If a self-sustaining flame does not last longer than 30 s, the test flame is applied again for 1 min at the same point or at any other point. If again a self-sustaining flame does not last longer than 30 s, the test flame is then applied for 2 min at the same point or at any other point.

Clause 8 – Conditioning

Except for high voltage transformers and high voltage multipliers the samples are stored for 2 h in an oven at a temperature of 100 °C ± 2 °C.

For high voltage transformers, a power of 10 W (d.c. or a.c. at mains frequency) is initially supplied to the high-voltage winding. This power is maintained for 2 min, after which it is increased by successive steps of 10 W at 2 min intervals to 40 W.

The treatment lasts 8 min or is terminated as soon as interruption of the winding or appreciable splitting of the protective covering occurs.

NOTE 1 Certain transformers are so designed that this preconditioning cannot be conducted. In such cases the oven preconditioning applies.

For high-voltage multipliers, a voltage taken from an appropriate high-voltage transformer, is supplied to each sample, its output circuit being short-circuited.

The input voltage is adjusted so that the short-circuit current is initially 25 mA ± 5 mA. This current is maintained for 30 min or is terminated as soon as any interruption of the circuit or appreciable splitting of the protective covering occurs.

NOTE 2 Where the design of a high-voltage multiplier is such that a short-circuit current of 25 mA cannot be obtained, a preconditioning current is used, which represents the maximum attainable current, determined either by the design of the multiplier or by its conditions of use in a particular apparatus.

Clause 11 – Evaluation of test results

After the first application of the test flame, the test sample shall not be consumed completely.

After any application of the test flame, any self-sustaining flame shall extinguish within 30 s. No burning of the WRAPPING TISSUE *shall occur and the board shall not be scorched.*

Table 4E – Summary of material flammability requirements

Part		**Requirement**
FIRE ENCLOSURES 4.7.3.2	MOVABLE EQUIPMENT > 18 kg and STATIONARY EQUIPMENT	– 5VB – Test A.1 – Hot wire test of IEC 60695-2-20 (If <13 mm of air from parts at high temperatures that could cause ignition)
	MOVABLE EQUIPMENT ≤ 18 kg	– V-1 – Test A.2 – Hot wire test of IEC 60695-2-20 (If < 13 mm of air from parts at high temperatures that could cause ignition)
	Parts that fill an opening	– V-1 – Test A.2 – Component standard
Components and parts, including MECHANICAL ENCLOSURES and ELECTRICAL ENCLOSURES, outside FIRE ENCLOSURES 4.7.3.1 and 4.7.3.3		– HB40 for thicknesses ≥ 3 mm – HB75 for thicknesses < 3 mm

	– HBF – Glow-wire test 550 °C of IEC 60695-2-11 For connectors and exceptions see 4.7.3.3
Components and parts, including MECHANICAL ENCLOSURES and ELECTRICAL ENCLOSURES, inside FIRE ENCLOSURES 4.7.3.4	– V-2 – HF-2 – Test A.2 – Component standard For exceptions see 4.7.3.4
Air filter assemblies 4.7.3.5	– V-2 – HF-2 – Test A.2 For exceptions see 4.7.3.5
High voltage (> 4 kV) components 4.7.3.6	– V-2 – HF-2 – Test of 14.4 of IEC 60065 – Needle flame test of IEC 60695-11-5

5 Electrical requirements and simulated abnormal conditions

5.1 Touch current and protective conductor current

In this subclause measurements of current through networks simulating the impedance of the human body are referred to as measurements of TOUCH CURRENT.

Except for application of 5.1.8.2, these requirements do not apply to equipment intended to be supplied by only a DC MAINS SUPPLY.

5.1.1 General

Equipment shall be so designed and constructed that neither TOUCH CURRENT nor PROTECTIVE CONDUCTOR CURRENT is likely to create an electric shock hazard.

Compliance is checked by testing in accordance with 5.1.2 to 5.1.7 inclusive, and, if relevant, 5.1.8 (see also 1.4.4).

However, if it is clear from a study of the circuit diagrams of either STATIONARY PERMANENTLY CONNECTED EQUIPMENT or STATIONARY PLUGGABLE EQUIPMENT TYPE B, that has a PROTECTIVE EARTHING CONDUCTOR, that the TOUCH CURRENT will exceed 3,5 mA r.m.s., but that the PROTECTIVE CONDUCTOR CURRENT will not exceed 5 % of input current, the tests of 5.1.5, 5.1.6 and 5.1.7.1 a) are not made.

NOTE In the above case, the requirement of 5.1.7.1 b) continues to apply.

5.1.2 Configuration of equipment under test (EUT)

5.1.2.1 Single connection to an a.c. mains supply

Systems of interconnected equipment with individual connections to the AC MAINS SUPPLY shall have each piece of equipment tested separately. Systems of interconnected equipment with one common connection to the AC MAINS SUPPLY shall be treated as a single piece of equipment. See also 1.4.10 regarding the inclusion of optional features.

NOTE Systems of interconnected equipment are specified in more detail in Annex A of IEC 60990.

5.1.2.2 Redundant multiple connections to an a.c. mains supply

Equipment that is designed for multiple connections to the AC MAINS SUPPLY, only one of which is required at a time, shall be tested with only one connection.

5.1.2.3 Simultaneous multiple connections to an a.c. mains supply

Equipment requiring power simultaneously from two or more AC MAINS SUPPLIES *shall be tested with all* AC MAINS SUPPLIES *connected.*

The total TOUCH CURRENT *through all* PROTECTIVE EARTHING CONDUCTORS *that are connected to each other and to earth is measured.*

A PROTECTIVE EARTHING CONDUCTOR *that is not connected within the equipment to other earthed parts in the equipment shall not be included in the above tests. If an a.c. power source has such a* PROTECTIVE EARTHING CONDUCTOR *it shall be tested separately according to 5.1.2.1 (see also 5.1.7.2).*

5.1.3 Test circuit

Equipment is tested using the test circuit in Figure 5A (for single-phase equipment to be connected only to a star TN or TT power distribution system) or Figure 5B (for three-phase equipment to be connected only to a star TN or TT power distribution system) or where appropriate, another test circuit from Figures 7, 9, 10, 12, 13 or 14 of IEC 60990.

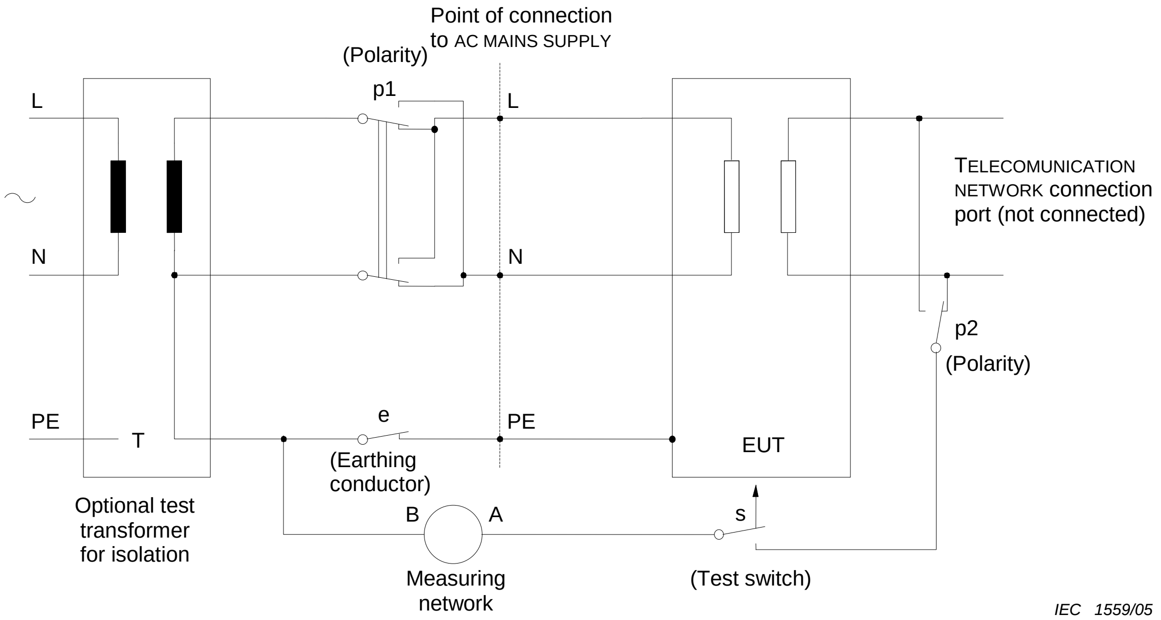
The use of a test transformer for isolation is optional. For maximum protection, a test transformer for isolation (T in Figures 5A and 5B) is used and the main protective earthing terminal of the EUT is earthed. Any capacitive leakage in the transformer shall then be taken into account. As an alternative to earthing the EUT, the test transformer secondary and the EUT are left floating (not earthed) in which case capacitive leakage in the transformer need not be taken into account.

If transformer T is not used, the EUT and the test circuitry shall not be earthed. The EUT is mounted on an insulating stand, and appropriate safety precautions are taken in view of the possibility of the BODY *of the equipment being at a* HAZARDOUS VOLTAGE.

Equipment to be connected to an IT power distribution system is tested accordingly (see Figures 9, 10 and 12 of IEC 60990). Such equipment may also be connected to a TN or TT power distribution system without further test.

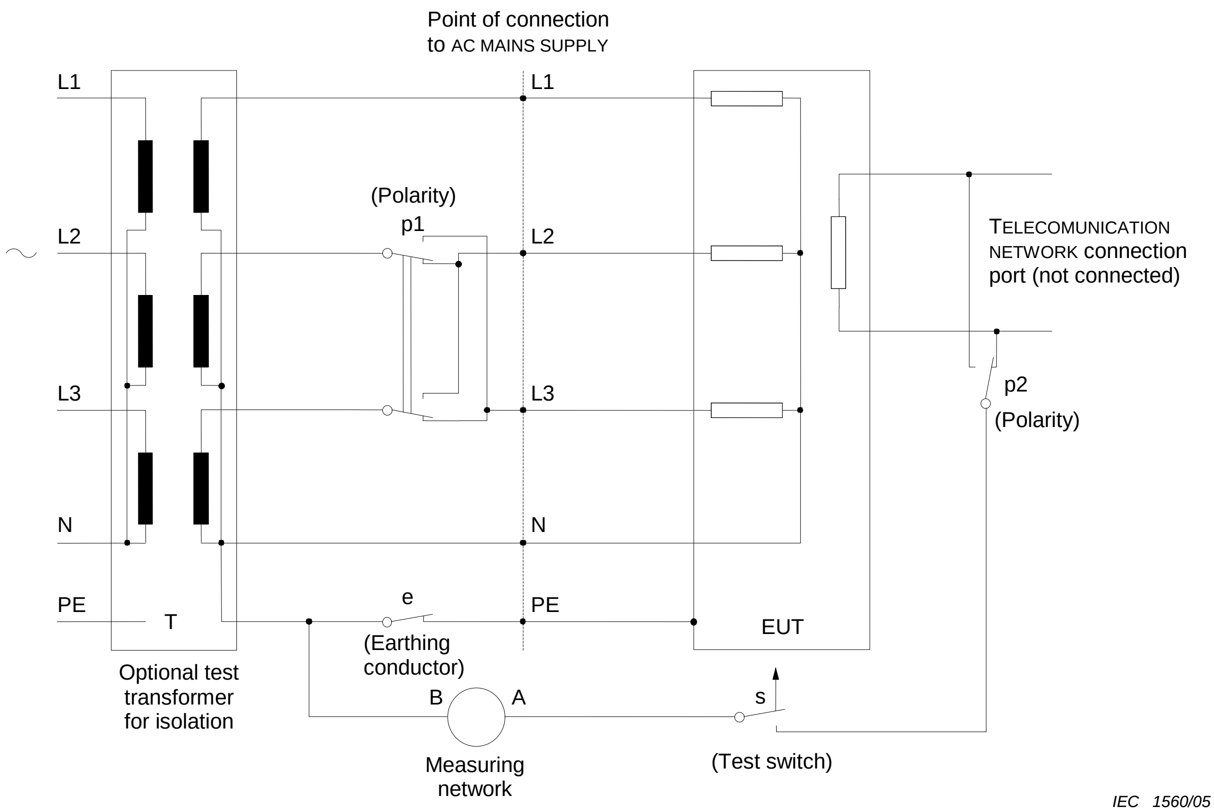
Single-phase equipment intended to be operated between two line conductors is tested using a three-phase test circuit such as Figure 5B.

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



NOTE *This figure is derived from Figure 6 of IEC 60990.*

Figure 5A – Test circuit for touch current of single-phase equipment on a star TN or TT power supply system



NOTE This figure is derived from Figure 11 of IEC 60990.

Figure 5B – Test circuit for touch current of three-phase equipment on a star TN or TT power supply system

5.1.4 Application of measuring instrument

Tests are conducted using one of the measuring instruments in Annex D, or any other circuit giving the same results.

Terminal B of the measuring instrument is connected to the earthed (neutral) conductor of the supply (see Figure 5A or 5B).

Terminal A of the measuring instrument is connected as specified in 5.1.5.

For an accessible non-conductive part, the test is made to metal foil having dimensions of 100 mm by 200 mm in contact with the part. 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 prevent the metal foil from affecting the heat dissipation of the equipment.

NOTE 1 The foil test simulates hand contact.

Accessible conductive parts that are incidentally connected to other parts are tested both as connected and disconnected parts.

NOTE 2 Incidentally connected parts are described in more detail in Annex C of IEC 60990.

5.1.5 Test procedure

For equipment having a protective earthing connection or a FUNCTIONAL EARTHING *connection, terminal A of the measuring instrument is connected via measurement switch "s" to the main protective earthing terminal of the EUT, with the earthing conductor switch "e" open.*

The test is also conducted, on all equipment, with terminal A of the measuring network connected via measurement switch "s" to each unearthed or non-conductive accessible part and each unearthed accessible circuit, in turn, with the earthing conductor switch "e" closed.

Additionally:

– *for single-phase equipment, the tests are repeated in reverse polarity (switch "p1");*

– *for three-phase equipment, the tests are repeated in reverse polarity (switch "p1") unless the equipment is sensitive to phase sequence.*

When testing three-phase equipment, any components used for EMC purposes and connected between line 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. Each time a line-to-earth component is disconnected the sequence of switch operations is repeated.

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

For each placement of the measuring instrument, any switches in the PRIMARY CIRCUIT *and likely to be operated in normal use are open and closed in all possible combinations.*

After applying each test condition, the equipment is restored to its original condition, that is without fault or consequential damage.

5.1.6 Test measurements

Either the r.m.s. value of the voltage, U_2, is measured using the measuring instrument of Figure D.1, or the r.m.s. value of the current is measured using the measuring instrument of Figure D.2.

The D.1 instrument gives a more accurate measurement than the D.2 instrument if the waveform is non-sinusoidal and the fundamental frequency exceeds 100 Hz.

Alternatively, the peak value of the voltage, U_2, is measured using the measuring instrument described in Clause D.1.

If the voltage, U_2, is measured using the measuring instrument described in Clause D.1, the following calculation is used:

$$\text{TOUCH CURRENT } (A) = U_2 / 500$$

NOTE Although r.m.s. values of TOUCH CURRENT have traditionally been measured, peak values provide better correlation with the response of the human body to non-sinusoidal current waveforms.

None of the values measured in accordance with 5.1.6 shall exceed the relevant limits in Table 5A, except as permitted in 2.4 (see also 1.5.6 and 1.5.7) and 5.1.7.

Table 5A – Maximum current

<table>
<tr><th>Type of equipment</th><th>Terminal A of measuring instrument connected to:</th><th>Maximum TOUCH CURRENT mA r.m.s.[a]</th><th>Maximum PROTECTIVE CONDUCTOR CURRENT</th></tr>
<tr><td>All equipment</td><td>Accessible parts and circuits not connected to protective earth [b]</td><td>0,25</td><td>–</td></tr>
<tr><td>HAND-HELD</td><td rowspan="6">Equipment main protective earthing terminal (if any)</td><td>0,75</td><td>–</td></tr>
<tr><td>MOVABLE (other than HAND-HELD, but including TRANSPORTABLE EQUIPMENT)</td><td>3,5</td><td>–</td></tr>
<tr><td>STATIONARY, PLUGGABLE TYPE A</td><td>3,5</td><td>–</td></tr>
<tr><td>All other STATIONARY EQUIPMENT</td><td></td><td></td></tr>
<tr><td>– not subject to the conditions of 5.1.7</td><td>3,5</td><td>–</td></tr>
<tr><td>– subject to the conditions of 5.1.7</td><td>–</td><td>5 % of input current</td></tr>
<tr><td colspan="4">[a] If peak values of TOUCH CURRENT are measured, the maximum values are obtained by multiplying the r.m.s. values in the table by 1,414.
[b] Some unearthed accessible parts are covered in 1.5.6 and 1.5.7 and the requirements of 2.4 apply. These may be different from those in 5.1.6.</td></tr>
</table>

5.1.7 Equipment with touch current exceeding 3,5 mA

5.1.7.1 General

TOUCH CURRENT measurement results exceeding 3,5 mA r.m.s. are permitted for the following equipment having a main protective earthing terminal:

- STATIONARY PERMANENTLY CONNECTED EQUIPMENT;
- STATIONARY PLUGGABLE EQUIPMENT TYPE B;
- STATIONARY PLUGGABLE EQUIPMENT TYPE A with a single connection to the AC MAINS SUPPLY, and provided with a separate protective earthing terminal in addition to the main protective earthing terminal, if any (see 2.6.4.1). The installation instructions shall specify that this separate protective earthing terminal be permanently connected to earth;

NOTE 1 The above equipment is not required to be installed in a RESTRICTED ACCESS LOCATION. However, the requirement to be STATIONARY EQUIPMENT is more onerous than the similar requirements in 2.3.2.3 a) because the potential hazard is greater.

– MOVABLE or STATIONARY PLUGGABLE EQUIPMENT TYPE A for use in a RESTRICTED ACCESS LOCATION, with a single connection to the AC MAINS SUPPLY, and provided with a separate protective earthing terminal in addition to the main protective earthing terminal, if any (see 2.6.4.1). The installation instructions shall specify that this separate protective earthing terminal be permanently connected to earth;

NOTE 2 The limitation of use to a RESTRICTED ACCESS LOCATION is more onerous than the similar requirements in 2.3.2.3 a) because the potential hazard is greater.

– STATIONARY PLUGGABLE EQUIPMENT TYPE A with simultaneous multiple connections to the AC MAINS SUPPLY, intended to be used in a location having equipotential bonding (such as a telecommunication centre, a dedicated computer room or a RESTRICTED ACCESS LOCATION). A separate additional protective earthing terminal shall be provided on the equipment. The installation instructions shall require all of the following:

  - the building installation shall provide a means for connection to protective earth; and
  - the equipment is to be connected to that means; and
  - a SERVICE PERSON shall check whether or not the socket-outlet from which the equipment is to be powered provides a connection to the building protective earth. If not, the SERVICE PERSON shall arrange for the installation of a PROTECTIVE EARTHING CONDUCTOR from the separate protective earthing terminal to the protective earth wire in the building.

NOTE 3 In Finland, Norway and Sweden, TOUCH CURRENT measurement results exceeding 3,5 mA r.m.s. are permitted only for the following equipment:

- STATIONARY PLUGGABLE EQUIPMENT TYPE A that
  - is intended to be used in a RESTRICTED ACCESS LOCATION where equipotential bonding has been applied, for example, in a telecommunication centre,
  - has provision for a permanently connected PROTECTIVE EARTHING CONDUCTOR, and
  - is provided with instructions for the installation of that conductor by a SERVICE PERSON;
- STATIONARY PLUGGABLE EQUIPMENT TYPE B;
- STATIONARY PERMANENTLY CONNECTED EQUIPMENT.

NOTE 4 In Denmark, TOUCH CURRENT measurement results exceeding 3,5 mA r.m.s. are permitted only for PERMANENTLY CONNECTED EQUIPMENT and PLUGGABLE EQUIPMENT TYPE B.

If the result of the TOUCH CURRENT measurement on any of the above equipments exceeds 3,5 mA r.m.s., the following requirements a) and b) apply, and also, if relevant, those in 5.1.7.2.

a) The r.m.s. PROTECTIVE CONDUCTOR CURRENT shall not exceed 5 % of the input current per line under normal operating conditions. If the load is unbalanced, the largest of the three line currents shall be used for this calculation.

   To measure the PROTECTIVE CONDUCTOR CURRENT, the procedure for measuring TOUCH CURRENT is used but the measuring instrument is replaced by an ammeter of negligible impedance; and

b) one of the following labels, or a label with similar wording, shall be affixed adjacent to the equipment AC MAINS SUPPLY connection:

WARNING	**WARNING**
HIGH LEAKAGE CURRENT EARTH CONNECTION ESSENTIAL BEFORE CONNECTING SUPPLY	**HIGH TOUCH CURRENT EARTH CONNECTION ESSENTIAL BEFORE CONNECTING SUPPLY**

Compliance is checked by inspection and measurement.

5.1.7.2 Simultaneous multiple connections to the supply

The following applies to EUT tested in accordance with 5.1.2.3. If the result of the total TOUCH CURRENT measurement exceeds 3,5 mA r.m.s., the test is repeated with each AC MAINS SUPPLY and its PROTECTIVE EARTHING CONDUCTOR connected one at a time, with the other AC MAINS SUPPLIES, including their PROTECTIVE EARTHING CONDUCTORS, disconnected. However, if two connections to the AC MAINS SUPPLY are inseparable, for example, connections for a motor and its control circuits, they shall both be energized for a repeat test.

NOTE It is not expected that the EUT will operate normally during this test.

If the result of the TOUCH CURRENT measurement for any of the repeat tests exceeds 3,5 mA r.m.s., the requirements of 5.1.7.1 a) apply to that connection to the AC MAINS SUPPLY. For calculating 5 % of the input current per line, the input current from the AC MAINS SUPPLY, measured during the repeat test, is used.

5.1.8 Touch currents to telecommunication networks and cable distribution systems and from telecommunication networks

NOTE In this subclause, references to "TELECOMMUNICATION NETWORK connection ports" (or telecommunication ports) are intended to cover those connection points to which a TELECOMMUNICATION NETWORK is intended to be attached. Such references are not intended to include other data ports, such as those commonly identified as serial, parallel, keyboard, game, joystick, etc.

5.1.8.1 Limitation of the touch current to a telecommunication network or to a cable distribution system

The TOUCH CURRENT from equipment supplied from the AC MAINS SUPPLY to a TELECOMMUNICATION NETWORK or a CABLE DISTRIBUTION SYSTEM shall be limited.

Compliance is checked using the test circuit detailed in 5.1.3.

The tests are not applied to equipment where the circuit to be connected to a TELECOMMUNICATION NETWORK or a CABLE DISTRIBUTION SYSTEM is connected to a protective earthing terminal in the equipment; the TOUCH CURRENT from the EUT to the TELECOMMUNICATION NETWORK or the CABLE DISTRIBUTION SYSTEM is considered to be zero.

For equipment having more than one circuit to be connected to a TELECOMMUNICATION NETWORK or a CABLE DISTRIBUTION SYSTEM, the test is applied to only one example of each type of circuit.

For equipment that has no main protective earthing terminal, the earthing conductor switch "e", if connected to a FUNCTIONAL EARTHING terminal on the EUT, is left open. Otherwise it is closed.

Terminal B of the measuring instrument is connected to the earthed (neutral) conductor of the supply. Terminal A is connected via the measurement switch "s" and the polarity switch "p2" to the TELECOMMUNICATION NETWORK or CABLE DISTRIBUTION SYSTEM connection port.

For single-phase equipment, the test is made in all combinations of the polarity switches "p1" and "p2".

For three-phase equipment, the test is made in both positions of polarity switch "p2".

After applying each test condition, the equipment is restored to its original operating state.

Test measurements are made using one of the measuring instruments of Annex D as described in 5.1.6.

None of the values measured in accordance with 5.1.8.1 shall exceed 0,25 mA r.m.s.

5.1.8.2 Summation of touch currents from telecommunication networks

NOTE Annex W explains the background to 5.1.8.2.

An EUT that provides TELECOMMUNICATION NETWORK connection ports for connection of multiple items of other telecommunication equipment, shall not create a hazard for USERS and TELECOMMUNICATION NETWORK SERVICE PERSONS due to summation of TOUCH CURRENT.

In these requirements, abbreviations have the following meanings:

- I_1 is the TOUCH CURRENT received from other equipment via a TELECOMMUNICATION NETWORK at a telecommunication port of the EUT;
- ΣI_1 is the summation of TOUCH CURRENTS received from other equipment at all such telecommunication ports of the EUT;
- I_2 is the TOUCH CURRENT due to the AC MAINS SUPPLY of the EUT.

It shall be assumed that each telecommunication port receives 0,25 mA (I_1) from the other equipment, unless the actual current from the other equipment is known to be lower.

The following requirements, a) or b) as applicable, shall be met:

a) EUT with earthed telecommunication ports

For an EUT in which each telecommunication port is connected to the main protective earthing terminal of the EUT, the following items 1), 2) and 3) shall be considered:

1) If ΣI_1 (not including I_2) exceeds 3,5 mA:
   - the equipment shall have provision for a permanent connection to protective earth in addition to the PROTECTIVE EARTHING CONDUCTOR in the power supply cord of PLUGGABLE EQUIPMENT TYPE A or PLUGGABLE EQUIPMENT B; and
   - the installation instructions shall specify the provision of a permanent connection to protective earth with a cross-sectional area of not less than 2,5 mm^2, if mechanically protected, or otherwise 4,0 mm^2; and
   - one of the following labels, or a label with similar wording, shall be affixed adjacent to the permanent earth connection. It is permitted to combine this label with the label in 5.1.7.1 b).

WARNING

HIGH LEAKAGE CURRENT
EARTH CONNECTION ESSENTIAL
BEFORE MAKING
TELECOMMUNICATION NETWORK
CONNECTIONS

WARNING

HIGH TOUCH CURRENT
EARTH CONNECTION ESSENTIAL
BEFORE MAKING
TELECOMMUNICATION NETWORK
CONNECTIONS

2) ΣI_1 plus I_2 shall comply with the limits in Table 5A (see 5.1.6).
3) If relevant, such equipment shall comply with 5.1.7. The value of I_2 shall be used to calculate the 5 % input current limit per phase specified in 5.1.7.

Compliance with item a) is checked by inspection and, if necessary, by test.

If the equipment has provision for a permanent protective earth connection in accordance with item 1) above, it is not necessary to make any measurements, except that I_2 shall comply with the relevant requirements of 5.1.

TOUCH CURRENT tests, if necessary, are made using the relevant measuring instrument described in Annex D or any other instrument giving the same results. A capacitively coupled a.c. source of the same line frequency and phase as the AC MAINS SUPPLY is applied to each telecommunication port such that 0,25 mA, or the actual current from other equipment if known to be lower, is available to flow into that telecommunication port. The current flowing in the earthing conductor is then measured.

b) EUT whose telecommunication ports have no reference to protective earth

If the telecommunication ports on the EUT do not have a common connection, each telecommunication port shall comply with 5.1.8.1.

If all telecommunication ports or any groups of such ports have a common connection, the total TOUCH CURRENT from each common connection shall not exceed 3,5 mA.

Compliance with item b) is checked by inspection and, if necessary, by the tests of 5.1.8.1 or, if there are common connection points, by the following test.

A capacitively coupled a.c. source of the same frequency and phase as the AC MAINS SUPPLY is applied to each telecommunication port such that 0,25 mA, or the actual current from the other equipment if known to be lower, is available to flow into that telecommunication port. Common connection points are tested in accordance with 5.1, whether or not the points are accessible.

5.2 Electric strength

NOTE Where specific reference to conducting the electric strength test according to 5.2 is made in other parts of this standard, it is intended that the electric strength test be conducted with the equipment in a well-heated condition according to 5.2.1.

Where specific reference to conducting the electric strength test according to 5.2.2 is made in other parts of this standard, it is intended that the electric strength test be conducted without preheating according to 5.2.1.

5.2.1 General

The electric strength of the SOLID INSULATION used in the equipment shall be adequate.

Compliance is checked in accordance with 5.2.2 while the equipment is still in a well-heated condition immediately following the temperature test in 4.5.2.

If a component or subassembly is tested separately outside the equipment, it is brought to the temperature attained by that part during the temperature test in 4.5.2 (for example, by placing it in an oven) prior to performing the electric strength test. However, it is permitted to conduct electric strength testing of thin sheet material for SUPPLEMENTARY INSULATION or REINFORCED INSULATION, according to 2.10.5.9 or 2.10.5.10, at room temperature.

No electric strength test applies to insulation in a transformer between any winding and the core or screen, provided that the core or screen is totally enclosed or encapsulated and there is no electrical connection to the core or screen. However, the tests between parts that have terminations continue to apply.

5.2.2 Test procedure

Unless otherwise specified elsewhere in this standard the insulation is subjected either to a voltage of substantially sine-wave form having a frequency of 50 Hz or 60 Hz, or to a d.c. test voltage equal to the peak voltage of the prescribed a.c. test voltage.

The test voltages for electric strength for the appropriate grade of insulation [FUNCTIONAL INSULATION if required by 5.3.4 b), BASIC INSULATION, SUPPLEMENTARY INSULATION or REINFORCED INSULATION] are as specified in either:

– *Table 5B using the* PEAK WORKING VOLTAGE *(U), as determined in 2.10.2; or*

– *Table 5C using the* REQUIRED WITHSTAND VOLTAGE, *as determined in G.4.*

NOTE 1 In various places in this standard, special electric strength tests or test voltages are specified for certain situations. The test voltages in 5.2.2 do not apply to these situations.

NOTE 2 For consideration of temporary overvoltages, see IEC 60664-1.

For equipment in Overvoltage Category I and Overvoltage Category II, it is permitted to use either Table 5B or Table 5C. However, for a SECONDARY CIRCUIT *that is neither connected to protective earth nor provided with a protective screen in accordance with 2.6.1 e), Table 5C shall be used.*

For equipment in Overvoltage Category III and Overvoltage Category IV, Table 5C shall be used.

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

Where, elsewhere in this standard, ROUTINE TESTS *are required to be conducted in accordance with 5.2.2, it is permitted to reduce the duration of the electric strength test to 1 s and to reduce the test voltage permitted in Table 5C, if used, by 10 %.*

There shall be no insulation breakdown during the test.

Insulation breakdown is considered to have occurred when the current that flows as a result of the application of the test voltage rapidly increases in an uncontrolled manner, that is 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, insulating 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.

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

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 INSULATION *or* SUPPLEMENTARY INSULATION.

NOTE 3 Where there are capacitors across the insulation under test (for example, radio-frequency filter capacitors), it is recommended that d.c. test voltages are used.

NOTE 4 Components providing a d.c. path in parallel with the insulation to be tested, such as discharge resistors for filter capacitors, voltage limiting devices or surge suppressors, should be disconnected.

Where insulation of a transformer winding varies along the length of the winding in accordance with 2.10.1.5, an electric strength test method is used that stresses the insulation accordingly.

NOTE 5 An example of such a test method is an induced voltage test that is applied at a frequency sufficiently high to avoid saturation of the transformer. The input voltage is raised to a value that would induce an output voltage equal to the specified test voltage.

No test is applied to FUNCTIONAL INSULATION, *unless 5.3.4 b) has been selected.*

Table 5B – Test voltages for electric strength tests based on peak working voltages Part 1

<table>
<tr><th rowspan="4">Grade of Insulation</th><th colspan="7">Points of application (as appropriate)</th></tr>
<tr><th colspan="5">PRIMARY CIRCUIT to BODY
PRIMARY CIRCUIT to SECONDARY CIRCUIT
between parts in PRIMARY CIRCUITS</th><th colspan="2">SECONDARY CIRCUIT to BODY
between independent SECONDARY CIRCUITS</th></tr>
<tr><th colspan="5">WORKING VOLTAGE U, peak or d.c.</th><th colspan="2">WORKING VOLTAGE U</th></tr>
<tr><th>Up to and including 210 V [a]</th><th>Over 210 V up to and including 420 V [b]</th><th>Over 420 V up to and including 1,41 kV</th><th>Over 1,41 kV up to and including 10 kV [c]</th><th>Over 10 kV up to and including 50 kV</th><th>Up to and including 42,4 V peak or 60 V d.c. [d]</th><th>Over 42,4 V peak or 60 V d.c. up to and including 10 kV peak or d.c. [d]</th></tr>
<tr><th></th><th colspan="7">Test voltage, volts a.c. r.m.s.</th></tr>
<tr><td>FUNCTIONAL</td><td>1 000</td><td>1 500</td><td>see V_a in Table 5B, part 2</td><td>see V_a in Table 5B, part 2</td><td>1,06 U</td><td>500</td><td>see V_a in Table 5B, part 2</td></tr>
<tr><td>BASIC, SUPPLE-MENTARY</td><td>1 000</td><td>1 500</td><td>see V_a in Table 5B, part 2</td><td>see V_a in Table 5B, part 2</td><td>1,06 U</td><td>No test</td><td>see V_a in Table 5B, part 2</td></tr>
<tr><td>REINFORCED</td><td>2 000</td><td>3 000</td><td>3 000</td><td>see V_b in Table 5B, part 2</td><td>1,06 U</td><td>No test</td><td>see V_b in Table 5B, part 2</td></tr>
</table>

For PEAK WORKING VOLTAGES exceeding 10 kV peak or d.c. in SECONDARY CIRCUITS, the same test voltages as for PRIMARY CIRCUITS apply.

[a] Use this column for unearthed DC MAINS SUPPLIES up to and including 210 V [see 2.10.3.2 c)].

[b] Use this column for unearthed DC MAINS SUPPLIES over 210 V, up to and including 420 V [see 2.10.3.2 c)].

[c] Use this column for unearthed DC MAINS SUPPLIES over 420 V [see 2.10.3.2 c)].

[d] Use these columns for d.c. derived within the equipment from an AC MAINS SUPPLY or for DC MAINS SUPPLIES that are earthed within the same building.

Table 5B – Test voltages for electric strength tests based on peak working voltages Part 2

U peak or d.c.	V_a a.c. r.m.s.	V_b a.c. r.m.s.	U peak or d.c.	V_a a.c. r.m.s.	V_b a.c. r.m.s.	U peak or d.c.	V_a a.c. r.m.s.	V_b a.c. r.m.s.
34	500	800	250	1 261	2 018	1 750	3 257	3 257
35	507	811	260	1 285	2 055	1 800	3 320	3 320
36	513	821	270	1 307	2 092	1 900	3 444	3 444
38	526	842	280	1 330	2 127	2 000	3 566	3 566
40	539	863	290	1 351	2 162	2 100	3 685	3 685
42	551	882	300	1 373	2 196	2 200	3 803	3 803
44	564	902	310	1 394	2 230	2 300	3 920	3 920
46	575	920	320	1 414	2 263	2 400	4 034	4 034
48	587	939	330	1 435	2 296	2 500	4 147	4 147
50	598	957	340	1 455	2 328	2 600	4 259	4 259
52	609	974	350	1 474	2 359	2 700	4 369	4 369
54	620	991	360	1 494	2 390	2 800	4 478	4 478
56	630	1 008	380	1 532	2 451	2 900	4 586	4 586
58	641	1 025	400	1 569	2 510	3 000	4 693	4 693
60	651	1 041	420	1 605	2 567	3 100	4 798	4 798
62	661	1 057	440	1 640	2 623	3 200	4 902	4 902
64	670	1 073	460	1 674	2 678	3 300	5 006	5 006
66	680	1 088	480	1 707	2 731	3 400	5 108	5 108
68	690	1 103	500	1 740	2 784	3 500	5 209	5 209
70	699	1 118	520	1 772	2 835	3 600	5 309	5 309
72	708	1 133	540	1 803	2 885	3 800	5 507	5 507
74	717	1 147	560	1 834	2 934	4 000	5 702	5 702
76	726	1 162	580	1 864	2 982	4 200	5 894	5 894
78	735	1 176	588	1 875	3 000	4 400	6 082	6 082
80	744	1 190	600	1 893	3 000	4 600	6 268	6 268
85	765	1 224	620	1 922	3 000	4 800	6 452	6 452
90	785	1 257	640	1 951	3 000	5 000	6 633	6 633
95	805	1 288	660	1 979	3 000	5 200	6 811	6 811
100	825	1 319	680	2 006	3 000	5 400	6 987	6 987
105	844	1 350	700	2 034	3 000	5 600	7 162	7 162
110	862	1 379	720	2 060	3 000	5 800	7 334	7 334
115	880	1 408	740	2 087	3 000	6 000	7 504	7 504
120	897	1 436	760	2 113	3 000	6 200	7 673	7 673
125	915	1 463	780	2 138	3 000	6 400	7 840	7 840
130	931	1 490	800	2 164	3 000	6 600	8 005	8 005
135	948	1 517	850	2 225	3 000	6 800	8 168	8 168
140	964	1 542	900	2 285	3 000	7 000	8 330	8 330
145	980	1 568	950	2 343	3 000	7 200	8 491	8 491
150	995	1 593	1 000	2 399	3 000	7 400	8 650	8 650
152	1 000	1 600	1 050	2 454	3 000	7 600	8 807	8 807
[a] 155	1 000	1 617	1 100	2 508	3 000	7 800	8 964	8 964
[a] 160	1 000	1 641	1 150	2 560	3 000	8 000	9 119	9 119
[a] 165	1 000	1 664	1 200	2 611	3 000	8 200	9 273	9 273
[a] 170	1 000	1 688	1 250	2 661	3 000	8 400	9 425	9 425
[a] 175	1 000	1 711	1 300	2 710	3 000	8 600	9 577	9 577
[a] 180	1 000	1 733	1 350	2 758	3 000	8 800	9 727	9 727
[a] 184	1 000	1 751	1 400	2 805	3 000	9 000	9 876	9 876
185	1 097	1 755	1 410	2 814	3 000	9 200	10 024	10 024
190	1 111	1 777	1 450	2 868	3 000	9 400	10 171	10 171
200	1 137	1 820	1 500	2 934	3 000	9 600	10 317	10 317
210	1 163	1 861	1 550	3 000	3 000	9 800	10 463	10 463
220	1 189	1 902	1 600	3 065	3 065	10 000	10 607	10 607
230	1 214	1 942	1 650	3 130	3 130			
240	1 238	1 980	1 700	3 194	3 194			

Linear interpolation is permitted between the nearest two points.

[a] At these voltages, the values of V_b are determined by the general curve $V_b = 155{,}86\ U^{0{,}4638}$ and are not 1,6 V_a.

Table 5C – Test voltages for electric strength tests based on required withstand voltages

REQUIRED WITHSTAND VOLTAGE up to and including	Test voltage for ~~FUNCTIONAL~~, BASIC INSULATION or SUPPLEMENTARY INSULATION	Test voltage for REINFORCED INSULATION
kV peak	kV peak a.c or d.c.	
0,33	~~0,35~~ 0,33	~~0,7~~ 0,5
0,5	~~0,55~~ 0,5	~~1,1~~ 0,8
0,8	~~0,9~~ 0,8	~~1,8~~ 1,5
1,5	1,5	~~3~~ 2,5
2,5	2,5	~~5~~ 4
4,0	4~~,0~~	~~8~~ 6
6,0	6~~,0~~	~~10~~ 8
8,0	8~~,0~~	~~13~~ 12
12	12	~~19~~ 18
U [a]	~~1,0 x~~ *U*	~~1,6~~ 1,5 x *U*

Linear interpolation is permitted between the nearest two points.

If FUNCTIONAL INSULATION is tested (as required by 5.3.4 b), the test voltage for a WORKING VOLTAGE up to and including 42,4 V peak or 60 V d.c. shall not exceed 707 V peak or d.c. For a higher WORKING VOLTAGE, the test voltage given in Table 5B or Table 5C is used.

[a] *U* is any REQUIRED WITHSTAND VOLTAGE higher than 12,0 kV.

5.3 Abnormal operating and fault conditions

5.3.1 Protection against overload and abnormal 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 single fault (see 1.4.14), the equipment shall remain safe for an OPERATOR in 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 5.3. Before the start of each test, it is checked that the equipment is operating normally.

If a component or subassembly is so enclosed that short-circuiting or disconnection as specified in 5.3 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 subassembly as a whole shall pass the tests.

Equipment is tested by applying any condition that may be expected in normal use and foreseeable misuse.

In addition, equipment that is provided with a protective covering, is tested with the covering in place under normal idling conditions until steady conditions are established.

5.3.2 Motors

Under overload, locked rotor and other abnormal conditions, motors shall not create a hazard due to excessive temperatures.

NOTE Methods of achieving this include the following:

– the use of motors that do not overheat under locked-rotor conditions (protection by inherent or external impedance);
– the use in SECONDARY CIRCUITS of motors that may exceed the permitted temperature limits but that 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 that 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 test of Annex B.

5.3.3 Transformers

Transformers shall be protected against overload, for example, by

– overcurrent protection,
– internal THERMAL CUT-OUTS, or
– use of current limiting transformers.

Compliance is checked by the applicable tests of Clause C.1.

5.3.4 Functional insulation

For FUNCTIONAL INSULATION, CLEARANCES and CREEPAGE DISTANCES shall satisfy one of the following requirements a) or b) or c).

For insulation between a SECONDARY CIRCUIT and an inaccessible conductive part that is earthed for functional reasons, CLEARANCES and CREEPAGE DISTANCES shall satisfy a) or b) or c).

a) They meet the CLEARANCE and CREEPAGE DISTANCE requirements for FUNCTIONAL INSULATION in 2.10 (or Annex G).
b) They withstand the electric strength tests for FUNCTIONAL INSULATION in 5.2.2.
c) They are short-circuited where a short-circuit could cause
   - overheating of any material creating a risk of fire, unless the material that could be overheated is of V-1 CLASS MATERIAL, or
   - thermal damage to BASIC INSULATION, SUPPLEMENTARY INSULATION or REINFORCED INSULATION, thereby creating a risk of electric shock.

Compliance criteria for 5.3.4 c) are in 5.3.9.

5.3.5 Electromechanical components

Where a hazard is likely to occur, electromechanical components other than motors are checked for compliance with 5.3.1 by applying the following conditions:

– *mechanical movement shall be locked in the most disadvantageous position while the component is energized normally; and*
– *in the case of a component that is normally energized intermittently, a fault shall be simulated in the drive circuit to cause continuous energizing 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; and*
– *for other equipment and components: 5 min or up to interruption of the circuit due to a failure of the component (for example, burn-out) or to other consequences of the simulated fault condition, whichever is the shorter.*

For compliance criteria see 5.3.9.

5.3.6 Audio amplifiers in information technology equipment

Equipment having audio amplifiers shall be tested in accordance with 4.3.4 and 4.3.5 of IEC 60065. The equipment shall be operating normally before the tests are conducted.

5.3.7 Simulation of faults

For components and circuits other than those covered by 5.3.2, 5.3.3, 5.3.5 and 5.3.6, compliance is checked by simulating single fault conditions (see 1.4.14).

NOTE 1 In Canada and the United States, additional requirements for overloading and other fault simulation for internal circuit connections apply.

The following faults are simulated.

a) *Short-circuit or disconnection of any components in* PRIMARY CIRCUITS*.*
b) *Short-circuit or disconnection of any components where failure could adversely affect* SUPPLEMENTARY INSULATION *or* REINFORCED INSULATION*.*
c) *Short-circuit, disconnection or overloading of all relevant components and parts unless they comply with the requirements of 4.7.3.*

NOTE 2 An overload condition is any condition between NORMAL LOAD and maximum current condition up to short-circuit.

d) *Faults arising from connection of the most unfavourable load impedance to terminals and connectors that deliver power from the equipment, other than mains power outlets.*
e) *Other single faults specified in 1.4.14.*

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, EMC filtering components, switches and their interconnecting wiring, no fault is simulated, provided that the component complies with 5.3.4 a) or 5.3.4 b).*

NOTE 3 Such components are still subject to other requirements of this standard where applicable, including 1.5.1, 2.10.5, 4.7.3 and 5.2.2.

In addition to the compliance criteria given in 5.3.9, 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 regarding transformers that would require replacement.

5.3.8 Unattended equipment

Equipment intended for unattended use and having THERMOSTATS, TEMPERATURE LIMITERS and THERMAL CUT-OUTS, 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 4.5.2 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 not intended for continuous operation, the test is repeated until the temperature has stabilized, regardless of any marking of RATED OPERATING TIME *or* RATED RESTING TIME. *For this test the* THERMOSTATS, TEMPERATURE LIMITERS *and* THERMAL CUT-OUTS *are not short-circuited.*

If in any test a MANUAL RESET THERMAL CUT-OUT *operates, or if the current is otherwise interrupted before the temperature has stabilized, 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 5.3.9.*

5.3.9 Compliance criteria for abnormal operating and fault conditions

5.3.9.1 During the tests

During the tests of 5.3.4 c), 5.3.5, 5.3.7, 5.3.8 and Clause C.1:

– *if a fire occurs, it shall not propagate beyond the equipment; and*

– *the equipment shall not emit molten metal; and*

– ENCLOSURES *shall not deform in such a way as to cause non-compliance with 2.1.1, 2.6.1, 2.10.3 (or Annex G) and 4.4.1.*

Moreover, during the tests of 5.3.7 c), unless otherwise specified, the temperatures of insulating materials other than thermoplastic materials shall not exceed those in Table 5D.

Table 5D – Temperature limits for overload conditions

Maximum temperature °C

Thermal class							
105 (A)	**120 (E)**	**130 (B)**	**155 (F)**	**180 (H)**	**200**	**220**	**250**
150	165	175	200	225	245	265	295
The designations A to H, formerly assigned in IEC 60085 to thermal classes 105 to 180, are given in parentheses.							

If the failure of the insulation would not result in HAZARDOUS VOLTAGES *or* HAZARDOUS ENERGY LEVELS *becoming accessible, a maximum temperature of 300 °C is permitted. Higher temperatures are permitted for insulation made of glass or ceramic material.*

5.3.9.2 After the tests

After the tests of 5.3.4 c), 5.3.5, 5.3.7 and 5.3.8 and Clause C.1, an electric strength test according to 5.2.2 is made on:

– REINFORCED INSULATION; *and*

– BASIC INSULATION *or* SUPPLEMENTARY INSULATION *forming part of* DOUBLE INSULATION; *and*

– BASIC INSULATION *between the* PRIMARY CIRCUIT *and the main protective earthing terminal;*

if any of the following applies:

– *the* CLEARANCE *or* CREEPAGE DISTANCE *has been reduced below the value specified in 2.10 (or Annex G); or*

– *the insulation shows visible signs of damage; or*

– *the insulation cannot be inspected.*

6 Connection to telecommunication networks

If the equipment is to be connected to a TELECOMMUNICATION NETWORK, the requirements of Clause 6 apply in addition to the requirements of Clauses 1 to 5 in this standard.

NOTE 1 It is assumed that adequate measures according to ITU-T Recommendation K.11 have been taken to reduce the likelihood that the overvoltages presented to the equipment exceed 1,5 kV peak. In installations where overvoltages presented to the equipment may exceed 1,5 kV peak, additional measures such as surge suppression may be necessary.

NOTE 2 Legal requirements may exist regarding the connection of information technology equipment to a TELECOMMUNICATION NETWORK operated by a public network operator.

NOTE 3 The requirements of 2.3.2, 6.1.2 and 6.2 can apply to the same physical insulation or CLEARANCE.

NOTE 4 The AC MAINS SUPPLY system, if used as a communication transmission medium, is not a TELECOMMUNICATION NETWORK (see 1.2.13.8), and Clause 6 does not apply. The other clauses of this standard will apply to coupling components, such as signal transformers, connected between the mains and other circuitry. The requirements for DOUBLE INSULATION or REINFORCED INSULATION will generally apply. See also IEC 60664-1 and Annex Z of this standard for overvoltages to be expected at various points in the AC MAINS SUPPLY system.

NOTE 5 In Canada and the United States, additional requirements apply for TNV CIRCUITS for protection from overvoltage due to power line cross (telecommunication line contact with a power line), induction and earth potential rise from power line fault current.

6.1 Protection of telecommunication network service persons, and users of other equipment connected to the network, from hazards in the equipment

6.1.1 Protection from hazardous voltages

Circuitry intended to be directly connected to a TELECOMMUNICATION NETWORK shall comply with the requirements for an SELV CIRCUIT or a TNV CIRCUIT.

Where protection of the TELECOMMUNICATION NETWORK relies on the protective earthing of the equipment, the installation instructions and other relevant literature shall state that integrity of protective earthing shall be ensured, see also 1.7.2.1.

Compliance is checked by inspection and measurement.

6.1.2 Separation of the telecommunication network from earth

6.1.2.1 Requirements

Except as specified in 6.1.2.2, there shall be insulation between circuitry intended to be connected to a TELECOMMUNICATION NETWORK and any parts or circuitry that will be earthed in some applications, either within the EUT or via other equipment.

Surge suppressors that bridge the insulation shall have a minimum rated operating voltage U_{op} (for example, the sparkover voltage of a gas discharge tube) of

$$U_{op} = U_{peak} + \Delta U_{sp} + \Delta U_{sa}$$

where

U_{peak} is one of the following values:

for equipment intended to be installed in an area where the nominal voltage of the AC MAINS SUPPLY exceeds 130 V:	360 V
for all other equipment:	180 V.

ΔU_{sp} is the maximum increase of the rated operating voltage due to variations in component production. If this is not specified by the component manufacturer, ΔU_{sp} shall be taken as 10 % of the rated operating voltage of the component.

ΔU_{sa} is the maximum increase of the rated operating voltage due to the component ageing over the expected life of the equipment. If this is not specified by the component manufacturer, ΔU_{sa} shall be taken as 10 % of the rated operating voltage of the component.

NOTE 1 (ΔU_{sp} + ΔU_{sa}) may be a single value provided by the component manufacturer.

Compliance is checked by inspection and by the following tests. The dimensional and construction requirements of 2.10 and Annex G do not apply for compliance with 6.1.2.

NOTE 2 In Finland, Norway and Sweden, there are additional requirements for the insulation. For the complete text, see EN 60950-1:~~200X~~2006.

Insulation is subjected to an electric strength test according to 5.2.2. The a.c. test voltage is as follows:

– *for equipment intended to be installed in an area where the nominal* AC MAINS SUPPLY *voltage exceeds 130 V:* *1,5 kV*

– *for all other equipment:* *1,0 kV.*

The test voltages apply whether or not the equipment is powered from the AC MAINS SUPPLY*.*

Components bridging the insulation that are left in place during electric strength testing shall not be damaged. There shall be no breakdown of insulation during electric strength testing.

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

If this option is chosen, an additional test with a test circuit according to Figure 6A is performed with all components in place.

For equipment powered from an AC MAINS SUPPLY*, the test is performed with a voltage equal to the* RATED VOLTAGE *of the equipment or to the upper voltage of the* RATED VOLTAGE RANGE*. For equipment powered from a* DC MAINS SUPPLY*, the test is performed with a voltage equal to the highest nominal voltage of the* AC MAINS SUPPLY *in the region where the equipment is to be used, for example, 230 V for Europe or 120 V for North America.*

The current flowing in the test circuit of Figure 6A shall not exceed 10 mA.

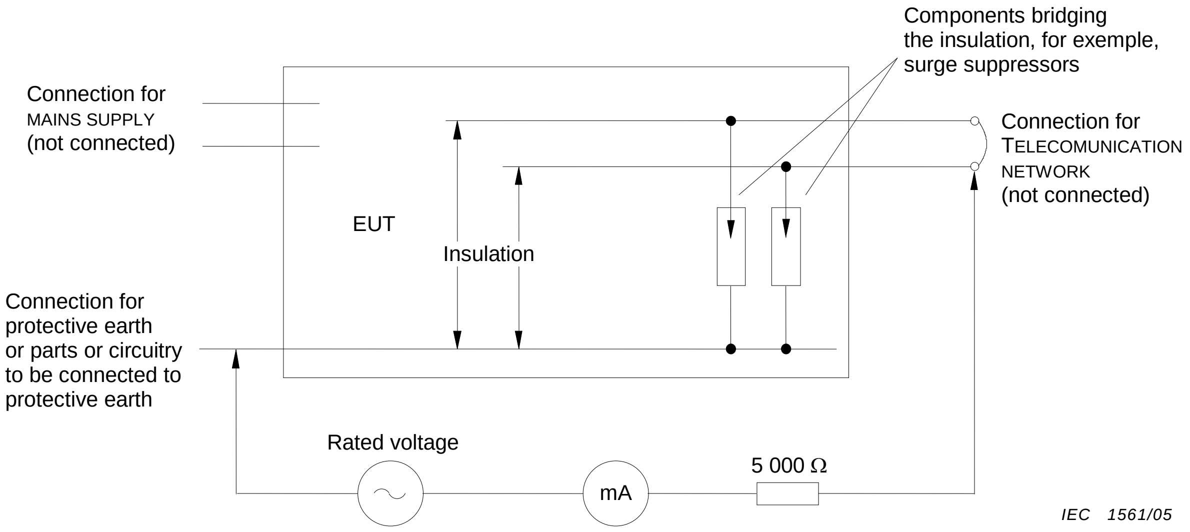


Figure 6A – Test for separation between a telecommunication network and earth

6.1.2.2 Exclusions

The requirements of 6.1.2.1 do not apply to any of the following:

– PERMANENTLY CONNECTED EQUIPMENT or PLUGGABLE EQUIPMENT TYPE B;

– equipment that is intended to be installed by a SERVICE PERSON and has installation instructions that require the equipment to be connected to a socket-outlet with a protective earthing connection (see 6.1.1);

– equipment that has provision for a permanently connected PROTECTIVE EARTHING CONDUCTOR and is provided with instructions for the installation of that conductor.

NOTE In Finland, Norway and Sweden, the exclusions are applicable only for PERMANENTLY CONNECTED EQUIPMENT, PLUGGABLE EQUIPMENT TYPE B and equipment intended to be used in a RESTRICTED ACCESS LOCATION where equipotential bonding has been applied, for example, in a telecommunication centre, and which has provision for a permanently connected PROTECTIVE EARTHING CONDUCTOR and is provided with instructions for the installation of that conductor by a SERVICE PERSON.

6.2 Protection of equipment users from overvoltages on telecommunication networks

6.2.1 Separation requirements

Equipment shall provide adequate electrical separation between a TNV-1 CIRCUIT or a TNV-3 CIRCUIT and the following parts of the equipment.

a) Unearthed conductive parts and non-conductive parts of the equipment expected to be held or ~~touched~~ otherwise maintained in continuous contact with the body during normal use (for example, a telephone handset ~~a keyboard or the entire exterior~~ or headset or the palm rest surface of a laptop or notebook computer).

b) Parts and circuitry that can be touched by the test finger, Figure 2A (see 2.1.1.1), except contacts of connectors that cannot be touched by the test probe, Figure 2C (see 2.1.1.1).

c) An SELV CIRCUIT, a TNV-2 CIRCUIT or a LIMITED CURRENT CIRCUIT provided for connection of other equipment. The requirement for separation applies whether or not this circuit is accessible.

These requirements do not apply where circuit analysis and equipment investigation indicate that adequate protection is assured by other means, for example, between two circuits each of which has a permanent connection to protective earth.

Compliance is checked by inspection and by the tests of 6.2.2. The dimensional and constructional requirements of 2.10 and Annex G do not apply for compliance with 6.2.1.

NOTE The requirements of 2.10 and Annex G may apply for compliance with 2.2 and 2.3. See Footnote e and Footnote f of Table 2H.

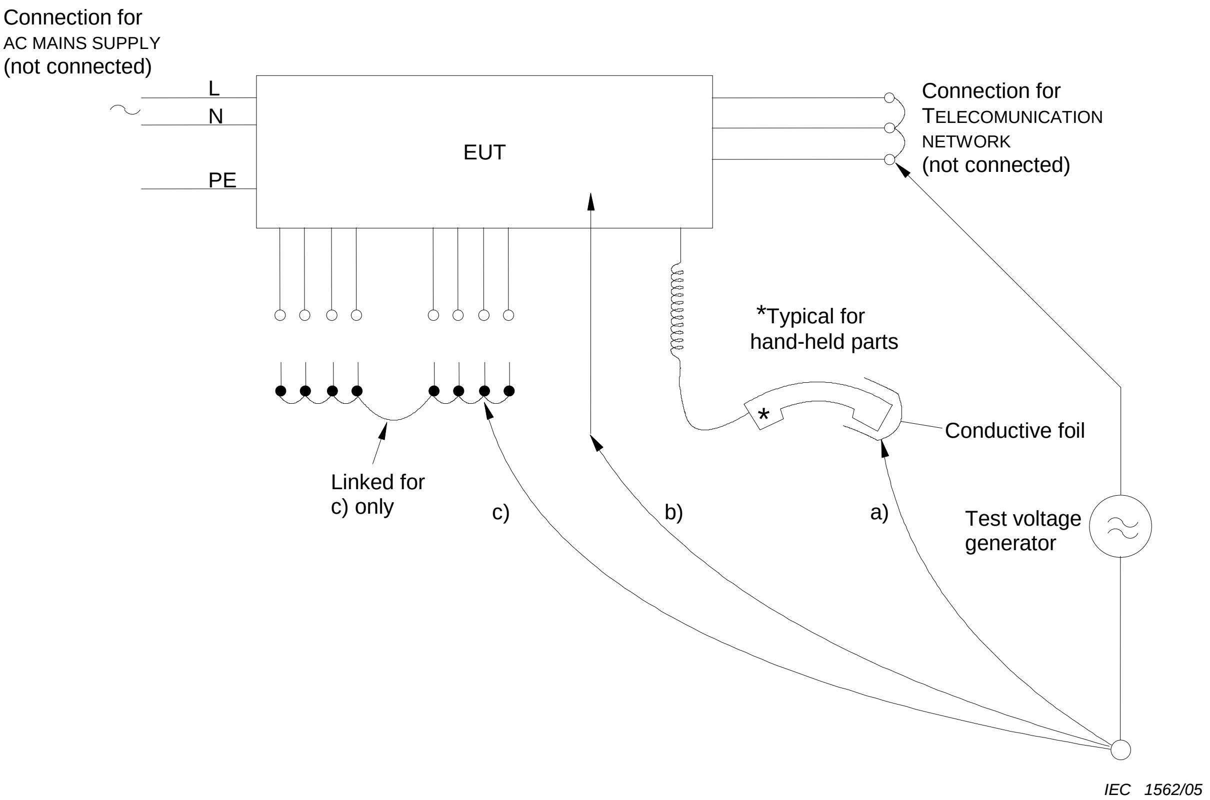


Figure 6B – Application points of test voltage

6.2.2 Electric strength test procedure

Compliance with 6.2.1 is checked by the test of either 6.2.2.1 or 6.2.2.2.

NOTE In Australia, ~~the tests of both 6.2.2.1 and 6.2.2.2 apply.~~ a value of 3,0 kV is used for 6.2.1 a) equipment and 1,5 kV for 6.2.1 b) and 6.2.1 c) equipment. These values have been determined considering the low frequency induced voltages from the power supply distribution system.

If a test is applied to a component (see 1.4.3), for example, a signal transformer, which is clearly intended to provide the separation required, the component shall not be bypassed by other components, mounting devices or wiring, unless these components or wiring also meet the separation requirements of 6.2.

For the tests, all conductors intended to be connected to the TELECOMMUNICATION NETWORK *are connected together (see Figure 6B), including any conductors required by the* TELECOMMUNICATION NETWORK *authority to be connected to earth. Similarly, all conductors intended to be connected to other equipment are connected together for testing related to 6.2.1 c).*

Non-conductive parts are tested with metal foil in contact with the surface. Where adhesive metal foil is used, the adhesive shall be conductive.

6.2.2.1 Impulse test

The electrical separation is subjected to ten impulses of alternating polarity, using the impulse test generator reference 1 of Table N.1. The interval between successive impulses is 60 s and U_c is equal to:

- *for 6.2.1 a): 2,5 kV; and*
- *for 6.2.1 b) and 6.2.1 c): 1,5 kV.*

NOTE 1 The value of 2,5 kV for 6.2.1 a) has been chosen primarily to ensure the adequacy of the insulation concerned and it does not necessarily simulate likely overvoltages.

NOTE 2 In Australia, a value of U_c = 7,0 kV is used in 6.2.1 a) for hand-held telephones and for headsets.

6.2.2.2 Steady-state test

The electrical separation is subjected to an electric strength test according to 5.2.2.

The a.c. test voltage is:

- *for 6.2.1 a): 1,5 kV; and*
- *for 6.2.1 b) and 6.2.1 c): 1,0 kV.*

NOTE In Australia, a value of 3,0 kV is used in 6.2.1 a) for hand-held telephones and headsets and 2,5 kV for other equipment, to simulate lightning surges on typical rural and semi rural network lines. A value of 1,5 kV is used in 6.2.1 b) and c).

For 6.2.1 b) and 6.2.1 c), it is permitted to remove surge suppressors, provided that such devices pass the impulse test of 6.2.2.1 for 6.2.1 b) and 6.2.1 c) when tested as components outside the equipment. For 6.2.1 a), surge suppressors shall not be removed.

6.2.2.3 Compliance criteria

During the tests of 6.2.2.1 and 6.2.2.2, there shall be no breakdown of insulation.

Insulation breakdown is considered to have occurred when the current that flows as a result of the application of the test voltage rapidly increases in an uncontrolled manner, that is 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:

- *for 6.2.1 a), such operation represents a failure; and*
- *for 6.2.1 b) and 6.2.1 c), such operation is permitted during the impulse test; and*
- *for 6.2.1 b) and 6.2.1 c), such operation during the electric strength test (by any surge suppressor left in place) represents a failure.*

For impulse tests, damage to insulation is verified in one of two ways, as follows:

- *during the application of the impulses, by observation of oscillograms. Surge suppressor operation or breakdown through insulation is judged from the shape of an oscillogram.*
- *after application of all the impulses, by an insulation resistance test. Disconnection of surge suppressors is permitted while insulation resistance is being measured. The test voltage is 500 V d.c. or, if surge suppressors are left in place, a d.c. test voltage that is 10 % less than the surge suppressor operating or striking voltage. The insulation resistance shall not be less than 2 MΩ.*

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

6.3 Protection of the telecommunication wiring system from overheating

Equipment intended to provide power over the telecommunication wiring system to remote equipment shall limit the output current to a value that does not cause damage to the telecommunication wiring system, due to overheating, under any external load condition. The maximum continuous current from equipment shall not exceed a current limit that is suitable for the minimum wire gauge specified in the equipment installation instructions. The current limit is 1,3 A if such wiring is not specified.

NOTE 1 The overcurrent protective device may be a discrete device such as a fuse, or a circuit that performs that function.

NOTE 2 The minimum wire diameter normally used in telecommunication wiring is 0,4 mm, for which the maximum continuous current for a multipair cable is 1,3 A. This wiring is not usually controlled by the equipment installation instructions, since the wiring is often installed independent of the equipment installation.

NOTE 3 Further current limitation may be necessary for equipment intended for connection to networks that are subject to overvoltages, due to operating parameters for protective devices.

Compliance is checked as follows.

If current limiting is due to the inherent impedance of the power source, the output current into any resistive load, including a short-circuit, is measured. The current limit shall not be exceeded after 60 s of test.

If current limiting is provided by an overcurrent protective device having a specified time/current characteristic:

– *the time/current characteristic shall show that a current equal to 110 % of the current limit will be interrupted within 60 min; and*

NOTE 4 Time/current characteristics of type gD and type gN fuses specified in IEC 60269-2-1 comply with the above limit. Type gD or type gN fuses rated 1 A, would meet the 1,3 A current limit.

– *the output current into any resistive load, including a short-circuit, with the overcurrent protective device bypassed, measured after 60 s of test, shall not exceed 1 000/U, where U is the output voltage measured in accordance with 1.4.5 with all load circuits disconnected.*

If current limiting is provided by an overcurrent protective device that does not have a specified time/current characteristic:

– *the output current into any resistive load, including a short-circuit, shall not exceed the current limit after 60 s of test; and*
– *the output current into any resistive load, including a short-circuit, with the overcurrent protective device bypassed, measured after 60 s of test, shall not exceed 1 000/U, where U is the output voltage measured in accordance with 1.4.5 with all load circuits disconnected.*

7 Connection to cable distribution systems

7.1 General

If the equipment is to be connected to a CABLE DISTRIBUTION SYSTEM, the requirements of Clause 7 apply in addition to the requirements of Clauses 1 to 5 of this standard.

NOTE 1 Unless the connection uses coaxial cable, the circuit is not a CABLE DISTRIBUTION SYSTEM, and Clause 6 applies.

NOTE 2 It is assumed that adequate measures have been taken to reduce the likelihood that transient overvoltages presented to the equipment exceed the following values:

– 10 kV for equipment to be connected only to an outdoor antenna;
– 4 kV to other equipment, see ITU-T Recommendations K.20, K.21 and K.45.

In installations where overvoltages presented to the equipment may exceed these values, additional measures such as surge suppression may be necessary.

NOTE 3 Legal requirements may exist regarding the connection of information technology equipment to a CABLE DISTRIBUTION SYSTEM operated by a public network operator.

NOTE 4 The AC MAINS SUPPLY system, if used as a communication medium, is not a CABLE DISTRIBUTION SYSTEM (see 1.2.13.14) and Clause 7 does not apply. For equipment to be connected to such systems, the other clauses of this standard will apply to coupling components, such as signal transformers and capacitors, connected between the mains and other circuitry. The requirements for DOUBLE INSULATION or REINFORCED INSULATION will generally apply. See also Annex Z of this standard and IEC 60664-1 for overvoltages to be expected at various points in the AC MAINS SUPPLY system.

NOTE 5 It is assumed that the cable shield will be earthed in accordance with the installation requirements of IEC 60728-11.

7.2 Protection of cable distribution system service persons, and users of other equipment connected to the system, from hazardous voltages in the equipment

Circuitry intended to be directly connected to a CABLE DISTRIBUTION SYSTEM shall comply with the requirements for a TNV-1 CIRCUIT, a TNV-3 CIRCUIT or a HAZARDOUS VOLTAGE SECONDARY CIRCUIT, depending on the normal operating voltage.

Where protection of the CABLE DISTRIBUTION SYSTEM relies on protective earthing of the equipment, the installation instructions and other relevant literature shall state that the integrity of the protective earth must be ensured, see also 1.7.2.1.

Compliance is checked by inspection and by measurement.

NOTE For requirements in Finland, Norway and Sweden, see 6.1.2.1, Note 2 and 6.1.2.2, Note. The term TELECOMMUNICATION NETWORK in 6.1.2 is replaced by CABLE DISTRIBUTION SYSTEM.

7.3 Protection of equipment users from overvoltages on the cable distribution system

The requirements and tests of 6.2 apply except that the term "TELECOMMUNICATION NETWORK" is replaced by "CABLE DISTRIBUTION SYSTEM" throughout 6.2. When applying 6.2 to CABLE DISTRIBUTION SYSTEMS, the separation requirements apply only to those circuit parts that are directly connected to the inner conductor (or conductors) of the coaxial cable; the separation requirements do not apply to those circuit parts that are directly connected to the outer screen or screens.

However, the separation requirements and tests of 6.2.1 a), b) and c) do not apply to a CABLE DISTRIBUTION SYSTEM if all of the following apply:

– the circuit under consideration is a TNV-1 CIRCUIT; and
– the common or earthed side of the circuit is connected to the screen of the coaxial cable and to all accessible parts and circuits (SELV, accessible metal parts and LIMITED CURRENT CIRCUITS, if any); and
– the screen of the coaxial cable is intended to be connected to earth in the building installation.

NOTE 1 In Sweden, there are many buildings where the screen of the coaxial cable is normally not connected to the earth in the building installation.

NOTE 2 For installation conditions in Norway, see IEC 60728-11:2005.

Compliance is checked by inspection and the application of the relevant requirements and tests of 6.2.

7.4 Insulation between primary circuits and cable distribution systems

7.4.1 General

Except as specified below, the insulation between the PRIMARY CIRCUIT and the terminal or lead provided for the connection of a CABLE DISTRIBUTION SYSTEM shall pass either:

– the voltage surge test of 7.4.2 for equipment intended to be connected to outdoor antennas; or

– the impulse test of 7.4.3 for equipment intended to be connected to other CABLE DISTRIBUTION SYSTEMS.

If an equipment is intended for connection to both an outdoor antenna and another CABLE DISTRIBUTION SYSTEM, it shall pass the tests of 7.4.2 and 7.4.3.

The above requirement does not apply to any of the following:

– equipment intended for indoor use only, provided with a built in (integral) antenna and not provided with a connection to a CABLE DISTRIBUTION SYSTEM;

– PERMANENTLY CONNECTED EQUIPMENT or PLUGGABLE EQUIPMENT TYPE B, in which the circuit intended to be connected to the CABLE DISTRIBUTION SYSTEM is also connected to protective earth in accordance with 2.6.1 e);

– PLUGGABLE EQUIPMENT TYPE A, in which the circuit intended to be connected to the CABLE DISTRIBUTION SYSTEM is also connected to protective earth in accordance with 2.6.1 e); and either

  - is intended to be installed by a SERVICE PERSON and has installation instructions that require the equipment to be connected to a socket-outlet with a protective earthing connection; or
  - has provision for a permanently connected PROTECTIVE EARTHING CONDUCTOR, including instructions for the installation of that conductor.

– to equipment where:

  - the circuit under consideration is a TNV-1 CIRCUIT; and
  - the common or earthed side of the circuit is connected to the screen of the coaxial cable and to all accessible parts and circuits (SELV, accessible metal parts and LIMITED CURRENT CIRCUITS, if any); and
  - the screen of the coaxial cable is intended to be connected to earth in the building installation.

Compliance is checked by inspection and, if necessary, by the voltage surge test of 7.4.2 or the impulse test of 7.4.3.

NOTE Minimum CLEARANCES are determined by the requirements of 2.10.3 (or Annex G). It may be necessary to increase the CLEARANCES between PRIMARY CIRCUITS and SECONDARY CIRCUITS intended for connection to CABLE DISTRIBUTION SYSTEMS so that the circuits can pass the tests of 7.4.2 or 7.4.3.

7.4.2 Voltage surge test

The test is applied between the supply circuit terminals and the main protective earthing terminal, if any, joined together, and the connection points for the CABLE DISTRIBUTION SYSTEM, excluding any earthed conductor, joined together. All components connected between the connection points for the CABLE DISTRIBUTION SYSTEM and the main protective earthing terminal are disconnected before the test. If an on/off switch is provided, it is in the "ON" position.

Conditioning pulses are applied between

– *the connection points for the CABLE DISTRIBUTION SYSTEM, excluding any earthed conductor, joined together, and*

– *the supply circuit terminals and the main protective earthing terminal, if any, joined together.*

Fifty discharges are applied from the impulse test generator reference 3 of Table N.1, at a maximum rate of 12 pulses per minute, with U_c equal to 10 kV.

After the above conditioning, the relevant electric strength tests of 5.2.2 are applied.

7.4.3 Impulse test

The test is applied between the supply circuit terminals and the main protective earthing terminal, if any, joined together, and the connection points for the CABLE DISTRIBUTION SYSTEM*, excluding any earthed conductor, joined together. All components connected between the connection points for the* CABLE DISTRIBUTION SYSTEM *and the main protective earthing terminal are disconnected before the test. If an on/off switch is provided, it is in the "ON" position.*

Ten conditioning pulses of alternating polarity are applied from the impulse test generator reference 1 of Table N.1. The interval between successive pulses is 60 s, and U_c *is equal to*

- *5 kV for power-fed repeaters;*
- *4 kV for all other terminal and network equipment.*

After the above conditioning, the relevant electric strength tests of 5.2.2 are applied.

The 4 kV test is not needed for an electrical separation that complies with the 3 000 V r.m.s. or 4 242 V peak a.c. or d.c. test in accordance with 5.2.2.

Annex A
(normative)

Tests for resistance to heat and fire

It should be noted that toxic fumes may be given off during the tests. Where appropriate the tests should be conducted either under a ventilated hood or in a well-ventilated room, but free from draughts that could invalidate the tests.

A.1 Flammability test for fire enclosures of movable equipment having a total mass exceeding 18 kg and of stationary equipment (see 4.7.3.2)

A.1.1 Samples

Three samples, each consisting of either a complete FIRE ENCLOSURE or a section of the FIRE ENCLOSURE representing the thinnest significant wall thickness and including any ventilation opening, are tested.

A.1.2 Conditioning of samples

Prior to being tested, the samples are conditioned in a circulating air oven for a period of 7 days (168 h), at a uniform temperature 10 K higher than the maximum temperature reached by the material measured during the test of 4.5.2, or 70 °C, whichever is the higher, and then cooled to room temperature.

A.1.3 Mounting of samples

Samples are mounted as they would be in actual use. A layer of untreated surgical cotton is located 300 mm below the point of application of the test flame.

A.1.4 Test flame

The test flame according to IEC 60695-11-3 is used.

A.1.5 Test procedure

The test flame is applied to an inside surface of the sample, at a location judged to be likely to become ignited because of its proximity to a source of ignition. If a vertical part is involved, the flame is applied at an angle of approximately 20° from the vertical. If ventilation openings are involved, the flame is applied to an edge of an opening, otherwise to a solid surface. In all cases, the tip of the inner blue cone is to be in contact with the sample. The flame is applied for 5 s and removed for 5 s. This operation is repeated, whether or not the sample is flaming, until the sample has been subjected to five applications of the test flame to the same location.

The test is repeated on the remaining two samples. If more than one part of the FIRE ENCLOSURE is near a source of ignition, each sample is tested with the flame applied to a different location.

A.1.6 Compliance criteria

During the test, the sample shall not release either flaming drops or particles capable of igniting the surgical cotton. The sample shall not continue to burn for more than 1 min after the fifth application of the test flame, and shall not be consumed completely.

A.2 Flammability test for fire enclosures of movable equipment having a total mass not exceeding 18 kg, and for material and components located inside fire enclosures (see 4.7.3.2 and 4.7.3.4)

A.2.1 Samples

Three samples are tested. For FIRE ENCLOSURES*, each sample consists of either a complete* FIRE ENCLOSURE *or a section of the* FIRE ENCLOSURE *representing the thinnest significant wall thickness and including any ventilation opening. For material to be located within the* FIRE ENCLOSURE*, each sample of the material consists of one of the following:*

– *the complete part; or*

– *a section of the part representing the thinnest significant wall thickness; or*

– *a test plaque or bar of uniform thickness representing the thinnest significant section of the part.*

For components to be located within the FIRE ENCLOSURE*, each sample is to be a complete component.*

A.2.2 Conditioning of samples

Prior to being tested, the samples are conditioned in a circulating air oven for a period of 7 days (168 h), at a uniform temperature 10 K higher than the maximum temperature of the part measured during the test of 4.5.2, or 70 °C, whichever is the higher, and then cooled to room temperature.

A.2.3 Mounting of samples

Samples are mounted and oriented as they would be in actual use.

A.2.4 Test flame

The test flame according to IEC 60695-11-4 is used.

A.2.5 Test procedure

The test flame is applied to an inside surface of the sample at a point judged to be likely to become ignited because of its proximity to a source of ignition. For the evaluation of materials located within the FIRE ENCLOSURE*, it is permitted to apply the test flame to an external surface of the sample. For the evaluation of components to be located within the* FIRE ENCLOSURE*, the test flame is applied directly to the component.*

If a vertical part is involved, the flame is applied at an angle of approximately 20° from the vertical. If ventilation openings are involved, the flame is applied to an edge of an opening, otherwise to a solid surface. In all cases, the tip of the flame is to be in contact with the sample. The flame is applied for 30 s and removed for 60 s, then reapplied to the same location for 30 s, whether or not the sample is flaming.

The test is repeated on the remaining two samples. If any part being tested is near a source of ignition at more than one point, each sample is tested with the flame applied to a different point that is near a source of ignition.

A.2.6 Compliance criteria

During the test, the samples shall not continue to burn for more than 1 min after the second application of the test flame, and shall not be consumed completely.

A.2.7 Alternative test

As an alternative to the apparatus and procedure specified in A.2.4 and A.2.5, it is permitted to use the apparatus and procedure specified in Clauses 5 and 9 of IEC 60695-11-5. The manner, duration and number of flame applications are as specified in A.2.5 and compliance is in accordance with A.2.6.

NOTE Compliance with the method of either A.2.4 and A.2.5 or of A.2.7 is acceptable; it is not required to comply with both methods.

A.3 Hot flaming oil test (see 4.6.2)

A.3.1 Mounting of samples

A sample of the complete finished bottom of the FIRE ENCLOSURE is securely supported in a horizontal position. Bleached CHEESECLOTH of approximately 40 g/m^2 is placed in one layer over a shallow, flat-bottomed pan approximately 50 mm below the sample, and is of sufficient size to cover completely the pattern of openings in the sample, but not large enough to catch any of the oil that runs over the edge of the sample or otherwise does not pass through the openings.

NOTE Use of a metal screen or a wired-glass partition surrounding the test area is recommended.

A.3.2 Test procedure

A small metal ladle (preferably no more than 65 mm in diameter), with a pouring lip and a long handle whose longitudinal axis remains horizontal during pouring, is partially filled with 10 ml of a distillate fuel oil that is a medium volatile distillate having a mass per unit volume between 0,845 g/ml and 0,865 g/ml, a flash point between 43,5 °C and 93,5 °C and an average calorific value of 38 MJ/l. The ladle containing the oil is heated and the oil ignited and permitted to burn for 1 min, at which time all of the hot flaming oil is poured at the rate of approximately 1 ml/s in a steady stream onto the centre of the pattern of openings, from a position approximately 100 mm above the openings.

The test is repeated twice at 5 min intervals, using clean CHEESECLOTH.

A.3.3 Compliance criterion

During these tests the CHEESECLOTH shall not ignite.

Annex B
(normative)

Motor tests under abnormal conditions

(see 4.7.2.2 and 5.3.2)

B.1 General requirements

Motors, other than d.c. motors in SECONDARY CIRCUITS, shall pass the tests of Clauses B.4 and B.5 and, where applicable, Clauses B.8, B.9 and B.10, except that the following motors are not required to pass the test of Clause B.4:

– *motors that are used for air-handling only and where the air propelling component is directly coupled to the motor shaft; and*

– *shaded pole motors whose values of locked-rotor current and no-load current do not differ by more than 1 A and have a ratio of not more than 2/1.*

DC motors in SECONDARY CIRCUITS shall pass the tests of B.6, B.7 and B.10 except that motors, which by their intrinsic operation normally operate under locked-rotor conditions, such as stepper motors, are not tested. In addition, d.c. motors in SECONDARY CIRCUITS that are used for air-handling only and where the air propelling component is directly coupled to the motor shaft are not required to pass the test of B.6.

B.2 Test conditions

Unless otherwise specified in this annex, during the test the equipment is operated at RATED VOLTAGE, or at the upper voltage of the RATED VOLTAGE RANGE.

The tests are conducted either in the equipment or under simulated conditions on the bench. It is permitted to use separate samples for bench tests. Simulated conditions include:

– *any protection devices that would protect the motor in the complete equipment; and*

– *use of any mounting means that may serve as a heat sink to the motor frame.*

Temperatures of windings are measured as specified in 1.4.13. Where thermocouples are used they are applied to the surface of the motor windings. Temperatures are determined at the end of the test period where specified, otherwise when the temperature has stabilized, or at the instant of operation of fuses, THERMAL CUT-OUTS, motor protection devices and the like.

For totally enclosed, impedance-protected motors, the temperatures are measured by thermocouples applied to the motor case.

When motors without inherent thermal protection are tested under simulated conditions on the bench, the measured winding temperature is adjusted to take into account the ambient temperature in which the motor is normally located within the equipment as measured during the test of 4.5.2.

B.3 Maximum temperatures

For the tests in Clauses B.5, B.7, B.8 and B.9, the temperature limits, as specified in Table B.1, shall not be exceeded for each class of insulating material.

Table B.1 – Temperature limits for motor windings (except for running overload test)

Maximum temperature °C

Method of protection	Thermal class							
	105 (A)	**120 (E)**	**130 (B)**	**155 (F)**	**180 (H)**	**200**	**220**	**250**
Protection by inherent or external impedance	150	165	175	200	225	245	265	295
Protection by protective device that operates during the first hour	200	215	225	250	275	295	315	345
Protection by any protective device:								
– maximum after first hour	175	190	200	225	250	270	290	320
– arithmetic average during the 2nd hour and during the 72nd hour	150	165	175	200	225	245	265	295
The designations A to H, formerly assigned in IEC 60085 to thermal classes 105 to 180, are given in parentheses.								

The arithmetic average temperature is determined as follows:

The graph of temperature against time (see Figure B.1), while the power to the motor is cycling on and off, is plotted for the period of test under consideration. The arithmetic average temperature (t_A) is determined by the formula:

$$t_A = \frac{t_{max} + t_{min}}{2}$$

where

t_{max} *is the average of the maxima;*

t_{min} *is the average of the minima.*

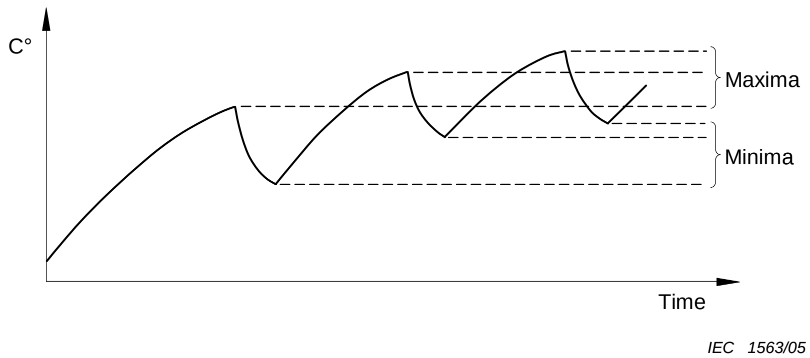


Figure B.1 – Determination of arithmetic average temperature

For the tests in Clauses B.4 and B.6, the temperature limits, as specified in Table B.2, shall not be exceeded for each class of insulating material.

B.4 Running overload test

A running overload protection test is conducted by operating the motor under NORMAL LOAD*. The load is then increased so that the current is increased in appropriate gradual steps, the motor supply voltage being maintained at its original value. When steady conditions are established, the load is again increased. The load is thus progressively increased in appropriate steps but without reaching locked-rotor condition (see Clause B.5), until the overload protection device operates.*

The motor winding temperatures are determined during each steady period and the maximum temperature recorded shall not exceed the values specified in Table B.2.

Table B.2 – Permitted temperature limits for running overload tests

Maximum temperature °C

Thermal class							
105 (A)	**120 (E)**	**130 (B)**	**155 (F)**	**180 (H)**	**200**	**220**	**250**
140	155	165	190	215	235	255	275
The designations A to H, formerly assigned in IEC 60085 to thermal classes 105 to 180, are given in parentheses.							

B.5 Locked-rotor overload test

A locked-rotor test is conducted starting at room temperature.

The duration of the test is as follows:

– *a motor protected by inherent or external impedance is operated with its rotor locked for 15 days except that testing may be discontinued when the windings of the motor, of either the open or totally enclosed type, reach a constant temperature, provided that the constant temperature is not more than that specified in 4.5.3, Table 4B for the insulation system used;*

– *a motor with an automatic reset protection device is cycled with its rotor locked for 18 days;*

– *a motor with a manual reset protection device is cycled with its rotor locked for 60 cycles, the protection device being reset after each operation as soon as possible for it to remain closed, but after not less than 30 s;*

– *a motor with a non-resettable protection device is operated with its rotor locked until the device operates.*

Temperatures are recorded at regular intervals during the first three days for a motor with inherent or external impedance protection or with an automatic reset protection device, or during the first ten cycles for a motor with a manual reset protection device, or at the time of operation of a non-resettable protection device.

The temperatures shall not exceed the values specified in Table B.1.

During the test, protective devices shall operate reliably without breakdown of insulation to the motor frame or permanent damage to the motor, including excessive deterioration of the insulation.

Permanent damage to the motor includes:

– *severe or prolonged smoking or flaming;*

– *electrical or mechanical breakdown of any associated component part such as a capacitor or starting relay;*

– *flaking, embrittlement or charring of insulation.*

Discoloration of the insulation is permitted but charring or embrittlement to the extent that insulation flakes off or material is removed when the winding is rubbed with the thumb is not permitted.

After the period specified for temperature measurement, the motor shall withstand the electric strength test in 5.2.2 after the insulation has cooled to room temperature and with test voltages reduced to 60 % of the specified values. No further electric strength test is required.

NOTE Continuation of the test of an automatic reset protection device beyond 72 h, and of a manual reset protection device beyond 10 cycles, is for the purpose of demonstrating the capability of the device to make and break locked-rotor current for an extended period of time.

B.6 Running overload test for d.c. motors in secondary circuits

B.6.1 General

The running overload test is conducted only if a possibility of an overload occurring is determined by inspection or by review of the design. The test need not be conducted, for example, where electronic drive circuits maintain a substantially constant drive current.

Motors shall pass the test in B.6.2, except that, if difficulty is experienced in obtaining accurate temperature measurements, due to the small size or unconventional design of the motor, the method of B.6.3 can be used instead. Compliance may be established by either method.

B.6.2 Test procedure

The motor is operated under NORMAL LOAD. *The load is then increased so that the current is increased in appropriate gradual steps, the motor supply voltage being maintained at its original value. When steady conditions are established the load is again increased. The load is thus progressively increased in appropriate steps until either the overload protection device operates or the winding becomes an open circuit.*

The motor winding temperatures are determined during each steady period and the maximum temperature recorded shall not exceed the value in Table B.2.

B.6.3 Alternative test procedure

The motor is placed on a wooden board that is covered with a single layer of WRAPPING TISSUE, *and the motor in turn is covered with a single layer of* CHEESECLOTH.

At the conclusion of the test, there shall be no ignition of the WRAPPING TISSUE *or* CHEESECLOTH.

Compliance with either method is acceptable; it is not necessary to comply with both methods.

B.6.4 Electric strength test

Following the test of B.6.2 or B.6.3, as applicable, if the motor voltage exceeds 42,4 V peak, or 60 V d.c., and after it has cooled to room temperature, the motor shall withstand the electric strength test in 5.2.2, but with test voltages reduced to 60 % of the specified values.

B.7 Locked-rotor overload test for d.c. motors in secondary circuits

B.7.1 General

Motors shall pass the test in B.7.2, except that, where difficulty is experienced in obtaining accurate temperature measurements, due to the small size or unconventional design of the motor, the method of B.7.3 can be used instead. Compliance may be established by either method.

B.7.2 Test procedure

The motor is operated at the voltage used in its application and with its rotor locked for 7 h or until steady state conditions are established, whichever is the longer. However, if the motor winding opens, or the motor otherwise becomes permanently de-energized, the test is discontinued.

Temperatures shall not exceed the values specified in Table B.1.

B.7.3 Alternative test procedure

The motor is placed on a wooden board that is covered with a single layer of WRAPPING TISSUE, and the motor in turn covered with a single layer of bleached cotton CHEESECLOTH of approximately 40 g/m^2.

The motor is then operated at the voltage used in its application and with its rotor locked for 7 h or until steady state conditions are established, whichever is the longer. However, if the motor winding opens, or the motor otherwise becomes permanently de-energized, the test is discontinued.

At the conclusion of the test there shall be no ignition of the WRAPPING TISSUE or CHEESECLOTH.

B.7.4 Electric strength test

Following the test of B.7.2 or B.7.3, as applicable, if the motor voltage exceeds 42,4 V peak, or 60 V d.c., and after it has cooled to room temperature, the motor shall withstand the electric strength test in 5.2.2 but with test voltages reduced to 60 % of the specified values.

B.8 Test for motors with capacitors

Motors having phase-shifting capacitors are tested under locked rotor conditions with the capacitor short-circuited or open-circuited (whichever is the more unfavourable).

The short-circuit test is not made if the capacitor is so designed that, upon failure, it will not remain short-circuited.

Temperatures shall not exceed the values specified in Table B.1.

NOTE Locked rotor is specified because some motors may not start and variable results could be obtained.

B.9 Test for three-phase motors

Three-phase motors are tested under NORMAL LOAD, with one line conductor disconnected, unless circuit controls prevent the application of voltage to the motor with one or more supply conductors disconnected.

The effect of other loads and circuits within the equipment may necessitate that the motor be tested within the equipment and with each of the three line conductors disconnected one at a time.

Temperatures shall not exceed the values specified in Table B.1.

B.10 Test for series motors

Series motors are operated at a voltage equal to 130 % of the motor voltage rating for 1 min with the lowest possible load.

After the test, windings and connections shall not have worked loose and no hazard shall be present in the meaning of this standard.

Annex C
(normative)

Transformers

(see 1.5.4 and 5.3.3)

C.1 Overload test

If the tests in this clause are conducted under simulated conditions on the bench, these conditions shall include any protection device that would protect the transformer in the complete equipment.

Transformers for switch mode power supply units are tested in the complete power supply unit or in the complete equipment. Test loads are applied to the output of the power supply unit.

A linear transformer or a ferro-resonant transformer has each secondary winding loaded in turn, with any other secondaries loaded between zero and their specified maxima to result in the maximum heating effect.

The output of a switch mode power supply unit is loaded to result in the maximum heating effect in the transformer.

NOTE For examples of loading to give the maximum heating effect, see Annex X.

Where an overload cannot occur or is unlikely to create a hazard, the above tests are not made.

Maximum temperatures of windings shall not exceed the values in Table C.1 when measured as specified in 1.4.12 and 1.4.13, and determined as specified below:

- *with external overcurrent protection: at the moment of operation, for determination of the time until the overcurrent protection operates, it is permitted to refer to a data sheet of the overcurrent protection device showing the trip time versus the current characteristics;*
- *with an* AUTOMATIC RESET THERMAL CUT-OUT*: as shown in Table C.1 and after 400 h;*
- *with a* MANUAL RESET THERMAL CUT-OUT*: at the moment of operation;*
- *for current-limiting transformers: after temperature has stabilized.*

If the temperature of the windings of a transformer with a ferrite core, measured as specified in 1.4.12, exceeds 180 °C, it shall be retested at maximum rated ambient temperature ($T_{amb} = T_{ma}$), and not as calculated according to 1.4.12.

NOTE The above procedure is to ensure that deteriorating Curie characteristics of ferrite at temperatures approaching 200 °C do not cause thermal runaway (unpredictable temperature rise).

Secondary windings that exceed the temperature limits but that become open circuit or otherwise require replacement of the transformer do not constitute a failure of this test, provided that no hazard is created in the meaning of this standard.

For compliance criteria see 5.3.9.

Table C.1 – Temperature limits for transformer windings

Maximum temperature °C

Method of protection	Thermal class							
	105 (A)	**120 (E)**	**130 (B)**	**155 (F)**	**180 (H)**	**200**	**220**	**250**
Protection by inherent or external impedance	150	165	175	200	225	245	265	295
Protection by protective device that operates during the first hour	200	215	225	250	275	295	315	345
Protection by any protective device:								
– maximum after first hour	175	190	200	225	250	270	290	320
– arithmetic average during the 2nd hour and during the 72nd hour	150	165	175	200	225	245	265	295
The designations A to H, formerly assigned in IEC 60085 to thermal classes 105 to 180, are given in parentheses.								

The arithmetic average temperature is determined as follows:

The graph of temperature against time (see Figure C.1), while the power to the transformer is cycling on and off, is plotted for the period of test under consideration. The arithmetic average temperature (t_A) is determined by the formula:

$$t_{\text{A}} = \frac{t_{\max} + t_{\min}}{2}$$

where

$t_{\max}$ *is the average of the maxima;*

$t_{\min}$ *is the average of the minima.*

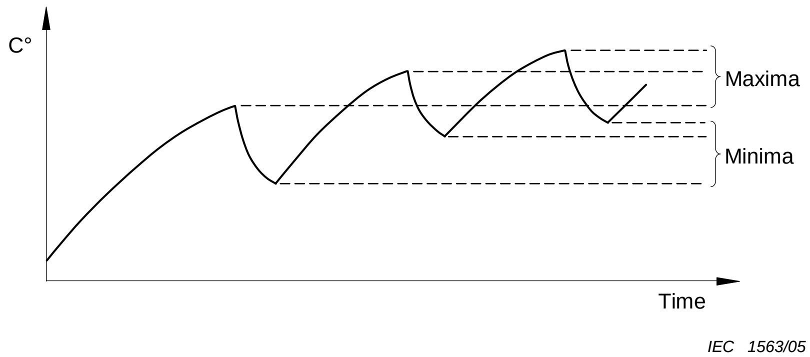


Figure C.1 – Determination of arithmetic average temperature

C.2 Insulation

Insulation in transformers shall comply with the following requirements.

Windings and conductive parts of transformers shall be treated as parts of the circuits to which they are connected, if any. The insulation between them shall comply with the relevant requirements of 2.10 (or Annex G) and pass the relevant tests of 5.2, according to the application of the insulation in the equipment (see 2.9.3).

Precautions shall be taken to prevent the reduction below the specified minimum values of CLEARANCES and CREEPAGE DISTANCE that provide BASIC INSULATION, SUPPLEMENTARY INSULATION or REINFORCED INSULATION by:

– displacement of windings or their turns;

– displacement of internal wiring or wires for external connections;

– undue displacement of parts of windings or internal wiring, in the event of rupture of wires adjacent to connections or loosening of the connections;

– bridging of insulation by wires, screws, washers and the like should they loosen or become free.

It is not expected that two independent fixings will loosen at the same time.

All windings shall have the end turns retained by positive means.

Compliance is checked by inspection, measurement and, if necessary, by the following tests.

If the transformer is fitted with a screen for protective earthing purposes that is separated from the primary winding connected to a HAZARDOUS VOLTAGE circuit by BASIC INSULATION only, the screen shall comply with one of the following:

– *meet the requirements of 2.6.3.3;*

– *meet the requirements of 2.6.3.4 between the earthed screen and the main protective earthing terminal of the equipment;*

– *pass a test simulating breakdown of BASIC INSULATION between the screen and the associated primary winding. The transformer shall be protected by any protective device used in the end application. The protective earthing path and the screen shall not be damaged.*

If tests are conducted, a specially prepared sample transformer having an extra lead-out wire from the free end of the screen is used to ensure that the current during the test passes through the screen.

Examples of acceptable forms of construction (see 1.3.8) are the following:

– *windings isolated from each other by placing them on separate limbs of the core, with or without spools;*

– *windings on a single spool with a partition wall, where either the spool and partition wall are pressed or moulded in one piece, or a pushed-on partition wall has an intermediate sheath or covering over the joint between the spool and the partition wall;*

– *concentric windings on a spool of insulating material without flanges, or on insulation applied in thin sheet form to the transformer core;*

– *insulation is provided between windings consisting of sheet insulation extending beyond the end turns of each layer;*

– *concentric windings, separated by an earthed conductive screen that consists of metal foil extending the full width of the windings, with suitable insulation between each winding and the screen. The conductive screen and its lead-out wire have a cross section sufficient to ensure that on breakdown of the insulation an overload device will open the circuit before the screen is destroyed. The overload device may be a part of the transformer.*

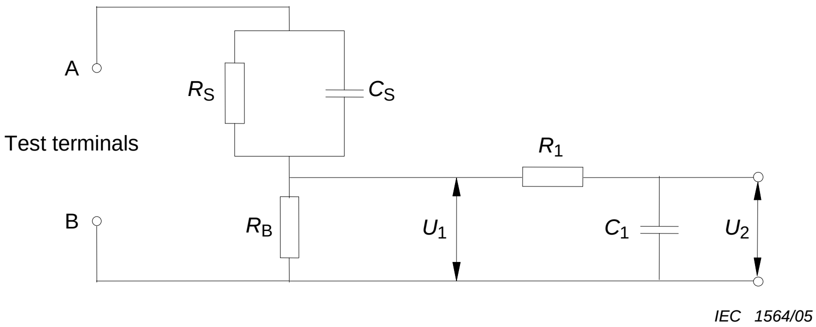
Annex D
(normative)

Measuring instruments for touch current tests

(see 5.1.4)

D.1 Measuring instrument

The measuring instrument of Figure D.1 is from Figure 4 of IEC 60990.

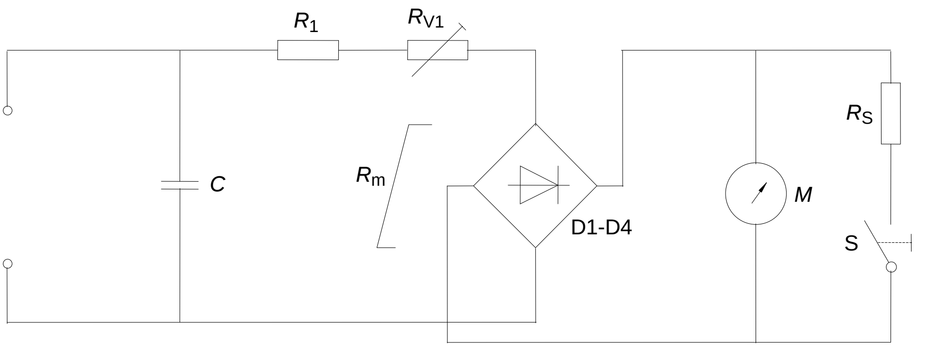


R_S	1 500 Ω	
R_B	500 Ω	
R_1	10 kΩ	
C_S	0,22 µF	
C_1	0,022 µF	
Voltmeter or oscilloscope (r.m.s. or peak reading)	Input resistance:	~~>~~≥1 MΩ
	Input capacitance:	<200 pF
	Frequency range: (appropriate for the highest frequency of interest, see 1.4.7)	~~15~~ 20 Hz up to 1 MHz

Figure D.1 – Measuring instrument

The measuring instrument is calibrated by comparing the frequency factor of U_2 with the solid line in Figure F.2 of IEC 60990 at various frequencies. A calibration curve is constructed showing the deviation of U_2 from the ideal curve as a function of frequency.

D.2 Alternative measuring instrument



M	0 mA – 1 mA moving coil movement
$R_1 + R_{V1} + R_m$ at 0,5 mA d.c. =	1 500 Ω ± 1 % with *C* = 150 nF ± 1 % or 2 000 Ω ± 1 % with *C* = 112 nF ± 1 %
D1-D4	Rectifier
R_s	Non-inductive shunt for × 10 range
S	Sensitivity button (press for maximum sensitivity)

Figure D.2 – Alternative measuring instrument

The instrument comprises a rectifier/moving coil meter with additional series resistance, the two being shunted by a capacitor, as shown in Figure D.2. The effect of the capacitor is to reduce the sensitivity to harmonics and other frequencies above the power frequency. The instrument should also include a × 10 range obtained by shunting the meter coil by a non-inductive resistor. It is also permitted to include overcurrent protection, provided that the method used does not affect the basic characteristics of the instrument.

R_{V1} is adjusted for the desired value of total resistance at 0,5 mA d.c.

The meter is calibrated at the following calibration points on the maximum sensitivity range at 50 Hz to 60 Hz sinusoidal:

0,25 mA, 0,5 mA, 0,75 mA.

The following response is checked at the 0,5 mA calibration point:

Sensitivity at 5 kHz sinusoidal: 3,6 mA ± 5 %.

Annex E
(normative)

Temperature rise of a winding

(see 1.4.13)

The value of the temperature rise of a winding is calculated from the formula:

for a copper winding

$$\Delta t = \frac{R_2 - R_1}{R_1}(234{,}5 + t_1) - (t_2 - t_1)$$

for an aluminium winding

$$\Delta t = \frac{R_2 - R_1}{R_1}(225 + t_1) - (t_2 - t_1)$$

where

Δt *is the temperature rise, in kelvins;*

R_1 *is the resistance of the winding at the beginning of the test, in ohms;*

R_2 *is the resistance of the winding at the end of the test, in ohms;*

t_1 *is the room temperature at the beginning of the test, in degrees Celsius;*

t_2 *is the room temperature at the end of the test, in degrees Celsius.*

At the beginning of the test, the windings are at room temperature.

It is recommended that the resistance of windings at the end of the test be determined by taking resistance measurements as soon as possible after switching off, and then at short intervals so that a curve of resistance against time can be plotted for ascertaining the resistance at the instant of switching off.

For comparison of winding temperatures determined by the resistance method of this annex with the temperature limits of Table 4B, 25 °C shall be added to the calculated temperature rise.

Annex F
(normative)

Measurement of clearances and creepage distances

(see 2.10 and Annex G)

The methods of measuring CLEARANCES and CREEPAGE DISTANCES that are specified in the following figures are used in interpreting the requirements of this standard.

In the following figures, the value of *X* is given in Table F.1. Where the distance shown is less than *X*, the depth of the gap or groove is disregarded when measuring a CREEPAGE DISTANCE.

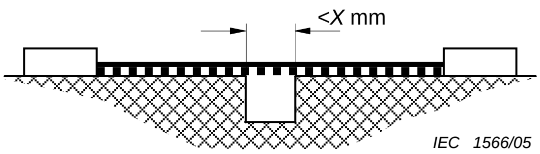
Table F.1 is valid only if the specified minimum CLEARANCE is 3 mm or more. If the specified minimum CLEARANCE is less than 3 mm, the value of *X* is the lesser of:

– the relevant value in Table F.1; or

– one third of the specified minimum CLEARANCE.

Table F.1 – Value of *X*

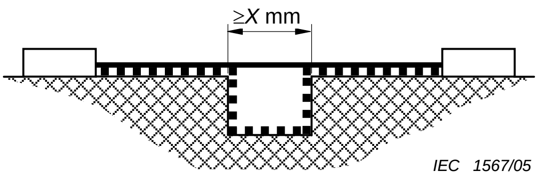
Pollution degree (see 2.10.1.2)	***X*** mm
1	0,25
2	1,0
3	1,5



Condition: Path under consideration includes a parallel or converging-sided groove of any depth with width less than *X* mm.

Rule: CLEARANCE and CREEPAGE DISTANCE are measured directly across the groove.

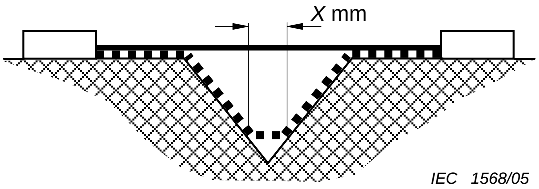
Figure F.1 – Narrow groove



Condition: Path under consideration includes a parallel-sided groove of any depth, and equal to or more than *X* mm wide.

Rule: CLEARANCE is the "line of sight" distance. CREEPAGE DISTANCE path follows the contour of the groove.

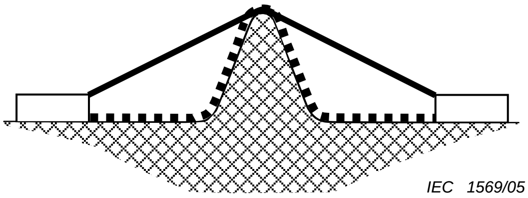
Figure F.2 – Wide groove



Condition: Path under consideration includes a V-shaped groove with internal angle of less than 80° and a width greater than *X* mm.

Rule: CLEARANCE is "line of sight" distance. CREEPAGE DISTANCE path follows the contour of the groove but "short-circuits" the bottom of the groove by a link *X* mm long.

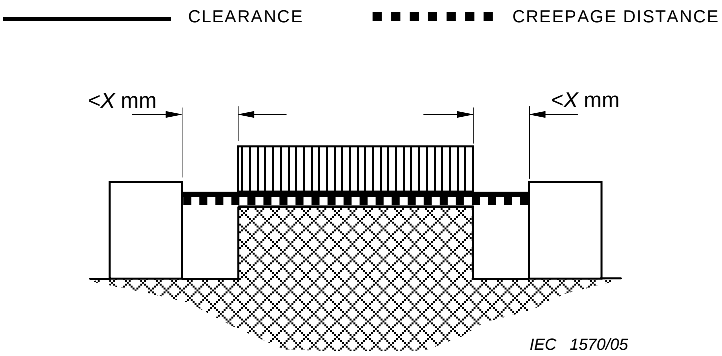
Figure F.3 – V-shaped groove



Condition: Path under consideration includes a rib.

Rule: CLEARANCE is the shortest direct air path over the top of the rib. CREEPAGE DISTANCE path follows the contour of the rib.

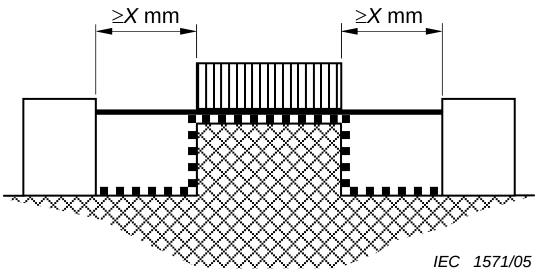
Figure F.4 – Rib



Condition: Path under consideration includes an uncemented joint with grooves less than *X* mm wide on either side.

Rule: CLEARANCE and CREEPAGE DISTANCE path is the "line of sight" distance shown.

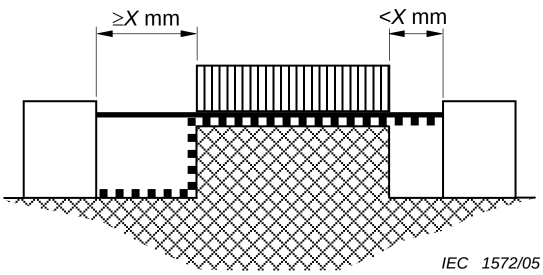
Figure F.5 – Uncemented joint with narrow groove



Condition: Path under consideration includes an uncemented joint with a groove equal to or more than *X* mm wide each side.

Rule: CLEARANCE is the "line of sight" distance. CREEPAGE DISTANCE path follows the contour of the groove.

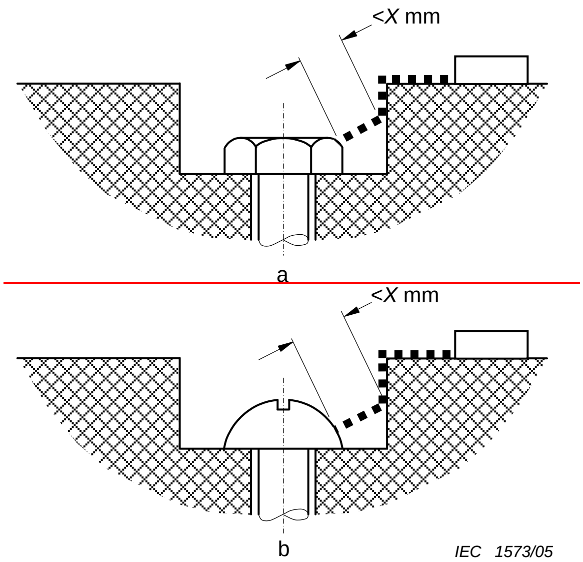
Figure F.6 – Uncemented joint with wide groove

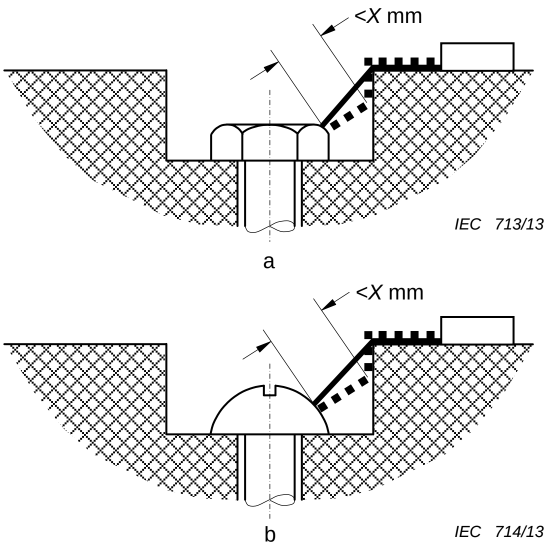


Condition: Path under consideration includes an uncemented joint with a groove on one side less than *X* mm wide and a groove on the other equal to or more than *X* mm wide.

Rule: CLEARANCE and CREEPAGE DISTANCE path are as shown.

Figure F.7 – Uncemented joint with narrow and wide grooves



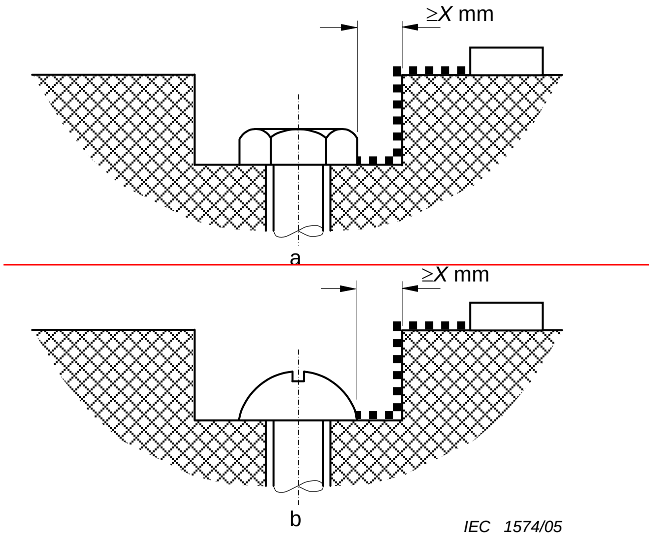


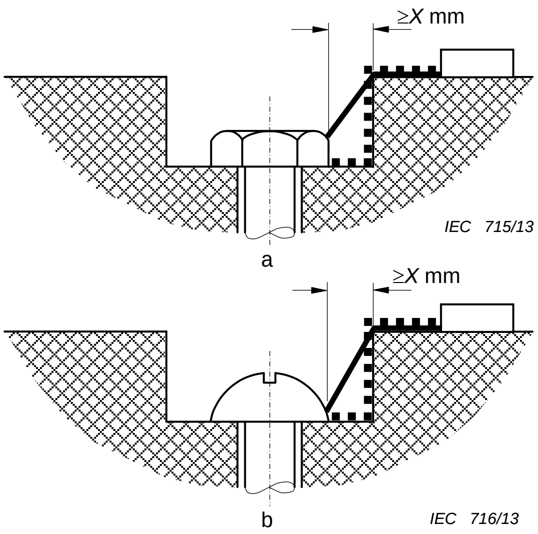
Gap between head of screw and wall of recess too narrow to be taken into account.

Measurement of creepage distance is from screw to wall where the distance is equal to *X* mm.

Figure F.8 – Narrow recess

CLEARANCE CREEPAGE DISTANCE





Gap between head of screw and wall of recess wide enough to be taken into account.

Figure F.9 – Wide recess

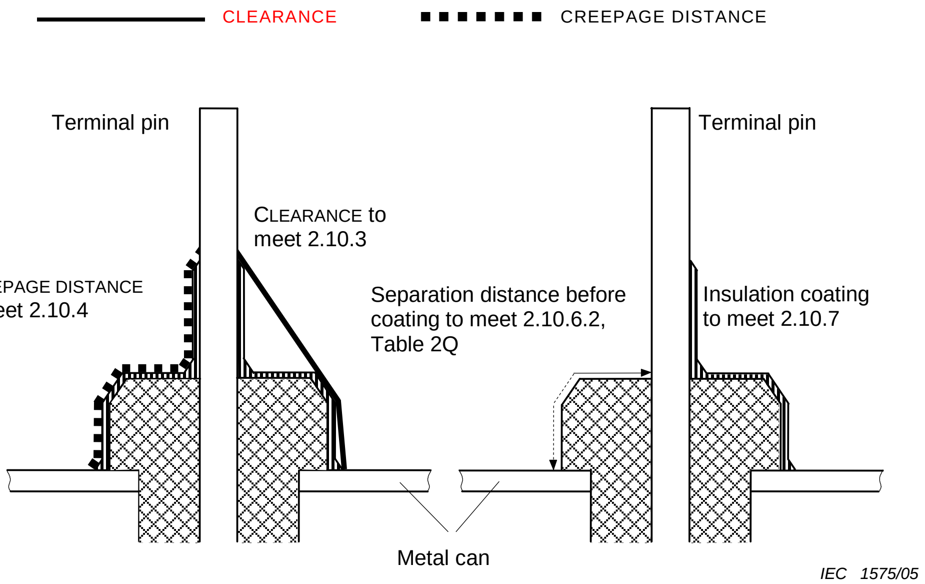


Figure F.10 – Coating around terminals

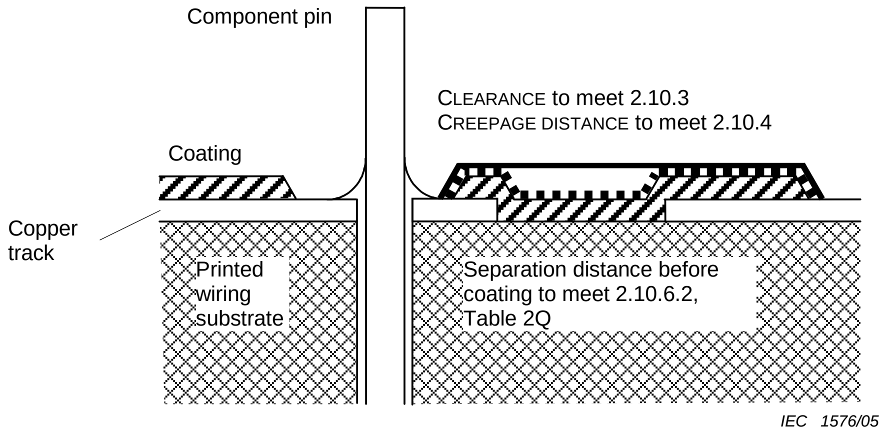
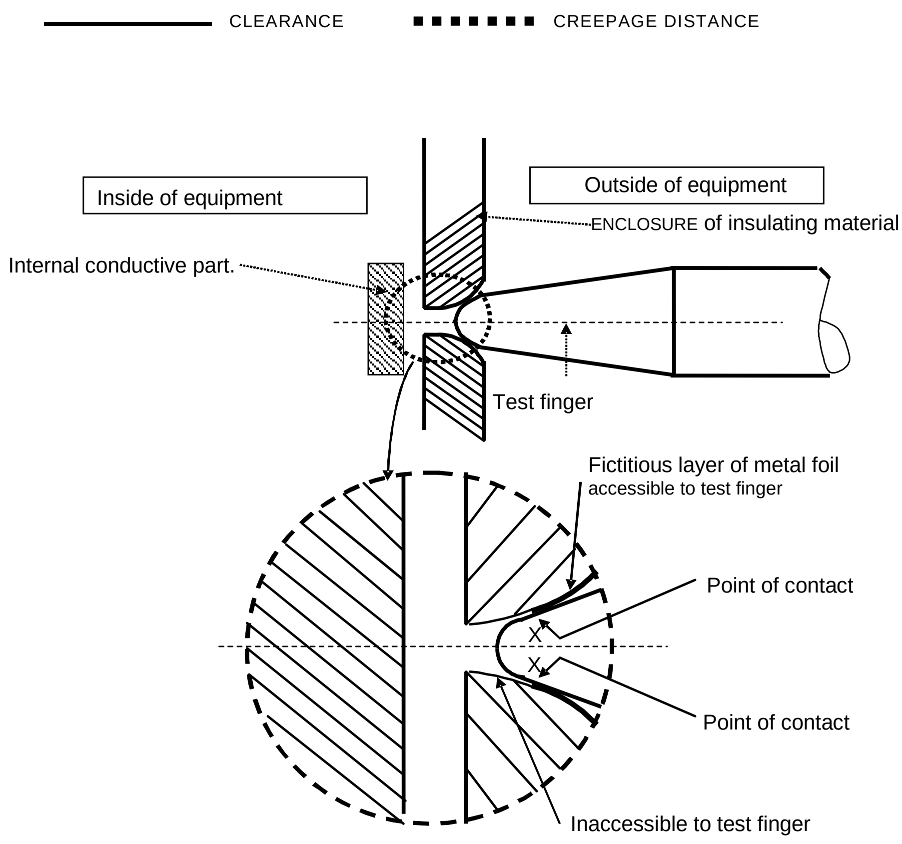


Figure F.11 – Coating over printed wiring



Point X is used for measurements of CLEARANCES and CREEPAGE DISTANCES from the BOUNDING SURFACE of an ENCLOSURE of insulating material to an internal conductive part (see 2.10.3.1 and 2.10.4)

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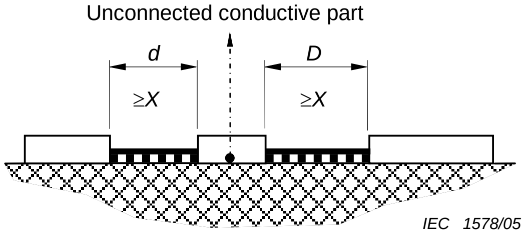
Figure F.12 – Measurements through openings in enclosures



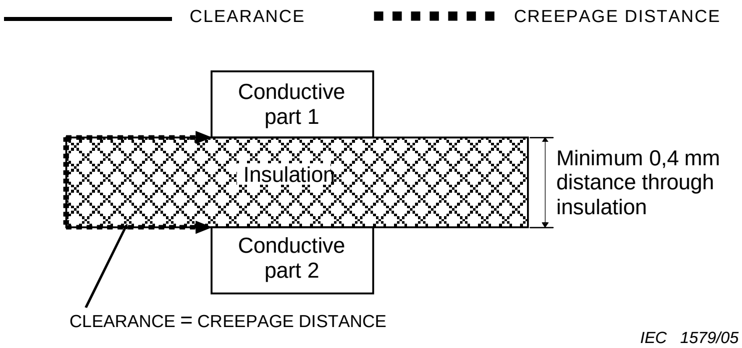
Condition: Insulation distance with intervening, unconnected conductive part.

Rule: CLEARANCE is the distance *d* + *D*.

CREEPAGE DISTANCE is also *d* + *D*.

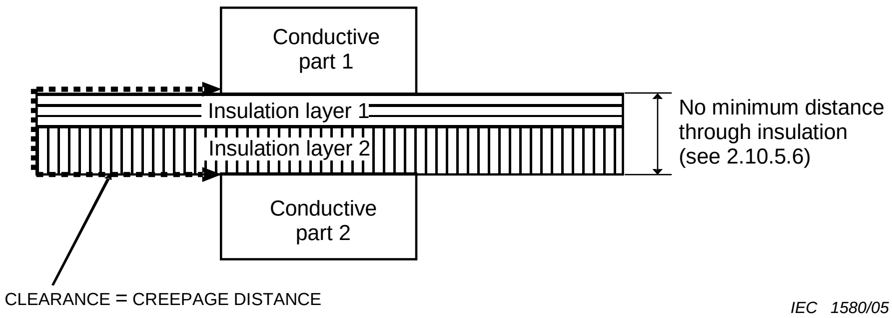
Where the value of *d* or *D* is smaller than *X*, it shall be considered as zero.

Figure F.13 – Intervening, unconnected conductive part



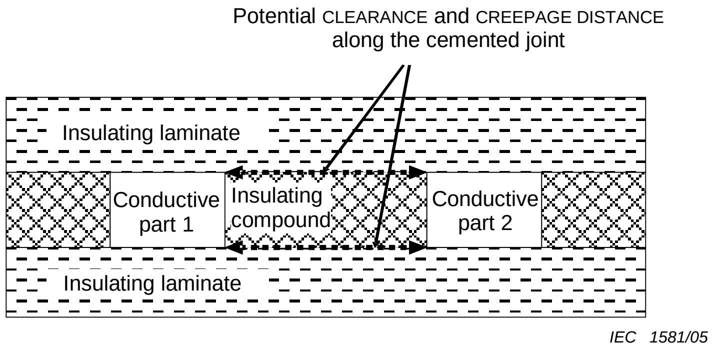
Thick sheet or solid insulating material as SUPPLEMENTARY INSULATION or REINFORCED INSULATION

Figure F.14 – Solid insulating material



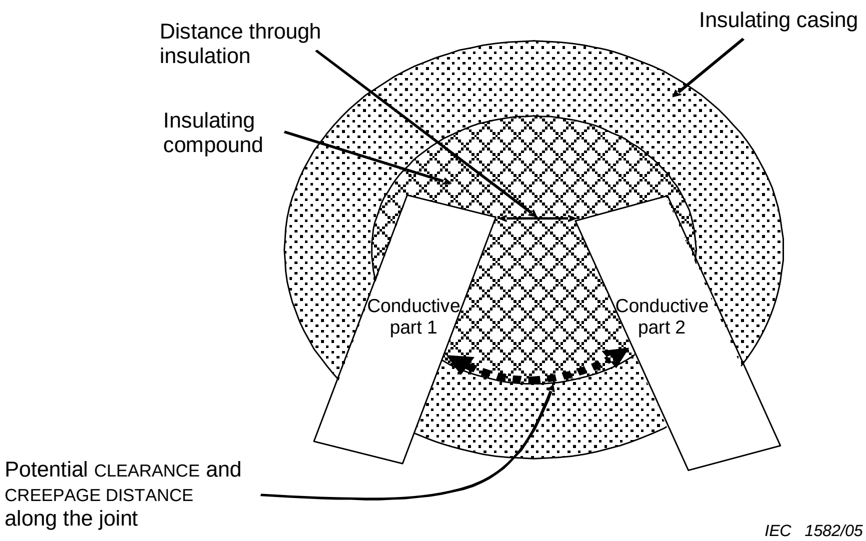
Two layers of thin sheet material as SUPPLEMENTARY INSULATION or REINFORCED INSULATION

Figure F.15 – Thin sheet insulating material



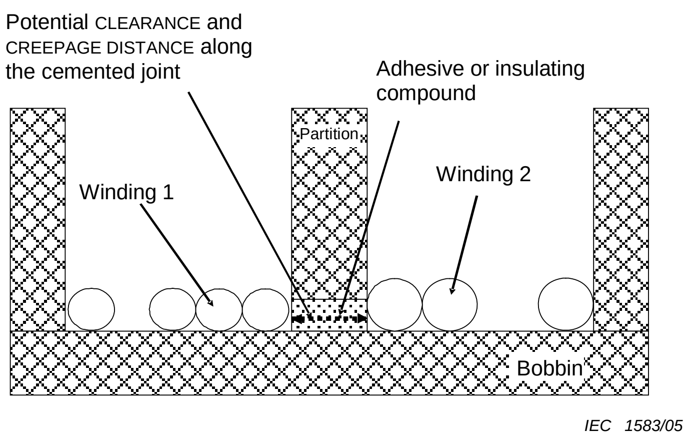
Insulating compound as SUPPLEMENTARY INSULATION or REINFORCED INSULATION

Figure F.16 – Cemented joints in multi-layer printed board



Insulating compound as SUPPLEMENTARY INSULATION or REINFORCED INSULATION inside a component

Figure F.17 – Component filled with insulating compound



Cemented joint as SUPPLEMENTARY INSULATION or REINFORCED INSULATION

Figure F.18 – Partitioned bobbin

Annex G
(normative)

Alternative method for determining minimum clearances

G.1 Clearances

G.1.1 General

CLEARANCES shall be so dimensioned that overvoltages, including transients, which may enter the equipment, and peak voltages that may be generated within the equipment, do not break down the CLEARANCE.

It is permitted to use either the requirements of 2.10.3 for Overvoltage Category I or Overvoltage Category II, using the PEAK WORKING VOLTAGE, or the requirements in Annex G for Overvoltage Category I, Overvoltage Category II, Overvoltage Category III or Overvoltage Category IV, using the REQUIRED WITHSTAND VOLTAGE, for a particular component or subassembly or for the whole equipment.

NOTE It is considered to be good practice to design SOLID INSULATION for higher transient overvoltages than the associated CLEARANCE.

G.1.2 Summary of the procedure for determining minimum clearances

NOTE 1 The minimum CLEARANCES for FUNCTIONAL INSULATION, BASIC INSULATION, SUPPLEMENTARY INSULATION and REINFORCED INSULATION, whether in a PRIMARY CIRCUIT or another circuit, depend on the REQUIRED WITHSTAND VOLTAGE. The REQUIRED WITHSTAND VOLTAGE depends in turn on the combined effect of the normal operating voltage (including repetitive peaks due to internal circuitry such as switch mode power supplies) and non-repetitive overvoltages due to external transients.

To determine the minimum value for each CLEARANCE, the following steps shall be used.

(1) Measure the PEAK WORKING VOLTAGE across the CLEARANCE in question.

(2) If the equipment is mains operated:

– determine the MAINS TRANSIENT VOLTAGE (Clause G.2); and

– for equipment to be connected to an AC MAINS SUPPLY, calculate the peak value of the nominal AC MAINS SUPPLY voltage.

(3) Use the rules in G.4.1 and the above voltage values to determine the ~~required withstand voltage~~ REQUIRED WITHSTAND VOLTAGE for mains transients and internal repetitive peaks. In the absence of transients coming from a ~~telecommunication network~~ TELECOMMUNICATION NETWORK, go to step 7.

(4) If the equipment is to be connected to a ~~telecommunication network~~ TELECOMMUNICATION NETWORK, determine the ~~telecommunication network transient voltage~~ TELECOMMUNICATION NETWORK TRANSIENT VOLTAGE (Clause G.3).

(5) Use the ~~telecommunication network transient voltage~~ TELECOMMUNICATION NETWORK TRANSIENT VOLTAGE and the rules in G.4.2 to determine the ~~required withstand voltage for telecommunication network transients~~ REQUIRED WITHSTAND VOLTAGE for TELECOMMUNICATION NETWORK TRANSIENTS. In the absence of mains and internal repetitive peaks, go to step 7.

(6) Use the rule in G.4.3 to determine the total ~~required withstand voltage~~ REQUIRED WITHSTAND VOLTAGE.

(7) Use the REQUIRED WITHSTAND VOLTAGE to determine the minimum CLEARANCE (Clause G.6).

NOTE 2 The effect of transients from a CABLE DISTRIBUTION SYSTEM is not taken into account (see G.4.4 and 7.4.1).

G.2 Determination of mains transient voltage

G.2.1 AC mains supply

For equipment to be supplied from the AC MAINS SUPPLY, the value of the MAINS TRANSIENT VOLTAGE depends on the overvoltage category and the AC MAINS SUPPLY voltage. In general, CLEARANCES in equipment intended to be connected to the AC MAINS SUPPLY shall be designed for Overvoltage Category II.

NOTE 1 See Annex Z for further guidance on the determination of overvoltage category.

Equipment that is likely, when installed, to be subjected to transient overvoltages that exceed those for its design Overvoltage Category II, will require additional protection to be provided external to the equipment. In this case, the installation instructions shall state the need for such external protection.

The applicable value of the MAINS TRANSIENT VOLTAGE shall be determined from the overvoltage category and the AC MAINS SUPPLY voltage, using Table G.1.

Table G.1 – AC mains transient voltages

AC MAINS SUPPLY voltage [a] V r.m.s.	MAINS TRANSIENT VOLTAGE [b] V peak			
	Overvoltage Category			
	I	II	III	IV
up to and including 50	330	500	800	1 500
over 50 up to and including 100	500	800	1 500	2 500
over 100 up to and including 150 [c]	800	1 500	2 500	4 000
over 150 up to and including 300 [d]	1 500	2 500	4 000	6 000
over 300 up to and including 600 [e]	2 500	4 000	6 000	8 000

[a] For equipment designed to be connected to a three-phase, three-wire supply, where there is no neutral conductor, the AC MAINS SUPPLY voltage is the line-to-line voltage. In all other cases, where there is a neutral conductor, it is the line-to-neutral voltage.

[b] The MAINS TRANSIENT VOLTAGE is always one of the values in the table. Interpolation is not permitted.

[c] Including 120/208 V and 120/240 V.

[d] Including 230/400 V and 277/480 V.

[e] Including 400/690 V.

NOTE 2 For Japan, the value of the MAINS TRANSIENT VOLTAGES for the nominal AC MAINS SUPPLY voltage of 100 V is determined from the row applicable to an AC MAINS SUPPLY voltage of 150 V.

G.2.2 Earthed d.c. mains supplies

If a DC MAINS SUPPLY is connected to protective earth and is entirely within a single building, the MAINS TRANSIENT VOLTAGE shall be assumed to be 71 V peak. If this connection is within the EUT, it shall be in accordance with 2.6.1 e).

NOTE The connection to protective earth can be at the source of the DC MAINS SUPPLY or at the equipment location, or both (see ITU-T Recommendation K.27).

G.2.3 Unearthed d.c. mains supplies

If a DC MAINS SUPPLY is not earthed and located as in G.2.2, the MAINS TRANSIENT VOLTAGE shall be assumed to be equal to the MAINS TRANSIENT VOLTAGE in the AC MAINS SUPPLY from which the DC MAINS SUPPLY is derived.

G.2.4 Battery operation

If equipment is supplied from a dedicated battery that has no provision for charging from an external MAINS SUPPLY, the MAINS TRANSIENT VOLTAGE shall be assumed to be 71 V peak.

G.3 Determination of telecommunication network transient voltage

If the TELECOMMUNICATION NETWORK TRANSIENT VOLTAGE is known for the TELECOMMUNICATION NETWORK in question, it is permitted to use the known value in G.4.2.

If the TELECOMMUNICATION NETWORK TRANSIENT VOLTAGE is not known, one of the following values shall be used:

– 1 500 V peak if the circuit connected to the TELECOMMUNICATION NETWORK is a TNV-1 CIRCUIT or a TNV-3 CIRCUIT; or

– 800 V peak if the circuit connected to the TELECOMMUNICATION NETWORK is an SELV CIRCUIT or a TNV-2 CIRCUIT.

The effect of a telephone ringing signal is not taken into account for this purpose.

G.4 Determination of required withstand voltage

G.4.1 Mains transients and internal repetitive peaks

In G.4.1, the effect of transients coming from a TELECOMMUNICATION NETWORK is ignored (see G.4.3).

The REQUIRED WITHSTAND VOLTAGE is determined according to Items a), b) or c).

NOTE Items a) and b) apply only for an AC MAINS SUPPLY. Item c) applies only for a DC MAINS SUPPLY.

The following abbreviations are used.

U_{pw}	the PEAK WORKING VOLTAGE of the CLEARANCE
$U_{\text{a.c. mains peak}}$	peak value of the AC MAINS SUPPLY voltage in the first column of Table G.1 corresponding to the RATED VOLTAGE or the upper limit of the RATED VOLTAGE RANGE.
$U_{\text{mains transient}}$	the MAINS TRANSIENT VOLTAGE determined in G.2.1 or G.2.2
U_{measured}	the maximum transient voltage from the mains, determined according to G.5 a)

a) **PRIMARY CIRCUITS**

It is permitted to use a1) or a2).

a1) The following Rules 1) and 2) shall be applied:

Rule 1) If $U_{pw} \leq U_{a.c.\ mains\ peak}$

$$U_{required\ withstand} = U_{mains\ transient}.$$

Rule 2) If $U_{pw} > U_{a.c.\ mains\ peak}$

$$U_{required\ withstand} = U_{mains\ transient} + U_{pw} - U_{a.c.\ mains\ peak}.$$

a2) The above Rules 1) and 2) shall be applied, but $U_{mains\ transient}$ shall be replaced by $U_{measured}$.

b) SECONDARY CIRCUITS whose PRIMARY CIRCUIT is supplied from an AC MAINS SUPPLY
It is permitted to use b1), b2) or b3).

b1) The following Rule 3) shall be applied:

Rule 3) $U_{required\ withstand} = U_{mains\ transient}$ or $U_{pw,}$ whichever is the greater.

b2) The above Rule 3) shall be applied, but with $U_{mains\ transient}$ replaced by $U_{measured}$.

b3) The above Rule 3 shall be applied, but with $U_{mains\ transient}$ replaced by a voltage that is one step smaller in the following list from Table G.1:

330, 500, 800, 1 500, 2 500, 4 000, 6 000 and 8 000 V peak.

This is permitted in the following cases:

– a SECONDARY CIRCUIT, derived from an AC MAINS SUPPLY, that is connected to the main protective earthing terminal in accordance with 2.6.1 e);

– a SECONDARY CIRCUIT, derived from an AC MAINS SUPPLY and separated from the PRIMARY CIRCUIT by a metal screen that is connected to the main protective earthing terminal in accordance with 2.6.1 e).

c) SECONDARY CIRCUIT supplied from a DC MAINS SUPPLY

The above b1) or b3) shall be applied.

G.4.2 Transients from telecommunication networks

In G.4.2, the effect of transients coming from the mains and from internal circuitry is ignored (see G.4.3).

For transients from a TELECOMMUNICATION NETWORK, the REQUIRED WITHSTAND VOLTAGE is:

– the TELECOMMUNICATION NETWORK TRANSIENT VOLTAGE determined in Clause G.3;

– or the value measured in accordance with G.5 b);

whichever is less.

G.4.3 Combination of transients

If the transients described in G.4.1 and those described in G.4.2 affect the same CLEARANCE, the REQUIRED WITHSTAND VOLTAGE is the larger of the two voltages. The two values shall not be added together.

G.4.4 Transients from cable distribution systems

The effect of transients from a CABLE DISTRIBUTION SYSTEM is not taken into account when determining REQUIRED WITHSTAND VOLTAGE (however, see 7.4.1).

G.5 Measurement of transient voltages

The following tests are conducted only if it is required to determine whether or not the maximum transient voltage across the CLEARANCE *in any circuit is lower than the* MAINS TRANSIENT VOLTAGE *determined in Clause G.2 (for example, due to the effect of a filter in the equipment). If these tests are not conducted, the maximum transient voltage across the* CLEARANCE *shall be assumed to be equal to the* MAINS TRANSIENT VOLTAGE*. If the situation covered by G.2.2 or the situation covered by G.2.4 applies, the transient voltage across the* CLEARANCE *shall be assumed to be negligible and no test is conducted.*

If necessary, the transient voltage across the CLEARANCE *is measured using the following test procedure.*

During the tests, the EUT is connected to its separate power supply unit, if any, but is not connected to the MAINS SUPPLY*, nor to any* TELECOMMUNICATION NETWORKS*, and any surge suppressors in* PRIMARY CIRCUITS *are disconnected.*

A voltage measuring device is connected across the CLEARANCE *in question.*

***a) Transients from a* MAINS SUPPLY**

To measure the transient voltages across a CLEARANCE *due to transients on a* MAINS SUPPLY*, the impulse test generator reference 2 of Table N.1 is used to generate 1,2/50 µs impulses.* U_c *is equal to the* MAINS TRANSIENT VOLTAGE *determined in Clause G.2.*

Three to six impulses of alternating polarity, with intervals of at least 1 s between impulses, are applied between each of the following points where relevant:

For an* AC MAINS SUPPLY*:

- *line-to-line;*
- *all line conductors conductively joined together and neutral;*
- *all line conductors conductively joined together and the main protective earthing terminal;*
- *neutral and the main protective earthing terminal.*

For a* DC MAINS SUPPLY*:

- *the positive and negative supply connection points;*
- *all supply connection points conductively joined together and the main protective earthing terminal.*

***b) Transients from a* TELECOMMUNICATION NETWORK**

To measure the transient voltage across a CLEARANCE *due to transients on a* TELECOMMUNICATION NETWORK*, the impulse test generator reference 1 of Table N.1 is used to generate 10/700 µs impulses.* U_c *is equal to the* TELECOMMUNICATION NETWORK TRANSIENT VOLTAGE *determined in Clause G.3.*

Three to six impulses of alternating polarity, with intervals of at least 1 s between impulses, are applied between each of the following TELECOMMUNICATION NETWORK *connection points of each interface type:*

- *each pair of terminals (for example, A and B or tip and ring) in an interface;*
- *all terminals of a single interface joined together and earth.*

Where there are several identical circuits, only one is tested.

G.6 Determination of minimum clearances

For equipment to be operated up to 2 000 m above sea level, each CLEARANCE shall comply with the minimum dimensions given in Table G.2, using the value of REQUIRED WITHSTAND VOLTAGE determined according to G.4.

For equipment to be operated at more than 2 000 m above sea level, the minimum CLEARANCES shall be multiplied by the factor given in Table A.2 of IEC 60664-1. Linear interpolation is permitted between the nearest two points in Table A.2 of IEC 60664-1. The calculated minimum CLEARANCE using this multiplication factor shall be rounded up to the next higher 0,1 mm increment.

The specified minimum CLEARANCES are subject to the following minimum values:

– 10 mm for an air gap serving as REINFORCED INSULATION between a part at 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;

– 2 mm for an air gap serving as BASIC INSULATION between a part at HAZARDOUS VOLTAGE and an earthed accessible conductive part of the ENCLOSURE of PLUGGABLE EQUIPMENT TYPE A.

The above two dashed paragraphs do not apply between a part at a HAZARDOUS VOLTAGE and a BOUNDING SURFACE.

Except as required by 2.8.7.1 the specified minimum CLEARANCES do not apply to the air gap between the contacts of THERMOSTATS, THERMAL CUT-OUTS, overload protection devices, switches of microgap construction and similar components where the air gap varies with the contacts.

NOTE 1 For air gaps between contacts of disconnect devices, see 3.4.2. For air gaps between the contacts of interlock switches, see 2.8.7.1.

The CLEARANCES between the BOUNDING SURFACE of a connector and conductive parts within the connector that are connected to a HAZARDOUS VOLTAGE shall comply with the requirements for REINFORCED INSULATION. As an exception, for connectors that are

– fixed to the equipment; and

– located internal to the outer ENCLOSURE of the equipment; and

– only accessible after removal of a USER-replaceable subassembly that is required to be in place during normal operation,

these CLEARANCES shall comply with the requirements for BASIC INSULATION.

NOTE 2 The tests of 2.1.1.1 for access to hazardous parts apply to such connectors after removal of the subassembly.

For all other CLEARANCES in connectors, including connectors that are not fixed to the equipment, the minimum values specified in Table G.2 apply.

The above minimum CLEARANCES for connectors do not apply to connectors that comply with a standard harmonized with IEC 60083, IEC 60309, IEC 60320, IEC 60906-1 or IEC 60906-2, see also 1.5.2.

Table G.2 – Minimum clearances up to 2 000 m above sea level

CLEARANCES in mm

REQUIRED WITHSTAND VOLTAGE	FUNCTIONAL INSULATION [a]			BASIC INSULATION and SUPPLEMENTARY INSULATION			REINFORCED INSULATION		
V peak or d.c. up to and including	**Pollution degree**								
	1 [b]	**2**	**3**	**1** [b]	**2**	**3**	**1** [b]	**2**	**3**
400	0,1	0,2	0,8	0,2 (0,1)	0,2	0,8	0,4 (0,2)	0,4	1,6
800	0,1	0,2	0,8	0,2 (0,1)	0,2	0,8	0,4 (0,2)	0,4	1,6
1 000	0,2	0,2	0,8	0,3 (0,2)		0,8	0,6 (0,4)		1,6
1 200	0,3		0,8	0,4 (0,3)		0,8	0,8 (0,6)		1,6
1 500	0,5		0,8	0,8 (0,5)		0,8	1,6 (1,0)		1,6
2 000	1,0			1,3 (1,0)			2,6 (2,0)		
2 500	1,5			2,0 (1,5)			4,0 (3,0)		
3 000	2,0			2,6 (2,0)			5,2 (4,0)		
4 000	3,0			4,0 (3,0)			6,0		
6 000	5,5			7,5 (5,5)			11		
8 000	8,0			11 (8,0)			16		
10 000	11			15 (11)			22		
12 000	14			19 (14)			28		
15 000	18			24 (18)			36		
25 000	33			44 (33)			66		
40 000	60			80 (60)			120		
50 000	75			100 (75)			150		
60 000	90			120 (90)			180		
80 000	130			173 (130)			260		
100 000	170			227 (170)			340		

Linear interpolation is permitted between the nearest two points, the calculated minimum CLEARANCES being rounded up to the next higher 0,1 mm increment.

The values in parentheses apply only if manufacturing is subjected to a quality control programme that provides at least the same level of assurance as the example given in Clause R.2. DOUBLE INSULATION and REINFORCED INSULATION shall be subjected to ROUTINE TESTS for electric strength.

In a SECONDARY CIRCUIT, a minimum CLEARANCE of 5 mm replaces any higher value, provided that the insulation involved passes an electric strength test according to 5.2.2 using:

- an a.c. test voltage whose r.m.s. value is 106 % of the PEAK WORKING VOLTAGE (peak value 150 % of the PEAK WORKING VOLTAGE), or
- a d.c. test voltage equal to 150 % of the PEAK WORKING VOLTAGE.

If the CLEARANCE path is partly along the surface of insulation that is not Material Group I, the test voltage is applied across the air gap and the Material Group I only. The part of the path along the surface of any other insulating material is bypassed.

[a] There is no minimum CLEARANCE for FUNCTIONAL INSULATION unless it is required by 5.3.4 a).

[b] It is permitted to use the values for Pollution Degree 1 if one sample passes the tests of 2.10.10.

Compliance is checked by measurement, taking into account Annex F. The following conditions apply

– *movable parts shall be placed in the most unfavourable position;*

– *for equipment incorporating ordinary NON-DETACHABLE POWER SUPPLY CORDS, CLEARANCE measurements are made with supply conductors of the largest cross-sectional area specified in 3.3.4, and also without conductors;*

NOTE 3 The force tests of 4.2.2, 4.2.3 and 4.2.4 apply.

– *when measuring CLEARANCES from the BOUNDING SURFACE of an ENCLOSURE of insulating material through a slot or opening in the ENCLOSURE, or through an opening in an accessible connector, 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 2A (see 2.1.1.1), applied without appreciable force (see Figure F.12, point X).*

There is no need to conduct an electric strength test to verify CLEARANCES *except as required in Table G.2 if a minimum 5 mm* CLEARANCE *is used.*

Annex H
(normative)

Ionizing radiation

(see 4.3.13)

Equipment that might produce ionizing radiation is checked by measuring the amount of radiation.

The amount of radiation is determined by means of a radiation monitor of the ionizing chamber type with an effective area of 1 000 mm^2 or by measuring equipment of other types giving equivalent results.

Measurements are made with the equipment on test operating at the most unfavourable supply voltage (see 1.4.5) and with OPERATOR *controls and service controls adjusted so as to give maximum radiation whilst maintaining the equipment operative for normal use.*

Internal preset controls not intended to be adjusted during the lifetime of the equipment are not considered to be service controls.

At any point 50 mm from the surface of the OPERATOR ACCESS AREA*, the dose-rate shall not exceed 36 pA/kg (5 μSv/h) (0,5 mR/h) (see Note 1). Account is taken of the background level.*

NOTE 1 This value is consistent with ICRP 60.

NOTE 2 In the member countries of CENELEC, the amount of ionizing radiation is regulated by European Council Directive 96/29/Euratom of 13 May 1996. This directive requires that at any point 10 cm from the surface of the equipment, the dose-rate shall not exceed 1 μSv/h (0,1 mR/h) taking account of the background level.

Annex J
(normative)

Table of electrochemical potentials (see 2.6.5.6)

Table J.1 – Electrochemical potentials (V)

Magnesium, magnesium alloys	Zinc, zinc alloys	80 tin/20 Zn on steel, Zn on iron or steel	Aluminium	Cd on steel	Al/Mg alloy	Mild steel	Duralumin	Lead	Cr on steel, soft solder	Cr on Ni on steel, tin on steel 12 % Cr stainless steel	High Cr stainless steel	Copper, copper alloys	Silver solder, Austenitic stainless steel	Ni on steel	Silver	Rh on Ag on Cu, silver/gold alloy	Carbon	Gold, platinum	
0	0,5	0,55	0,7	0,8	0,85	0,9	1,0	1,05	1,1	1,15	1,25	1,35	1,4	1,45	1,6	1,65	1,7	1,75	Magnesium, magnesium alloys
	0	0,05	0,2	0,3	0,35	0,4	0,5	0,55	0,6	0,65	0,75	0,85	0,9	0,95	1,1	1,15	1,2	1,25	Zinc, zinc alloys
		0	0,15	0,25	0,3	0,35	0,45	0,5	0,5	0,6	0,7	0,8	0,85	0,9	1,05	1,1	1,15	1,2	80 tin/20 Zn on steel, Zn on iron or steel
			0	0,1	0,15	0,2	0,3	0,35	0,4	0,45	0,55	0,65	0,7	0,75	0,9	0,95	1,0	1,05	Aluminium
				0	0,05	0,1	0,2	0,25	0,3	0,35	0,45	0,55	0,6	0,65	0,8	0,85	0,9	0,95	Cd on steel
					0	0,05	0,15	0,2	0,2	0,3	0,4	0,5	0,55	0,6	0,75	0,8	0,85	0,9	Al/Mg alloy
						0	0,1	0,15	0,2	0,25	0,35	0,45	0,5	0,55	0,7	0,75	0,8	0,85	Mild steel
							0	0,05	0,1	0,15	0,25	0,35	0,4	0,45	0,6	0,65	0,7	0,75	Duralumin
								0	0,5	0,1	0,2	0,3	0,35	0,4	0,55	0,6	0,66	0,7	Lead
									0	0,05	0,15	0,25	0,3	0,35	0,5	0,55	0,6	0,65	Cr on steel, soft solder
										0	0,1	0,2	0,25	0,3	0,45	0,5	0,55	0,6	Cr on Ni on steel, tin on steel 12 % Cr stainless steel
											0	0,1	0,15	0,2	0,35	0,4	0,45	0,5	High Cr stainless steel
												0	0,05	0,1	0,25	0,3	0,35	0,4	Copper, copper alloys
													0	0,15	0,2	0,25	0,3	0,35	Silver solder, Austenitic stainless steel
														0	0,15	0,2	0,25	0,3	Ni on steel
															0	0,5	0,1	0,15	Silver
																0	0,05	0,1	Rh on Ag on Cu, silver/gold alloy
																	0	0,5	Carbon
																		0	Gold, platinum

Ag Silver
Al Aluminium
Cd Cadmium
Cr Chromium
Cu Copper
Mg Magnesium
Ni Nickel
Rh Rhodium
Zn Zinc

NOTE Corrosion due to electrochemical action between dissimilar metals that are in contact is minimized if the combined electrochemical potential is below about 0,6 V. In the table the combined electrochemical potentials are listed for a number of pairs of metals in common use; combinations above the dividing line should be avoided.

Magnesium, magnesium alloys		80 tin/20 zinc on steel, zinc on iron or steel	Aluminium	Cadmium on steel	Aluminium/magnesium alloy	Mild steel		Lead	Chromium on steel, soft solder	Cr on Ni on steel, tin on steel, 12 % Cr stainless steel	High chromium stainless steel	Copper, copper alloys	Silver solder, austenitic stainless steel	Nickel on steel	Silver	Rhodium on silver on copper, silver/gold alloy	Carbon	Gold, platinum	
0	0,5	0,55	0,7	0,8	0,85	0,9	1,0	1,05	1,1	1,15	1,25	1,35	1,4	1,45	1,6	1,65	1,7	1,75	Magnesium, magnesium alloys
	0	0,05	0,2	0,3	0,35	0,4	0,5	0,55	0,6	0,65	0,75	0,85	0,9	0,95	1,1	1,15	1,2	1,25	Zinc, zinc alloys
		0	0,15	0,25	0,3	0,35	0,45	0,5	0,55	0,6	0,7	0,8	0,85	0,9	1,05	1,1	1,15	1,2	80 tin/20 zinc on steel, zinc on iron or steel
			0	0,1	0,15	0,2	0,3	0,35	0,4	0,45	0,55	0,65	0,7	0,75	0,9	0,95	1,0	1,05	Aluminium
				0	0,05	0,1	0,2	0,25	0,3	0,35	0,45	0,55	0,6	0,65	0,8	0,85	0,9	0,95	Cadmium on steel
					0	0,05	0,15	0,2	0,25	0,3	0,4	0,5	0,55	0,6	0,75	0,8	0,85	0,9	Aluminium/magnesium alloy
						0	0,1	0,15	0,2	0,25	0,35	0,45	0,5	0,55	0,7	0,75	0,8	0,85	Mild steel
							0	0,05	0,1	0,15	0,25	0,35	0,4	0,45	0,6	0,65	0,7	0,75	Duralumin
								0	0,05	0,1	0,2	0,3	0,35	0,4	0,55	0,6	0,66	0,7	Lead
									0	0,05	0,15	0,25	0,3	0,35	0,5	0,55	0,6	0,65	Chromium on steel, soft solder
										0	0,1	0,2	0,25	0,3	0,45	0,5	0,55	0,6	Cr on Ni on steel, tin on steel, 12 % Cr stainless steel
											0	0,1	0,15	0,2	0,35	0,4	0,45	0,5	High chromium stainless steel
												0	0,05	0,1	0,25	0,3	0,35	0,4	Copper, copper alloys
													0	0,05	0,2	0,25	0,3	0,35	Silver solder, austenitic stainless steel
														0	0,15	0,2	0,25	0,3	Nickel on steel
															0	0,05	0,1	0,15	Silver
																0	0,05	0,1	Rhodium on silver on copper, silver/gold alloy
																	0	0,05	Carbon
																		0	Gold, platinum

Cr = Chromium
Ni = Nickel

NOTE Corrosion due to electrochemical action between dissimilar metals which are in contact is minimized if the combined electrochemical potential is below about 0,6 V. In the above table the combined electrochemical potentials are listed for a number of pairs of metals in common use. Combinations above the dividing line should be avoided.

Annex K
(normative)

Thermal controls

(see 1.5.3 and 5.3.8)

K.1 Making and breaking capacity

THERMOSTATS and TEMPERATURE LIMITERS shall have adequate making and breaking capacity.

Compliance is checked by subjecting three samples either to the tests of Clauses K.2 and K.3, or to the tests of K.4, as appropriate. If the component is T-marked, one sample is tested with the switch part at room temperature, and two samples with the switch part at a temperature in accordance with the marking.

Components not marked with individual ratings are tested either in the equipment or separately, whichever is more convenient, but, if tested separately, the test conditions are to be similar to those occurring in the equipment.

During the tests, no sustained arcing shall occur.

After the tests, the samples shall show no damage impairing their further use. Electrical connections shall not have worked loose. The component shall withstand an electric strength test as specified in 5.2.2, except that the test voltage for the insulation between the contacts is twice the voltage applied when the equipment is operated at RATED VOLTAGE or at the upper voltage of the RATED VOLTAGE RANGE.

For test purposes the switching frequency can be increased above the normal switching frequency inherent to the equipment, provided that no greater risk of failure is induced.

If it is not possible to test the component separately, three samples of the equipment in which it is used are tested.

K.2 Thermostat reliability

THERMOSTATS are caused, thermally, to perform 200 cycles of operation (200 makes and 200 breaks) when the equipment is operated at a voltage equal to 110 % of the RATED VOLTAGE or to 110 % of the upper voltage of the RATED VOLTAGE RANGE, and under NORMAL LOAD.

K.3 Thermostat endurance test

THERMOSTATS are caused, thermally, to perform 10 000 cycles of operation (10 000 makes and 10 000 breaks) when the equipment is operated at RATED VOLTAGE or at the upper voltage of the RATED VOLTAGE RANGE, and under NORMAL LOAD.

K.4 Temperature limiter endurance

TEMPERATURE LIMITERS are caused, thermally, to perform 1 000 cycles of operation (1 000 makes and 1 000 breaks) when the equipment is operated at RATED VOLTAGE, or at the upper voltage of the RATED VOLTAGE RANGE, and under NORMAL LOAD.

K.5 Thermal cut-out reliability

THERMAL CUT-OUTS shall operate reliably.

Compliance is checked while the equipment is operating under the conditions specified in 4.5.2.

AUTOMATIC RESET THERMAL CUT-OUTS are caused to operate 200 times; MANUAL RESET THERMAL CUT-OUTS are reset after each operation and thus caused to operate ten times.

After the tests, the samples shall show no damage impairing their further use.

Forced cooling and resting periods are permitted to prevent damage to the equipment.

K.6 Stability of operation

THERMOSTATS, TEMPERATURE LIMITERS and THERMAL CUT-OUTS shall be so constructed that their setting is not changed appreciably by heating, vibration, etc., occurring in normal use.

Compliance is checked by inspection during the abnormal operation tests of 5.3.

Annex L
(normative)

Normal load conditions for some types of electrical business equipment

(see 1.2.2.1 and 4.5.2)

L.1 Typewriters

Typewriters are energized with no load applied until steady conditions are established. Manually keyed machines are then operated at a rate of 200 characters per minute, with a line transport operation after each 60 characters including spaces, until steady conditions are established. Automatically operated machines are operated at the maximum typing speed recommended in the manufacturer's instructions.

L.2 Adding machines and cash registers

For adding machines and cash registers, four digit numbers are entered or set and the repeat key or operating bar activated 24 times per minute, until steady conditions are established, the four digit number to be used being that which loads the machine most heavily. If the cash register has a drawer that opens every time an item is rung up, the cash register is operated at a rate of 15 operation cycles per minute, the drawer being shut after each operation, until steady conditions are established. For an adding machine or cash register, an operation consists of the OPERATOR *setting or inserting the figures with which the machine is to operate and then pressing the operating bar, repeating key or the like for each operation.*

L.3 Erasers

Erasers are operated continuously at no load for 1 h.

L.4 Pencil sharpeners

For a pencil sharpener, five new pencils are each sharpened eight times according to the following timetable. Except for new pencils, the point is broken off before each sharpening.

Sharpening period	*4 s for a new pencil*
	2 s for subsequent sharpenings
Interval between sharpenings	*6 s*
Interval between pencils	*60 s*

All times are approximate.

L.5 Duplicators and copy machines

Duplicators and copy machines are operated continuously at maximum speed until steady conditions are established. It is permitted to introduce a rest period of 3 min after each 500 copies if this is compatible with the design of the machine.

L.6 Motor-operated files

Motor-operated files are loaded to simulate a condition of unbalance caused by uneven distribution of the contents. During operation, the unbalanced load is moved approximately one-third of the total carrier travel of the path that will impose maximum loading during each operation. The operation is repeated each 15 s until steady conditions are established.

A load caused by the non-uniform distribution of the contents is permitted to be simulated as follows.

In the case of vertical transport, three-eighths of the filing area are to be loaded, without leaving clearances, with three-eighths of the admissible load. The entire transport way is to be travelled with this load. The transport cycle is to be repeated, at intervals of 10 s, until the temperature has stabilized.

In the case of a different transport, for example, horizontal or circular mode of transport, the total load is moved over the whole transport way. The transport cycle is to be repeated, at intervals of 15 s, until the temperature has stabilized.

L.7 Other business equipment

Other business equipment is operated according to the most unfavourable way of operation given in the operating instructions.

Annex M
(normative)

Criteria for telephone ringing signals

(see 2.3.1)

M.1 Introduction

The two alternative methods described in this annex reflect satisfactory experience in different parts of the world. Method A is typical of analogue telephone networks in Europe, and Method B of those in North America. The two methods result in standards of electrical safety that are broadly equivalent.

M.2 Method A

This method requires that the currents $\cancel{I_{TSI}}$ I_{TS1} *and* I_{TS2} *flowing through a 5 000* Ω *resistor, between any two conductors or between one conductor and earth do not exceed the limits specified, as follows.*

a) *For normal operation,* $\cancel{I_{TSI}}$ I_{TS1}, *the current determined from the calculated or measured current for any single active ringing period* t_1 *(as defined in Figure M.1), does not exceed:*

1) *for cadenced ringing* ($t_1 < \infty$), *the current given by the curve of Figure M.2 at* t_1;

2) *for continuous ringing* ($t_1 = \infty$), *16 mA.*

$\cancel{I_{TSI}}$ I_{TS1}, *in mA, is as given by*

$$I_{TS1} = \frac{I_p}{\sqrt{2}} \qquad \text{for } (t_1 \le 600 \text{ ms})$$

$$I_{TS1} = \frac{t_1 - 600}{600} \times \frac{I_{pp}}{2\sqrt{2}} + \frac{1\,200 - t_1}{600} \times \frac{I_p}{\sqrt{2}} \qquad \text{for } (600 \text{ ms} < t_1 < 1\,200 \text{ ms})$$

$$I_{TS1} = \frac{I_{pp}}{2\sqrt{2}} \qquad \text{for } (t_1 \ge 1\,200 \text{ ms})$$

where

I_p is the peak current, in mA, of the relevant waveform given in Figure M.3;

I_{pp} is the peak-to-peak current, in mA, of the relevant waveform given in Figure M.3;

t_1 is expressed in ms.

b) *For normal operation,* I_{TS2}, *the average current for repeated bursts of a cadenced ringing signal calculated for one ringing cadence cycle* t_2 *(as defined in Figure M.1), does not exceed 16 mA r.m.s.*

I_{TS2} *in mA is as given by*

$$I_{TS2} = \left[\frac{t_1}{t_2} \times I_{TS1}^2 + \frac{t_2 - t_1}{t_2} \times \frac{I_{dc}^2}{3{,}75^2} \right]^{1/2}$$

where

~~I_{TSI}~~ I_{TS1} *in mA, is as given by item a) of Clause M.2;*

I_{dc} *is the d.c. current in mA flowing through the 5 000 Ω resistor during the non-active period of the cadence cycle;*

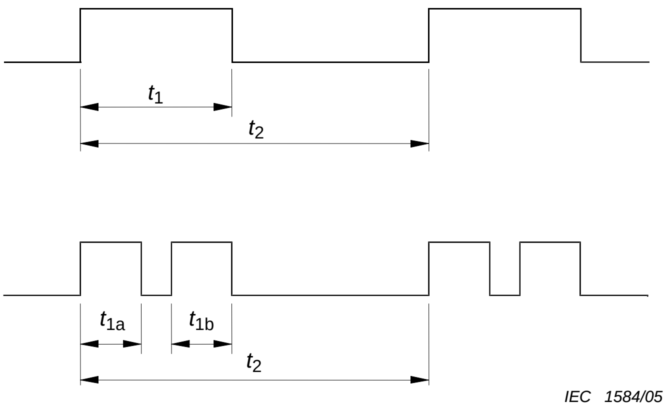
t_1 *and* t_2 *are expressed in milliseconds.*

NOTE The frequencies of telephone ringing voltages are normally within the range of 14 Hz to 50 Hz.

c) Under single fault conditions, including where cadenced ringing becomes continuous:

– ~~I_{TSI}~~ I_{TS1} *shall not exceed the current given by the curve of Figure M.2, or 20 mA, whichever is greater;*

– I_{TS2} *shall not exceed a limit of 20 mA.*



t_1 *is:*

– *the duration of a single ringing period, where the ringing is active for the whole of the single ringing period;*

– *the sum of the active periods of ringing within the single ringing period, where the single ringing period contains two or more discrete active periods of ringing, as in the example shown, for which* $t_1 = t_{1a} + t_{1b}$.

t_2 *is the duration of one complete cadence cycle.*

Figure M.1 – Definition of ringing period and cadence cycle

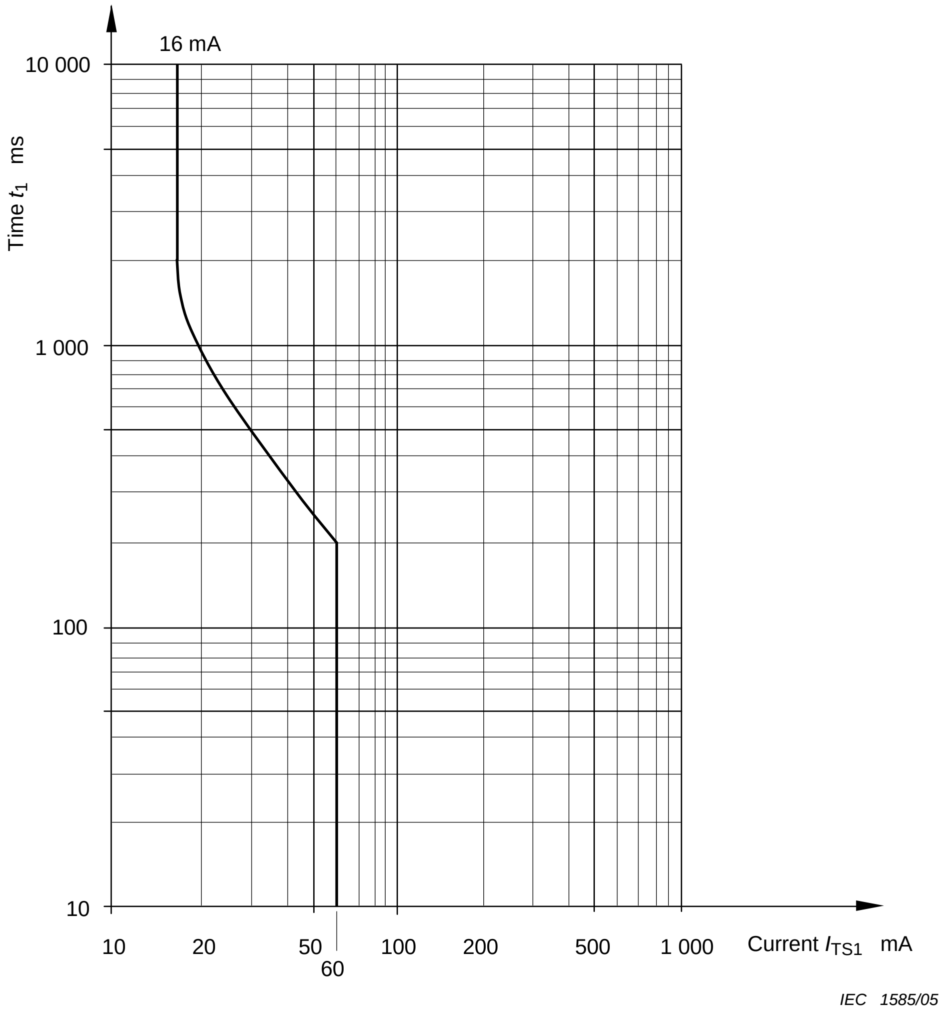
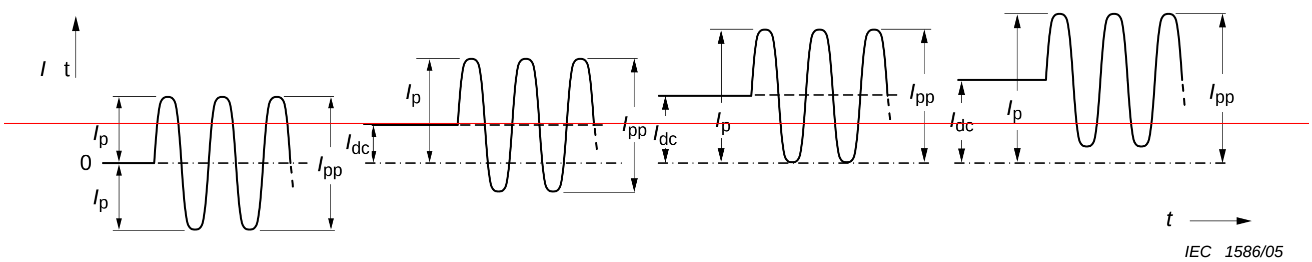


Figure M.2 – I_{TS1} limit curve for cadenced ringing signal



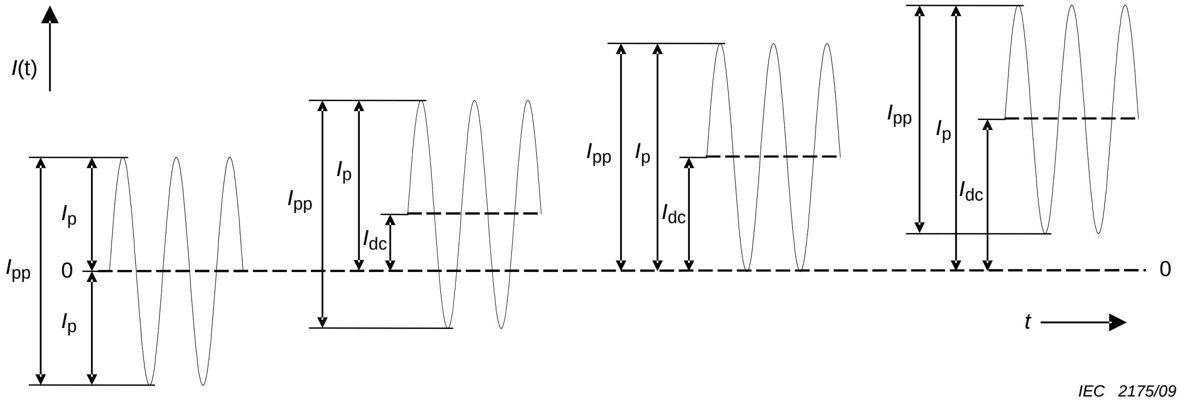


Figure M.3 – Peak and peak-to-peak currents

M.3 Method B

NOTE This method is aligned with USA CFR 47 ("FCC Rules") Part 68, Sub-part D, with additional requirements that apply under fault conditions.

M.3.1 Ringing signal

M.3.1.1 Frequency

The ringing signal shall use only frequencies whose fundamental component is equal to or less than 70 Hz.

M.3.1.2 Voltage

The ringing voltage shall be less than 300 V peak-to-peak and less than 200 V peak with respect to earth, measured across a resistance of at least 1 MΩ.

M.3.1.3 Cadence

The ringing voltage shall be interrupted to create quiet intervals of at least 1 s duration separated by no more than 5 s. During the quiet intervals, the voltage to earth shall not exceed 60 V d.c.

M.3.1.4 Single fault current

Where cadenced ringing becomes continuous as a consequence of a single fault, the current through a 5 000 Ω resistor connected between any two output conductors or between one output conductor and earth shall not exceed 56,5 mA peak-to-peak, as shown in Figure M.3.

M.3.2 Tripping device and monitoring voltage

M.3.2.1 Conditions for use of a tripping device or a monitoring voltage

A ringing signal circuit shall include a tripping device as specified in M.3.2.2, or provide a monitoring voltage as specified in M.3.2.3, or both, depending on the current through a specified resistance connected between the ringing signal generator and earth, as follows:

– if the current through any resistor of 500 Ω or greater, does not exceed 100 mA peak-to-peak, neither a tripping device nor a monitoring voltage is required;

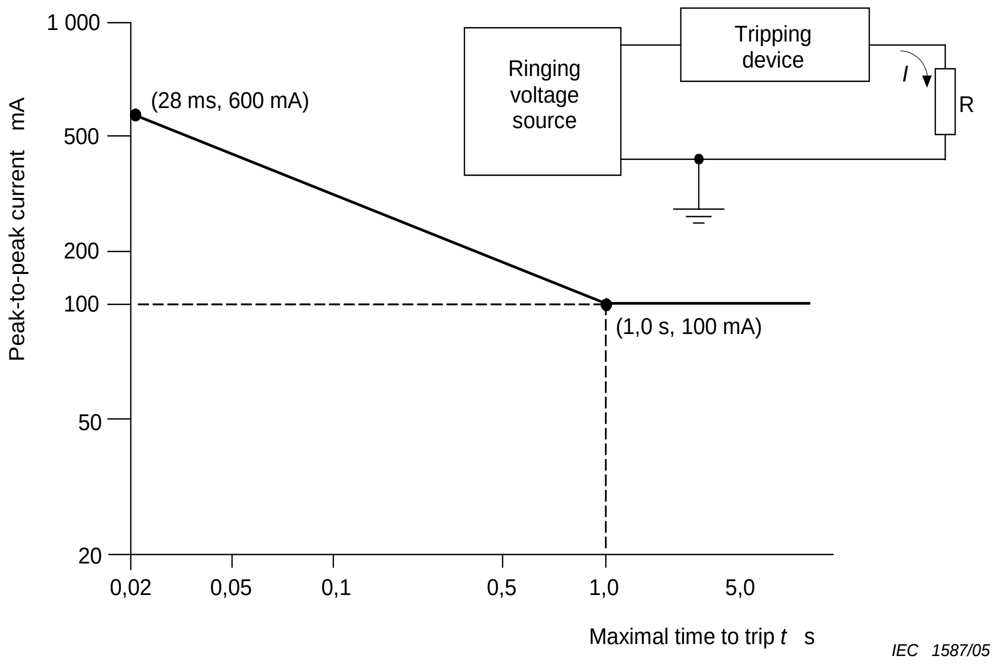
– if the current through any resistor of 1 500 Ω or greater, exceeds 100 mA peak-to-peak, a tripping device shall be included. If the tripping device meets the trip criteria specified in Figure M.4 with any resistor of R = 500 Ω or greater, no monitoring voltage is required. If, however, the tripping device only meets the trip criteria with any resistor of R = 1 500 Ω or greater, a monitoring voltage shall also be provided;

– if the current through any resistor of 500 Ω or greater, exceeds 100 mA peak-to-peak, but the current through any resistor of 1 500 Ω or greater, does not exceed this value, either:

- a tripping device shall be provided, meeting the trip criteria specified in Figure M.4 with any resistor of R = 500 Ω or greater, or
- a monitoring voltage shall be provided.

NOTE 1 Tripping devices are, in general, current-sensitive and do not have a linear response, due to the resistance/current characteristics and time delay/response factor in their design.

NOTE 2 In order to minimize testing time, a variable resistor box should be used.



NOTE 1 *t* is measured from the time of connection of the resistor R to the circuit.

NOTE 2 The sloping part of the curve is defined as $I = 100 / \sqrt{t}$.

Figure M.4 – Ringing voltage trip criteria

M.3.2.2 Tripping device

A series current-sensitive tripping device in the ringlead that will trip ringing as specified in Figure M.4.

M.3.2.3 Monitoring voltage

A voltage to earth on the tip or ring conductor with a magnitude of at least 19 V peak, but not exceeding 60 V d.c., whenever the ringing voltage is not present (idle state).

Annex N
(normative)

Impulse test generators

(see 1.5.7.2, 1.5.7.3, 2.10.3.9, 6.2.2.1, 7.4.2, 7.4.3 and Clause G.5)

NOTE Extreme care is necessary when using these test generators due to the high electric charge stored in the capacitor C_1.

N.1 ITU-T impulse test generators

The circuit in Figure N.1, using the component values in references 1 and 2 of Table N.1, is used to generate impulses, the C_1 capacitor being charged initially to a voltage U_c.

Circuit reference 1 of Table N.1 generates 10/700 µs impulses (10 µs virtual front time, 700 µs virtual time to half value) as specified in ITU-T Recommendation K.44 to simulate lightning interference in the TELECOMMUNICATION NETWORK.

Circuit reference 2 of Table N.1 generates 1,2/50 µs impulses (1,2 µs virtual front time, 50 µs virtual time to half value) as specified in ITU-T Recommendation K.44 to simulate transients in power distribution systems.

The impulse wave shapes are under open-circuit conditions and can be different under load conditions.

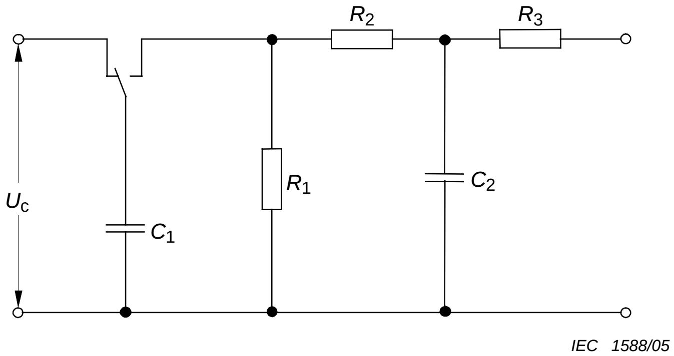


Figure N.1 – ITU-T impulse test generator circuit

N.2 IEC 60065 impulse test generator

The circuit in Figure N.2, using the component values reference 3 in Table N.1, is used to generate impulses, the C_1 capacitor being charged initially to a voltage U_c. The switch used in Figure N.2 is a critical part of the circuit. See 10.1 of IEC 60065, for further information.

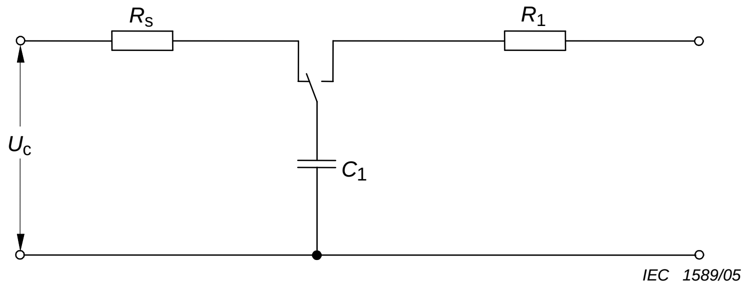


Figure N.2 – IEC 60065 impulse test generator circuit

Table N.1 – Component values for Figures N.1 and N.2

Reference	Test impulse	Figure	C_1	C_2	R_1	R_2	R_3	R_s	See
1 [a]	10/700 µs	N.1	20 µF	0,2 µF	50 Ω	15 Ω	25 Ω	–	1.5.7.3, 2.10.3.9, 6.2.2.1, 7.4.3 and item b) of Clause G.5
2 [b]	1,2/50 µs	N.1	1 µF	30 nF	76 Ω	13 Ω	25 Ω	–	1.5.7.2, 2.10.3.9 and item a) of Clause G.5
3 [c]	–	N.2	1 nF	–	1 kΩ	–	–	15 MΩ	1.5.7.3 and 7.4.2

[a] Reference 1 impulse is typical of voltages induced into telephone wires and coaxial cables in long outdoor cable runs by nearby lightning strikes to earth.

[b] Reference 2 impulse is typical of earth potential rises caused either by lightning strikes to power lines or by power line faults.

[c] Reference 3 impulse is typical of voltages induced into antenna system wiring caused by nearby lightning strikes to earth.

Annex P
(normative)

Normative references

~~The following reference documents are indispensable for the application of this standard. If the date of the reference document is given, only that edition applies, excluding any subsequent corrigenda and amendments. For undated references, the latest edition of the referenced document applies, including any corrigenda and amendments.~~

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies taking into account any transition period, effective date or date of withdrawal established for the existing document.

These documents are referenced, in whole, in part or as alternative requirements to the requirements contained in this standard. Their use is specified, where necessary, for the application of the requirements of this standard.

NOTE The list below is a summary of all standards that are referred to within this standard. Appearance of a standard in the list on itself does not mean that the standard or parts of it are applicable. Only those parts that are specifically referenced in this standard are applicable.

Further information on the reference documents, including how to obtain copies, can be found on the following internet sites:

http://www.iec.ch
http://www.iso.org
http://www.itu.int

For the locations in the standard where these documents are mentioned, see the Index.

IEC 60065:2001:, *Audio, video and similar electronic apparatus – Safety requirements*
Amendment 1[2)]

IEC 60068-2-78, *Environmental testing – Part 2-78: Tests – Test Cab: Damp heat, steady state*

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

IEC 60083, *Plugs and socket-outlets for domestic and similar general use standardized in member countries of IEC*

IEC 60085:2004, *Electrical Insulation – Thermal classification*

IEC 60112, *Method for determination of the proof and the comparative tracking indices of insulating materials*

IEC 60127-1, *Miniature fuses – Part 1: Definitions for miniature fuses and general requirements for miniature fuse-links*

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2) To be published.

~~IEC 60216-4-1, *Guide for the determination of thermal endurance properties of electrical insulating materials – Part 4: Ageing ovens – Section 1: Single-chamber ovens*~~

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

IEC 60227-1:2007, *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V – Part 1: General requirements*

IEC 60227-2:1997, *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V – Part 2: Test methods*
Amendment 1: 2003

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

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

IEC 60317 (all parts), *Specifications for particular types of winding wires*

IEC 60317-43, *Specifications for particular types of winding wires – Part 43: Aromatic polyimide tape wrapped round copper wire, class 240*

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

IEC 60364-1:2001, *Electrical installations of buildings - Part 1: Fundamental principles, assessment of general characteristics, definitions*

IEC 60384-14:1993, *Fixed capacitors for use in electronic equipment – Part 14: Sectional specification: Fixed capacitors for electromagnetic interference suppression and connection to the supply mains*
Amendment 1 (1995)

IEC 60417-DB:2002[3)], *Graphical symbols for use on equipment*

IEC 60664-1:1992, *Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests*[4)]
Amendment 1 (2000)
Amendment 2 (2002)

IEC 60695-2-11, *Fire hazard testing – Part 2-11: Glowing/hot-wire based test methods – Glow-wire flammability test method for end-products*

IEC 60695-2-20, *Fire hazard testing – Part 2-20: Glowing/hot wire based test methods – Hot-wire coil ignitability - Apparatus, test method and guidance*

IEC 60695-10-2, *Fire hazard testing – Part 10-2: Abnormal heat – Ball pressure test*

IEC 60695-10-3, *Fire hazard testing – Part 10-3: Abnormal heat – Mould stress relief distortion test*

IEC 60695-11-3, *Fire hazard testing – Part 11-3: Test flames – 500 W flames – Apparatus and confirmational test methods*

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3) "DB" refers to the IEC on-line database.

4) A consolidated edition 1.2 exists, including IEC 60664-1:1992 and its Amendments 1 (2000) and 2 (2002).

IEC 60695-11-4, *Fire hazard testing – Part 11-4: Test flames – 50 W flames – Apparatus and confirmational test methods*

IEC 60695-11-5:2004, *Fire hazard testing – Part 11-5: Test flames – Needle-flame test method – Apparatus, confirmatory test arrangement and guidance*

IEC 60695-11-10, *Fire hazard testing – Part 11-10: Test flames – 50 W horizontal and vertical flame test methods*

IEC 60695-11-20, *Fire hazard testing – Part 11-20: Test flames – 500 W flame test methods*

IEC 60730-1:1999, *Automatic electrical controls for household and similar use – Part 1: General requirements*[5)]
Amendment 1 (2003)

IEC 60747-5-5,___[6)] *Discrete semiconductor devices – Part 5-5: Optoelectronic devices – Photocouplers, optocouplers*

IEC 60825-1, *Safety of laser products – Part 1: Equipment classification, requirements and user's guide*

IEC 60825-2, *Safety of laser products – Part 2: Safety of optical fibre communication systems*

IEC 60825-9, *Safety of laser products – Part 9: Compilation of maximum permissible exposure to incoherent optical radiation*

IEC 60825-12, *Safety of laser products - Part 12: Safety of free space optical communication systems used for transmission of information*

~~IEC 60851-3:1996~~ IEC 60851-3:2009, *Winding wires – Test methods – Part 3: Mechanical properties*[~~7~~)]
~~Amendment 1 (1997)~~

~~IEC 60851-5:1996~~ IEC 60851-5:2008, *Winding wires – Test methods – Part 5: Electrical properties* [~~8~~)]
~~Amendment 1 (1997)~~
~~Amendment 2 (2004)~~

IEC 60851-6:1996, *Winding wires - Test methods – Part 6: Thermal properties*

IEC 60885-1:1987, *Electrical test methods for electric cables – Part 1: Electrical tests for cables, cords and wires for voltages up to and including 450/750 V*

IEC 60906-1, *IEC system of plugs and socket-outlets for household and similar purposes – Part 1: Plugs and socket-outlets 16 A 250 V a.c.*

IEC 60906-2, *IEC system of plugs and socket-outlets for household and similar purposes – Part 2: Plugs and socket-outlets 15 A 125 V a.c.*

IEC 60947-1:2004, *Low voltage switchgear and control gear - Part 1: General rules*

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5) A consolidated edition 3.1 exists, including IEC 60730-1:1999 and its Amendment 1 (2003).

6) To be published.

~~7) A consolidated edition 2.1 exists, including IEC 60851-3:1996 and its Amendment 1 (1997).~~

~~8) A consolidated edition 3.2 exists, including IEC 60851-5:1996 and its Amendments 1 (1997) and 2 (2004).~~

IEC 60990:1999, *Methods of measurement of touch current and protective conductor current*

IEC 60998-1, *Connecting devices for low-voltage circuits for household and similar purposes – Part 1: General requirements*

IEC 60999-1, *Connecting devices – Electrical copper conductors – Safety requirements for screw-type and screwless-type clamping units – Part 1: General requirements and particular requirements for clamping units for conductors from 0,2 mm^2 up to 35 mm^2 (included)*

IEC 60999-2, *Connecting devices – Electrical copper conductors – Safety requirements for screw-type and screwless-type clamping units – Part 2: Particular requirements for clamping units for conductors above 35 mm^2 up to 300 mm^2 (included)*

IEC 61051-2:1991, *Varistors for use in electronic equipment – Part 2: Sectional specification for surge suppression varistors*

IEC 61058-1:2000, *Switches for appliances – Part 1: General requirements*

IEC 62133:2012, *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for portable sealed secondary cells, and for batteries made from them, for use in portable applications*

IEC 62368-1, *Audio/video, information and communication technology equipment – Part 1: Safety requirements*

IEC 62471:2006, *Photobiological safety of lamps and lamp systems*

ISO 178, *Plastics – Determination of flexural properties*

ISO 179 (all parts), *Plastics – Determination of Charpy impact properties*

ISO 180, *Plastics – Determination of Izod impact strength*

ISO 261, *ISO General-purpose metric screw threads – General plan*

ISO 262, *ISO General-purpose metric screw threads – Selected sizes for screws, bolts and nuts*

ISO 527 (all parts), *Plastics – Determination of tensile properties*

ISO 3864 (all parts), *Graphical symbols – Safety colours and safety signs*

ISO 4892-1, *Plastics – Methods of exposure to laboratory light sources – Part 1: General guidance*

ISO 4892-2, *Plastics – Methods of exposure to laboratory light sources – Part 2: Xenon-arc sources*

ISO 4892-4, *Plastics*, *Methods of exposure to laboratory light sources – Part 4: Open-flame carbon-arc lamps*

ISO 7000-DB:2004[9], *Graphical symbols for use on equipment – Index and synopsis*

ISO 8256, *Plastics – Determination of tensile-impact strength*

ISO 9772, *Cellular plastics – Determination of horizontal burning characteristics of small specimens subjected to a small flame*

ISO 9773, *Plastics – Determination of burning behaviour of thin flexible vertical specimens in contact with a small-flame ignition source*

ITU-T Recommendation K.44, *Resistibility tests for telecommunication equipment exposed to overvoltages and overcurrents – Basic Recommendation*

[9] "DB" refers to the IEC and ISO on-line database.

Annex Q
(normative)

Voltage dependent resistors (VDRs)

(see 1.5.9.1)

~~A VDR used in a PRIMARY CIRCUIT shall comply with IEC 61051-2, with the following details.~~

~~**a) Preferred climatic categories (2.1.1 of IEC 61051-2)**~~

~~Lower category temperature: - 10 °C~~

~~Upper category temperature: + 85 °C~~

~~Duration of damp heat, steady state test: 21 days~~

~~**b) Maximum continuous voltage (2.1.2 of IEC 61051-2)**~~

~~The maximum continuous a.c. voltage is selected from the list of preferred voltages and shall be at least 120 % of~~

~~– the RATED VOLTAGE of the equipment or~~

~~– the upper voltage of the RATED VOLTAGE RANGE of the equipment.~~

~~**c) Pulse current (Table I group 1 of IEC 61051-2)**~~

~~*Combination pulses of 6 kV/3 kA of alternating polarity are used, having a pulse shape of 1,2/50 µs for voltage and 8/20 µs for current.*~~

~~*In addition to the performance requirements of Table I group 1, the clamping voltage after the test shall not have changed by more than 10 % when measured with the manufacturer's specified current.*~~

A VDR shall comply with IEC 61051-2, whether a FIRE ENCLOSURE is provided or not, taking into account all of the following:

- Preferred climatic categories (2.1.1 of IEC 61051-2:1991):
  - lower category temperature: – 10 °C
  - upper category temperature: + 85 °C
  - duration of damp heat, steady state test: 21 days.
- Maximum continuous voltage
  - at least 1,25 times the rated voltage of the equipment or
  - at least 1,25 times the upper voltage of the rated voltage range.

NOTE The maximum continuous voltages are not limited to values specified in 2.1.2 of IEC 61051-2:1991, other voltages are permitted.

- Combination pulse (Table I group 1 of IEC 61051-2:1991 including Amendment 1:2009).

  For the test, a combination pulse is selected from 2.3.6 in IEC 61051-2:1991, Amendment 1: 2009. The test consists of 10 positive pulses or 10 negative pulses, each having a shape of 1,2/50 µs for voltage and 8/20 µs for current.

  For the selection, AC MAINS SUPPLY voltage and overvoltage category, see Table G.1.

MAINS SUPPLY under 300 V is considered to be 300 V.

For overvoltage category IV of Table G.1, a combination pulse 6 kV/3 kA is used except for equipment intended for connection to a system supply of 600 V, for which a combination pulse of 8 kV/4 kA is used. As an alternative to the 6 kV/3 kA test, the combination pulse test of IEC 61051-2:1991, Amendment 1:2009 (2.3.6, Table I group 1 and Annex A), including consideration of the nominal MAINS SUPPLY voltage and overvoltage category, is acceptable.

In addition to the performance requirements of Table I group 1 of IEC 61051-2: 1991 and its Amendment 1: 2009, the VDR voltage at the manufacturer's specified current after the test shall not have changed by more than 10 % when compared to the value before the test.

The body of the VDR shall comply with the needle flame according to IEC 60695-11-5, with the following test severities:

- duration of application of the test flame: 10 s;
- after flame time: 5 s.

If the body of the VDR complies with V-1 CLASS MATERIAL, the needle flame test does not need to be performed.

Annex R
(informative)

Examples of requirements for quality control programmes

NOTE This annex gives examples of requirements for quality control programmes as specified in 2.10.6.2 for minimum separation distances for coated printed boards and in 2.10.3 and Clause G.2 for reduced CLEARANCES.

R.1 Minimum separation distances for unpopulated coated printed boards (see 2.10.6.2)

A manufacturer wishing to use the reduced separation distances permitted by 2.10.6.2, Table 2Q, shall implement a quality control programme for those features of the boards that are listed in Table R.1. This programme shall include specific quality controls for the tools and materials that affect conductor spacing, adequate inspection of pattern and spacing, cleanliness, coating thickness, electrical tests for short-circuits, insulation resistance and electric withstand voltage.

The manufacturer shall also identify and plan the protection and, where applicable, installation processes that directly affect quality and shall ensure that these processes are conducted under controlled conditions. Controlled conditions shall include the following:

– documented work instructions defining process, equipment, environment and manner of production where the absence of such instructions would adversely affect quality, use of suitable production and installation equipment, suitable working environment, compliance with reference standards, specifications and quality plans;
– monitoring and control of suitable processes and product characteristics during production and installation in the equipment;
– criteria for workmanship stipulated to the extent necessary in written specifications or by means of representative samples;
– records maintained for qualified processes, equipment and personnel as appropriate.

Table R.1 provides the sampling plan for attributes and tests necessary to conform to the requirements of 2.10.6.2. The number of samples of production boards shall be based on IEC 60410 or ISO 2859-1 or equivalent national standards.

Table R.1 – Rules for sampling and inspection – coated printed boards

Tests	BASIC INSULATION	SUPPLEMENTARY INSULATION	REINFORCED INSULATION
Spacing mm [a]	Sampling S2 AQL 1,0	Sampling S2 AQL 1,0	Sampling S2 AQL 1,0
Electric strength test [b]	Sampling S2 AQL 2,5	Sampling S2 AQL 2,5	ROUTINE TEST; one failure requires evaluation for cause
Abrasion resistance	Sampling S1 AQL 2,5	Sampling S1 AQL 2,5	Sampling S1 AQL 2,5
Thermal ageing [c]	Sampling S3 AQL 4	Sampling S3 AQL 4	Sampling S3 AQL 4
Thermal cycling [c]	Sampling S1 AQL 1,5	Sampling S1 AQL 1,5	Sampling S1 AQL 1,5
Insulation resistance [d]	Sampling S2 AQL 2,5	Sampling S2 AQL 2,5	Sampling S2 AQL 2,5
Visual inspection of coating [e]	ROUTINE TEST	ROUTINE TEST	ROUTINE TEST

[a] To minimize test and inspection time, it is permitted to replace measurement of separation distances by measurement of breakdown voltage. Initially the breakdown voltage is established for ten uncoated boards for which the correct spacing measurements have been confirmed. The breakdown voltage of subsequent uncoated production boards is then checked against a lower limit equal to the minimum breakdown voltage for the ten initial boards minus 100 V. If breakdown occurs at this lower limit, a board is considered a failure unless direct measurement of the spacing conforms with the requirement.

[b] The electric strength test shall be conducted according to 5.2.2 except that the duration shall be 1 s to 5 s.

[c] The thermal ageing and thermal cycling tests shall be done whenever the type of coating material, printed board material, or the process is changed. It is recommended that it should be done at least once a year.

[d] The insulation resistance shall be not less than 1 000 MΩ.

[e] Visual inspection without optical magnification or automated optical inspection with equivalent resolution shall show no cracks, no bubbles, no pinholes, or detachment of the coating in the area of reduced spacings. Any such defects shall be reason for rejection of the printed board.

R.2 Reduced clearances (see 2.10.3)

A manufacturer wishing to use reduced CLEARANCES permitted by 2.10.3, Tables 2J, 2K, 2L and G.2, shall implement a quality control programme for those features of the construction listed in Table R.2. This programme shall include specific quality controls for the tools and materials that affect CLEARANCES.

The manufacturer shall also identify and plan the protection and, where applicable, installation processes that directly affect quality and shall ensure that these processes are conducted under controlled conditions. Controlled conditions shall include the following:

– documented work instructions defining process, equipment, environment, and manner of production where the absence of such instructions would adversely affect quality, suitable working environment, compliance with reference standards or specifications and quality plans;

– monitoring and control of suitable processes and product characteristics during production and installation in the equipment;

– criteria for workmanship stipulated to the extent necessary in written specifications or by means of representative samples;

– records maintained for qualified processes, equipment and personnel as appropriate.

Table R.2 provides the sampling plan for attributes and tests necessary to conform to the requirements of 2.10.3. The number of samples of production parts or assemblies shall be based on IEC 60410 or ISO 2859-1 or equivalent national standards.

Table R.2 – Rules for sampling and inspection – reduced clearances

Tests	**BASIC INSULATION**	**SUPPLEMENTARY INSULATION**	**REINFORCED INSULATION**
CLEARANCE [a]	Sampling S2 AQL 4	Sampling S2 AQL 4	Sampling S2 AQL 4
Electric strength test [b]	No test	No test	ROUTINE TEST; one failure requires evaluation for cause

[a] To minimize test and inspection time, it is permitted to replace measurement of CLEARANCES by measurement of breakdown voltage. Initially the breakdown voltage is established for ten samples for which the correct CLEARANCE measurements have been confirmed. The breakdown voltage of subsequent parts or assemblies is then checked against a lower limit equal to the minimum breakdown voltage of the initial ten samples minus 100 V. If breakdown occurs at this lower limit, a part or assembly is considered a failure unless direct measurement of the CLEARANCE conforms to the requirement.

[b] The electric strength test for REINFORCED INSULATION shall consist of one of the following alternatives:

- six impulses of alternating polarity, using a 1,2/50 µs impulse with a magnitude equal to the peak of the test voltage in accordance with 5.2.2;
- a three cycle pulse of a.c. power frequency with a magnitude equal to the test voltage in accordance with 5.2.2;
- six impulses of alternating polarity, using 10 ms d.c. impulses with a magnitude equal to the peak of the test voltage in accordance with 5.2.2.

Annex S
(informative)

Procedure for impulse testing

(see 6.2.2.3)

S.1 Test equipment

Impulse generator according to Annex N.

Storage oscilloscope with a bandwidth of a few MHz.

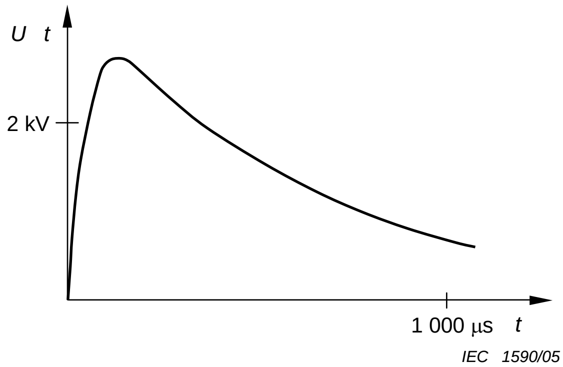
High voltage probe with compensating elements.

S.2 Test procedure

Apply the required number of impulses to the equipment under test and record the waveform patterns.

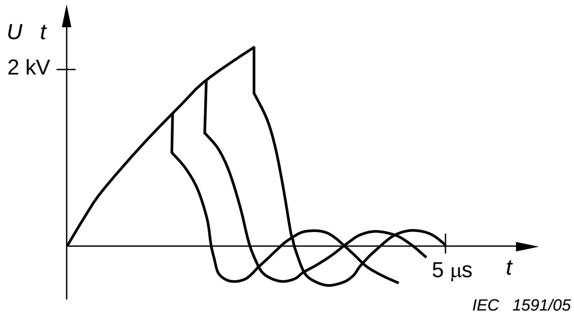
Examples are given in S.3 to assist in judging whether or not a surge suppressor has operated or insulation has broken down.

S.3 Examples of waveforms during impulse testing



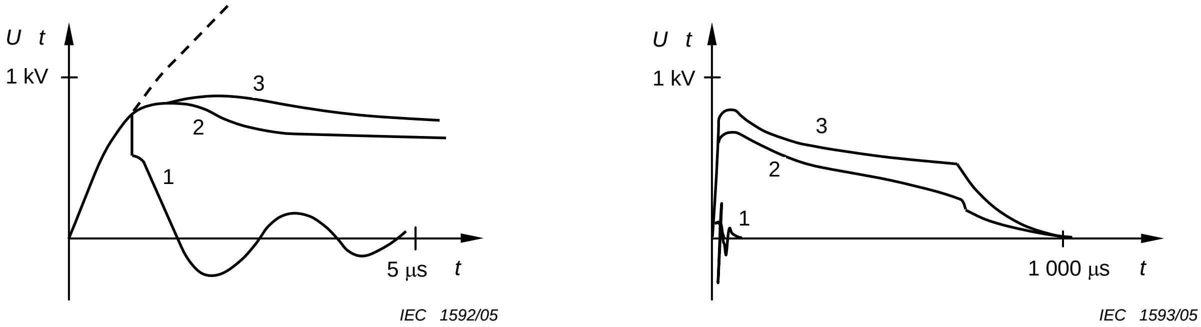
Consecutive impulses are identical in their waveforms.

Figure S.1 – Waveform on insulation without surge suppressors and no breakdown



Consecutive impulses are not identical in their waveforms. The pulse shape changes from pulse to pulse until a stable resistance path through the insulation is established. Breakdown can be seen clearly on the shape of the pulse voltage oscillogram.

Figure S.2 – Waveforms on insulation during breakdown without surge suppressors



1 – gas discharge type

2 – semiconductor type

3 – metal oxide type

Consecutive impulses are identical in their waveforms.

Figure S.3 – Waveforms on insulation with surge suppressors in operation

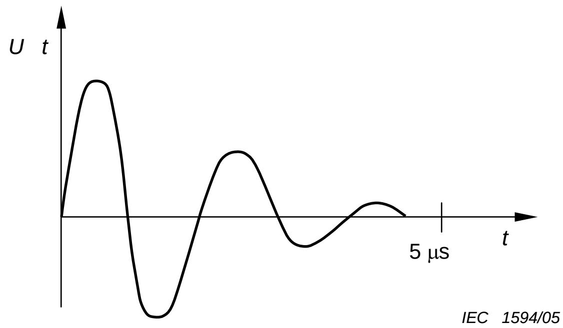


Figure S.4 – Waveform on short-circuited surge suppressor and insulation

Annex T
(informative)

Guidance on protection against ingress of water

(see 1.1.2)

When the intended application is such that ingress of water is possible, an appropriate degree of protection other than IPX0 should be selected by the manufacturer from IEC 60529, an extract from which is included in this annex.

Additional design features should then be included to ensure that ingress of water does not affect insulation.

IEC 60529 gives test conditions for each degree of protection other than IPX0. The conditions appropriate to the selected degree of protection should be applied to the equipment, immediately followed by an electric strength test as specified in 5.2.2 on any insulation that may have become wet, and inspection should show that water has not created a risk of personal injury or fire. In particular, there should be no trace of water on insulation that is not designed to operate when wet.

If the equipment is provided with drain holes, inspection should show that any water that enters does not accumulate and that it drains away without affecting compliance.

If the equipment is not provided with drain holes, account should be taken of the possibility of build-up of water.

Where equipment is only partly exposed to water, for example, when it is to be installed through an opening in an outside wall, only the exposed parts should be subjected to the IEC 60529 test conditions. For these tests, such equipment should be installed in an appropriate test assembly, simulating actual conditions of installation according to the installation instructions, including the use of a kit of sealing parts where required.

It should not be possible to remove, without the aid of a TOOL, parts that ensure the required degree of protection against ingress of water.

The information in Table T.1 is extracted from IEC 60529.

Table T.1 – Extract from IEC 60529

Second characteristic numeral	Degree of protection	
	Brief description	**Definition**
0	Non-protected	–
1	Protected against vertically falling water drops	Vertically falling water drops shall have no harmful effects
2	Protected against vertically falling water drops when enclosure tilted up to 15°	Vertically falling drops shall have no harmful effects when the enclosure is tilted at any angle up to 15° on either side of the vertical
3	Protected against spraying water	Water sprayed at an angle up to 60° on either side of the vertical shall have no harmful effects
4	Protected against splashing water	Water splashed against the enclosure from any direction shall have no harmful effects
5	Protected against water jets	Water projected in jets against the enclosure from any direction shall have no harmful effects
6	Protected against powerful water jets	Water projected in powerful jets against the enclosure from any direction shall have no harmful effects
7	Protected against the effects of temporary immersion in water	Ingress of water in quantities causing harmful effects shall not be possible when the enclosure is temporarily immersed in water under standardized conditions of pressure and time
8	Protected against the effects of continuous immersion in water	Ingress of water in quantities causing harmful effects shall not be possible when the enclosure is continuously immersed in water under conditions which shall be agreed between the manufacturer and user but that are more severe than for numeral 7

Annex U
(normative)

Insulated winding wires for use without interleaved insulation

(see 2.10.5.4)

~~This annex specifies winding wire whose insulation may be used to provide BASIC INSULATION, SUPPLEMENTARY INSULATION, DOUBLE INSULATION or REINFORCED INSULATION in wound components without interleaved insulation.~~

~~This annex covers round solid winding wires having diameters between 0,05 mm and 5,0 mm and stranded winding wires with equivalent cross-sectional areas.~~

~~U.1 Wire construction~~

~~If the wire is insulated with overlapping spirally wrapped tape, the overlap shall be adequate to ensure continued overlap during manufacture of the wound component. The overlaps shall be sufficiently secured to maintain the amount of overlap.~~

~~U.2 Type tests~~

~~The wire shall pass the tests of U.2.1 to U.2.4, conducted at a temperature between 15 °C and 35 °C and a relative humidity between 45 % and 75 %, unless specified otherwise.~~

~~U.2.1 Electric strength~~

~~The test sample is prepared according to 4.4.1 of IEC 60851-5, (for a twisted pair). The sample is then subjected to the test of 5.2.2 of this standard. The test voltage shall be not less than twice the appropriate voltage in accordance with 5.2.2 of this standard, with a minimum of~~

- *~~3 000 V a.c. r.m.s. for BASIC INSULATION or SUPPLEMENTARY INSULATION, or~~*
- *~~6 000 V a.c. r.m.s. for REINFORCED INSULATION.~~*

~~U.2.2 Flexibility and adherence~~

~~Test 8 in 5.1.1 of IEC 60851-3 is applied using the mandrel diameters of Table U.1. The test sample is then examined in accordance with 5.1.1.4 of IEC 60851-3, followed by the test of 5.2.2 of this standard except that the test voltage is applied between the wire and the mandrel. The test voltage shall be not less than the appropriate voltage in accordance with 5.2.2 of this standard, with a minimum of~~

- *~~1 500 V a.c. r.m.s. for BASIC INSULATION or SUPPLEMENTARY INSULATION, or~~*
- *~~3 000 V a.c. r.m.s. for REINFORCED INSULATION.~~*

~~Table U.1 – Mandrel diameter~~

~~Nominal conductor diameter~~ ~~mm~~	~~Mandrel diameter~~ ~~mm ± 0,2 mm~~
~~0,05 – 0,34~~	~~4,0~~
~~0,35 – 0,49~~	~~6,0~~
~~0,50 – 0,74~~	~~8,0~~
~~0,75 – 2,49~~	~~10,0~~
~~2,50 – 5,00~~	~~four times the nominal conductor diameter~~ [a]
~~[a] In accordance with IEC 60317-43.~~	

~~The tension to be applied to the wire during winding on the mandrel is calculated from the wire diameter to be equivalent to 118 MPa ± 10 % (118 N/mm~~^{2} *~~± 10 %).~~*

~~U.2.3 Heat shock~~

~~Test 9 of IEC 60851-6, followed by the electric strength test of 5.2.2 of this standard except that the test voltage is applied between the wire and the mandrel. The voltage shall be not less than the appropriate voltage in accordance with 5.2.2 of this standard, with a minimum of~~

- *~~1 500 V a.c. r.m.s. for BASIC INSULATION or SUPPLEMENTARY INSULATION, or~~*
- *~~3 000 V a.c. r.m.s. for REINFORCED INSULATION.~~*

~~The oven temperature is the relevant temperature for the thermal class of insulation in Table U.2.~~

~~The mandrel diameter and tension applied to the wire during winding on the mandrel are as in U.2.2.~~

~~The electric strength test is conducted at room temperature after removal from the oven.~~

~~Table U.2 – Oven temperature~~

~~Thermal class~~	~~Oven temperature °C ± 5 °C~~
~~105 (A)~~	~~200~~
~~120 (E)~~	~~215~~
~~130 (B)~~	~~225~~
~~155 (F)~~	~~250~~
~~180 (H)~~	~~275~~
~~200~~	~~295~~
~~220~~	~~315~~
~~250~~	~~345~~
~~The designations A to H, formerly assigned in IEC 60085 to thermal classes 105 to 180, are given in parentheses.~~	

~~**U.2.4 Retention of electric strength after bending**~~

~~*Five samples are prepared as in U.2.2 above and tested as follows. Each sample is removed from the mandrel, placed in a container and positioned so that it can be surrounded by at least 5 mm of metal shot. The ends of the conductor in the sample shall be sufficiently long to avoid flash over. The shot shall be not more than 2 mm in diameter and shall consist of balls of stainless steel, nickel or nickel plated iron. The shot is gently poured into the container until the sample under test is covered by at least 5 mm of shot. The shot shall be cleaned periodically with a suitable solvent (for example, 1,1,1-trichloroethane).*~~

~~NOTE The above test procedure is reproduced from 4.6.1 c) of IEC 60851-5 (second edition including amendment 1), now withdrawn. It is not included in the third edition of that standard.~~

~~*The test voltage shall be not less than the appropriate test voltage in accordance with 5.2.2 of this standard, with a minimum of*~~

- ~~*1 500 V a.c. r.m.s. for BASIC INSULATION or SUPPLEMENTARY INSULATION, or*~~
- ~~*3 000 V a.c. r.m.s. for REINFORCED INSULATION.*~~

~~*The test voltage is applied between the shot and the conductor.*~~

~~*The mandrel diameter and tension applied to the wire during winding on the mandrel are as in U.2.2.*~~

~~**U.3 Tests during manufacture**~~

~~*The wire shall be subjected by the wire manufacturer to electric strength tests during manufacture as specified in U.3.1 and U.3.2.*~~

~~**U.3.1 Routine testing**~~

~~*The test voltage for ROUTINE TESTING shall be the appropriate test voltage in accordance with 5.2.2 of this standard, with a minimum of*~~

- ~~*1 500 V a.c. r.m.s. for BASIC INSULATION or SUPPLEMENTARY INSULATION, or*~~
- ~~*3 000 V a.c. r.m.s. for REINFORCED INSULATION.*~~

~~**U.3.2 Sampling tests**~~

~~*Twisted pair samples shall be tested in accordance with 4.4.1 of IEC 60851-5. The minimum breakdown voltage shall be twice the appropriate test voltage in accordance with 5.2.2 of this standard, with a minimum of*~~

- ~~*3 000 V a.c. r.m.s. for BASIC INSULATION or SUPPLEMENTARY INSULATION, or*~~
- ~~*6 000 V a.c. r.m.s. for REINFORCED INSULATION.*~~

U.1 General

This annex specifies winding wires whose insulation may be used to provide BASIC INSULATION, SUPPLEMENTARY INSULATION, DOUBLE INSULATION or REINFORCED INSULATION in wound components without interleaved insulation.

This annex applies to solid round winding wires having diameters between 0,01 mm and 5,0 mm, stranded winding wires with equivalent cross-sectional areas and solid square and solid rectangular (flatwise bending) winding wires with cross-sectional areas of 0,000 079 mm^2 to 19,6 mm^2).

NOTE See 2.10.5.12 for the minimum number of overlapping layers.

U.2 Type tests

U.2.1 General

The winding wire shall pass the following TYPE TESTS*, carried out at a temperature between 15 °C and 35 °C and a relative humidity between 45 % and 75 %, unless otherwise specified.*

U.2.2 Electric strength

U.2.2.1 Solid round winding wires and stranded winding wires

U.2.2.1.1 Wires with a nominal conductor diameter up to and including 0,100 mm

The test specimen is prepared according to 4.3 of IEC 60851-5:2008. The specimen is then subjected to the electric strength test of 5.2.2 between the conductor of the wire and the cylinder, with a minimum test voltage of:

– *3 kV r.m.s. or 4,2 kV peak for* REINFORCED INSULATION*, or*

– *1,5 kV r.m.s. or 2,1 kV peak for* BASIC INSULATION *or* SUPPLEMENTARY INSULATION*.*

U.2.2.1.2 Wires with a nominal conductor diameter over 0,100 mm up to and including 2,500 mm

The test specimen is prepared according to 4.4.1 of IEC 60851-5:2008 (twisted pair). The specimen is then subjected to the electric strength test of 5.2.2 with a test voltage that is not less than twice the appropriate voltage of 5.2.2, with a minimum of:

– *6 kV r.m.s. or 8,4 kV peak for* REINFORCED INSULATION*, or*

– *3 kV r.m.s. or 4,2 kV peak for* BASIC INSULATION *or* SUPPLEMENTARY INSULATION*.*

U.2.2.1.3 Wires with a nominal conductor diameter over 2,500 mm

The test specimen is prepared according to 4.5 of IEC 60851-5:2008. The specimen is then subjected to the electric strength test of 5.2.2 between the conductor of the wire and the shot, with a minimum test voltage of:

– *3 kV r.m.s. or 4,2 kV peak for* REINFORCED INSULATION*, or*

– *1,5 kV r.m.s. or 2,1 kV peak for* BASIC INSULATION *or* SUPPLEMENTARY INSULATION*.*

U.2.2.2 Square or rectangular wires

The test specimen is prepared according to 4.7.1 of IEC 60851-5:2008 (single conductor surrounded by metal shots). The specimen is then subjected to the electric strength test of 5.2.2, with a minimum test voltage of:

– *3 kV r.m.s. or 4,2 kV peak for* REINFORCED INSULATION*, or*

– *1,5 kV r.m.s. or 2,1 kV peak for* BASIC INSULATION *or* SUPPLEMENTARY INSULATION*.*

U.2.3 Flexibility and adherence

Subclause 5.1 (in Test 8) of IEC 60851-3:2009 shall be used, using the mandrel diameters of Table U.1.

The test specimen is then examined in accordance with 5.1.1.4 of IEC 60851-3:2009, followed by the electric strength test of 5.2.2 in this standard, with minimum test voltage of:

– *3 kV r.m.s. or 4,2 kV peak for* REINFORCED INSULATION*, or*

– *1,5 kV r.m.s. or 2,1 kV peak for BASIC INSULATION or SUPPLEMENTARY INSULATION.*

The test voltage is applied between the wire and the mandrel.

Table U.1 – Mandrel diameter

Nominal conductor diameter or thickness mm **less than**	**Mandrel diameter** mm
0,35	4,0 ± 0,2
0,50	6,0 ± 0,2
0,75	8,0 ± 0,2
2,50	10,0 ± 0,2
5,00	Four times the conductor diameter or thickness [a]

[a] In accordance with IEC 60317-43.

The tension to be applied to the wire during winding on the mandrel is calculated from the wire diameter to be equivalent to 118 MPa ± 10 % (118 N/mm^2 ± 10 %).

Edgewise bending on the smaller dimension side (width) is not required for rectangular wire.

For mandrel winding test of the square and rectangular wire, two adjacent turns do not need to contact each other.

U.2.4 Heat shock

The test specimen shall be prepared in accordance with 3.1.1 (in Test 9) of IEC 60851-6:1996, followed by the electric strength test of 5.2.2 in this standard , with a minimum test voltage of:

– *3 kV r.m.s. or 4,2 kV peak for REINFORCED INSULATION, or*

– *1,5 kV r.m.s. or 2,1 kV peak for BASIC INSULATION or SUPPLEMENTARY INSULATION.*

The test voltage is applied between the wire and the mandrel. The oven temperature is the relevant temperature of the thermal class of insulation in Table U.2. The mandrel diameter and tension applied to the wire during winding on the mandrel are as in Table U.1. The electric strength test is conducted at room temperature after removal from the oven.

Table U.2 – Oven temperature

Thermal class	**Class 105 (A)**	**Class 120 (E)**	**Class 130 (B)**	**Class 155 (F)**	**Class 180 (H)**	**Class 200 (N)**	**Class 220 (R)**	**Class 250 -**
Oven temperature °C	200	215	225	250	275	295	315	345

Oven temperatures shall be maintained within ±5 ° of the specified temperature.

The classes are related to the classification of electrical insulating materials and EISs in accordance with IEC 60085. The assigned letter designations are given in parentheses.

Edgewise bending on the smaller dimension side (width) is not required for rectangular wire.

NOTE Subclause 3.1.2 in Test 9 of IEC 60851-6:1996 is not used for solid square and solid rectangular winding wires.

U.2.5 Retention of electric strength after bending

Five specimens are prepared as in U.2.3 and tested as follows. Each specimen is removed from the mandrel, placed in a container and positioned so that it can be surrounded by at least 5 mm of metal shot. The ends of the conductor in the specimen shall be sufficiently long to avoid flash over. The shot shall be not more than 2 mm in diameter and shall consist of balls of stainless steel, nickel or nickel plated iron. The shot is gently poured into the container until the specimen under test is covered by at least 5 mm of shot. The shot shall be cleaned periodically with a suitable solvent.

The specimen shall be subjected to the electric strength test of 5.2.2, with a minimum test voltage of:

– *3 kV r.m.s. or 4,2 kV peak for REINFORCED INSULATION, or*

– *1,5 kV r.m.s. or 2,1 kV peak for BASIC INSULATION or SUPPLEMENTARY INSULATION.*

The mandrel diameter and tension applied to the wire during winding on the mandrel are as in Table U.1.

U.3 Testing during manufacturing

U.3.1 General

The wire shall be subjected by the wire manufacturer to electric strength tests during manufacture as specified in U.3.2 and U.3.3.

U.3.2 Routine test

The test voltage for ROUTINE TEST shall be in accordance with the electric strength test of 5.2.2, with a minimum of:

– *3 kV r.m.s. or 4,2 kV peak for REINFORCED INSULATION, or*

– *1,5 kV r.m.s. or 2,1 kV peak for BASIC INSULATION or SUPPLEMENTARY INSULATION.*

U.3.3 Sampling test

THE SAMPLING TEST SHALL BE CONDUCTED ACCORDING TO THE SUITABLE TEST SPECIFIED IN U.2.2

Annex V
(normative)

AC power distribution systems

(see 1.6.1)

V.1 Introduction

In 3.1.2 of IEC 60364-1, a.c. power distribution systems are classified TN, TT and IT, depending on the arrangement of current-carrying conductors and the method of earthing. The classes and codes are explained in this annex. Some examples of each class are given in the figures; other configurations also exist.

In the figures:

– in most cases, the power distribution systems apply for single-phase and three-phase equipment, but for simplicity, only single-phase equipment is illustrated;

– the power sources may be transformer secondaries, motor-driven generators or uninterruptible power distribution systems;

– for transformers within a user's building, some of the figures apply, and the building boundary represents a floor of the building;

– some power distribution systems are earthed at additional points, for example, at the power entry points of users' buildings (see 413.1.3.1, Notes 1 and 2 of IEC 60364-4-41).

The following types of equipment connection are taken into account; the numbers of wires mentioned do not include conductors used exclusively for earthing.

Single-phase, two-wire

Single-phase, three-wire

Two-phase, three-wire

Three-phase, three-wire

Three-phase, four-wire

The system codes used have the following meaning:

– First letter: relationship of the power distribution system to earth;

T means direct connection of one pole to earth,

I means system isolated from earth, or one point connected to earth through an impedance.

– Second letter: earthing of the equipment;

T means direct electrical connection of the equipment to earth, independently of the earthing of any point of the power distribution system,

N means direct electrical connection of the equipment to the earthed point of the power distribution system (in a.c. systems, the earthed point of the power distribution system is normally the neutral point or, if a neutral point is not available, a phase conductor).

– Subsequent letters if any: arrangement of neutral and protective conductors;

S means the protective function is provided by a conductor separate from the neutral or from the earthed line (or in a.c. systems, earthed phase) conductor,

C means the neutral and protective functions are combined in a single conductor (PEN conductor).

V.2 TN power distribution systems

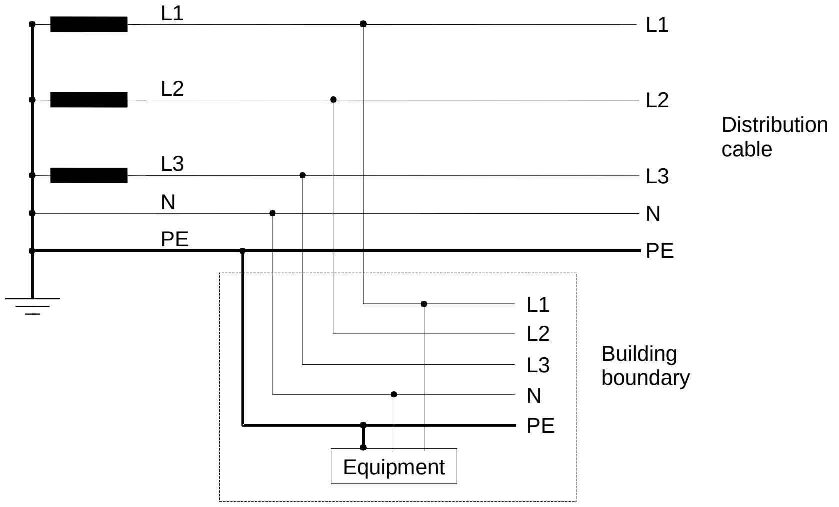
TN power distribution systems are directly earthed, the parts of the equipment required to be earthed being connected by PROTECTIVE EARTHING CONDUCTORS. Three types of TN power distribution systems are considered:

– TN-S power distribution system, – in which a separate protective conductor is used through-out the system;

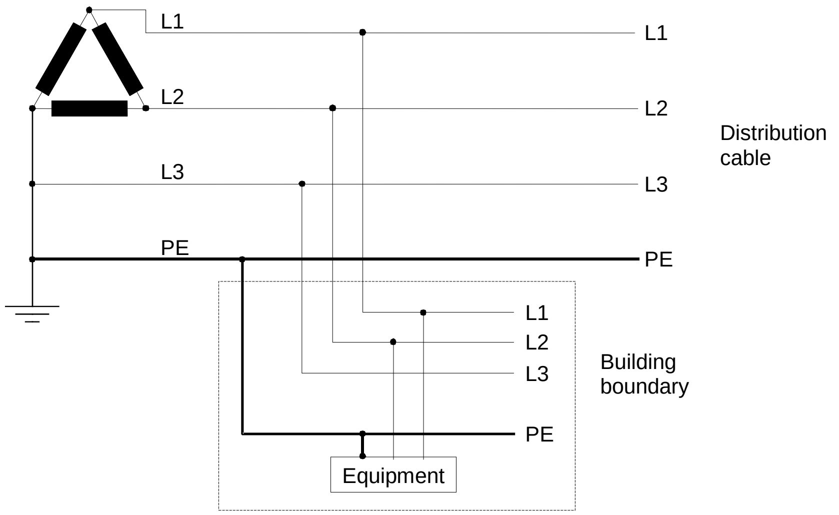
– TN-C-S power distribution system, – in which neutral and protective functions are combined in a single conductor in part of the system;

– TN-C power distribution system, – in which neutral and protective functions are combined in a single conductor throughout the system.

Some TN power distribution systems are supplied from a secondary winding of a transformer that has an earthed centre tap (neutral). Where the two-phase conductors and the neutral conductor are available, these systems are commonly known as "single-phase, three-wire power distribution systems".



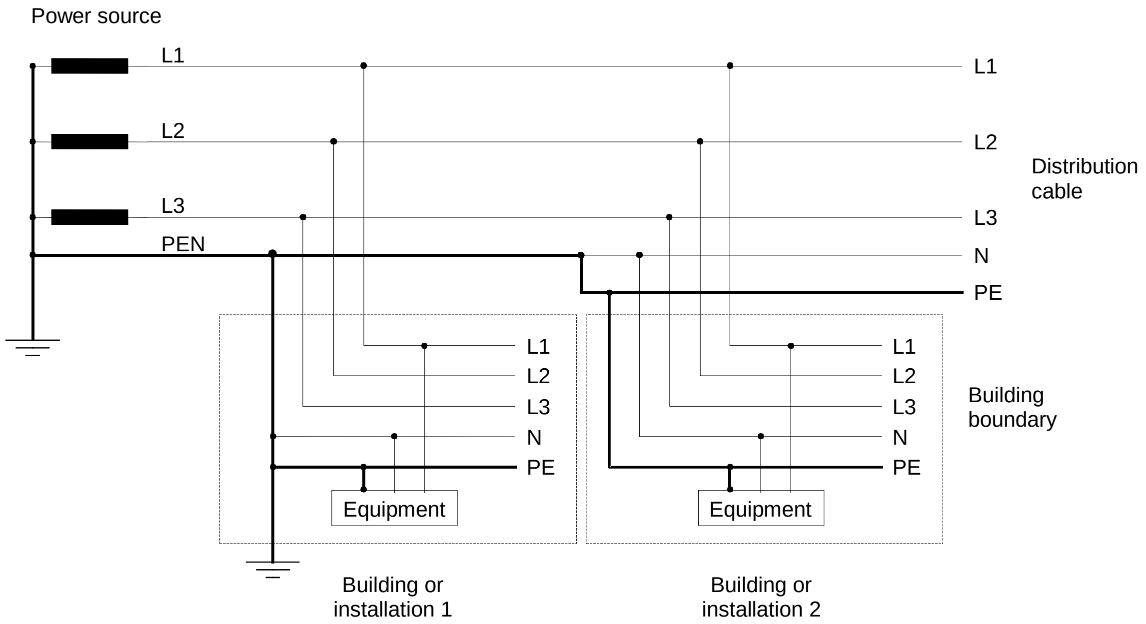
Separate neutral and protective conductors



Earted line conductor

IEC 1595/05

Figure V.1 – Examples of TN-S power distribution systems

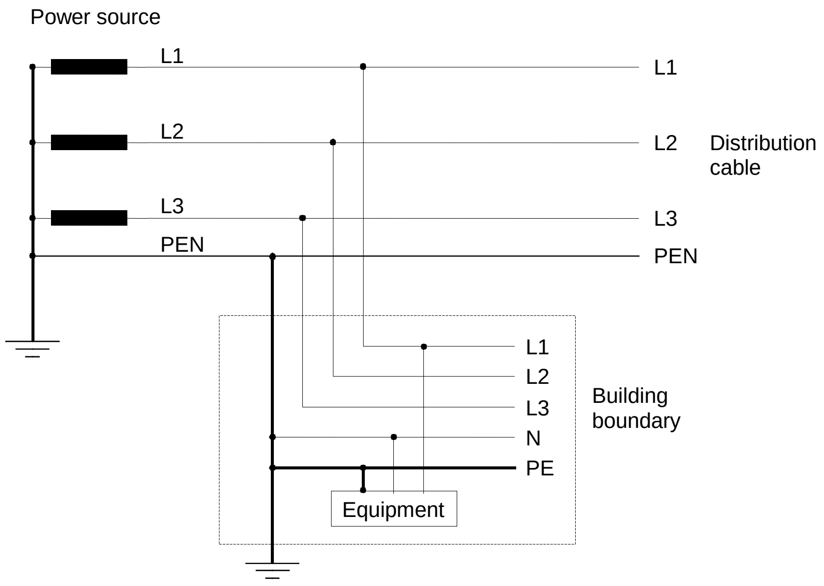


Neutral and protective functions combined in a single conductor in part of the system (PEN)

IEC 1596/05

NOTE The point at which the PEN conductor is separated into protective earth and neutral conductors may be at the building entrance or at distribution panels within the building.

Figure V.2 – Example of TN-C-S power distribution system



Neutral and protective functions combined in one conductor (PEN)

IEC 1597/05

Figure V.3 – Example of TN-C power distribution system

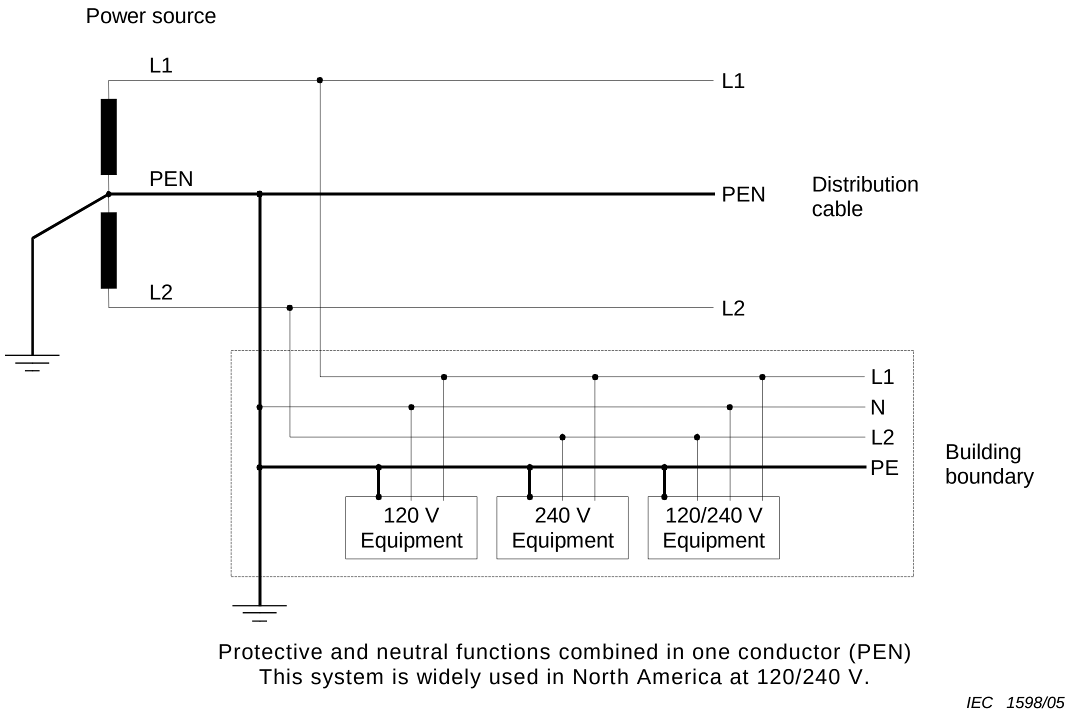


Figure V.4 – Example of single-phase, three-wire TN-C power distribution system

V.3 TT power distribution systems

TT power distribution systems have one point directly earthed, the parts of the equipment required to be earthed being connected at the user's premises to earth electrodes that are electrically independent of the earth electrodes of the power distribution system.

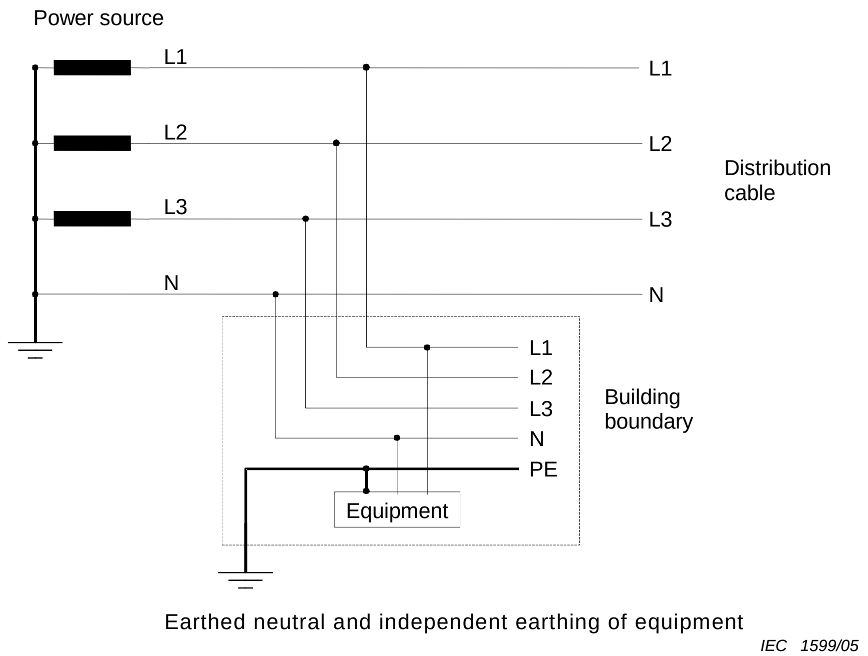


Figure V.5 – Example of three line and neutral TT power distribution system

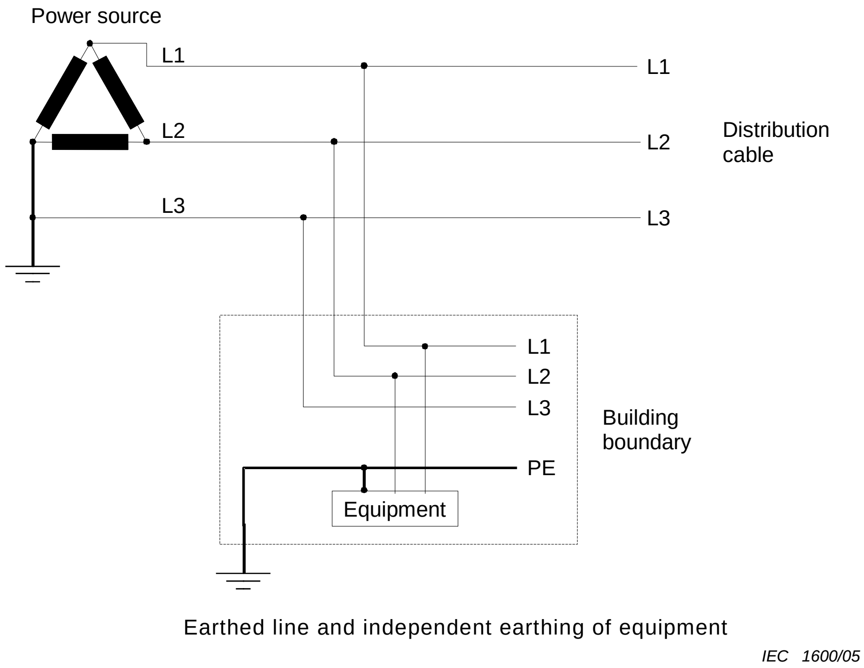
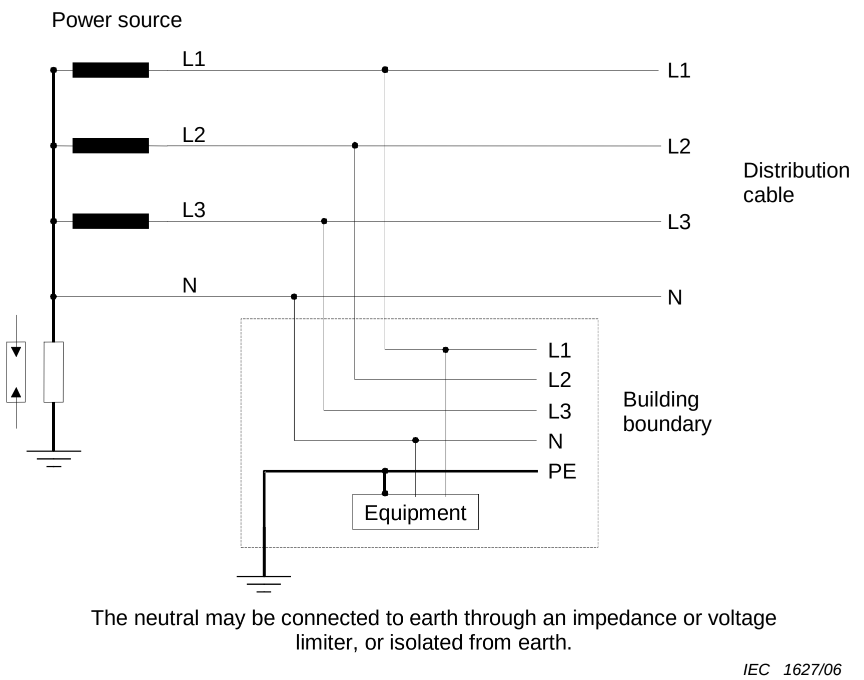


Figure V.6 – Example of three line TT power distribution system

V.4 IT power distribution systems

IT power distribution systems are isolated from earth, except that one point may be connected to earth through an impedance or a voltage limiter. The parts of the equipment required to be earthed are connected to earth electrodes at the user's premises.



This system is widely used isolated from earth, in some installations in France, with impedance to earth, at 230/400 V, and in Norway, with voltage limiter, neutral not distributed, at 230 V line-to-line.

Figure V.7 – Example of three line (and neutral) IT power distribution system

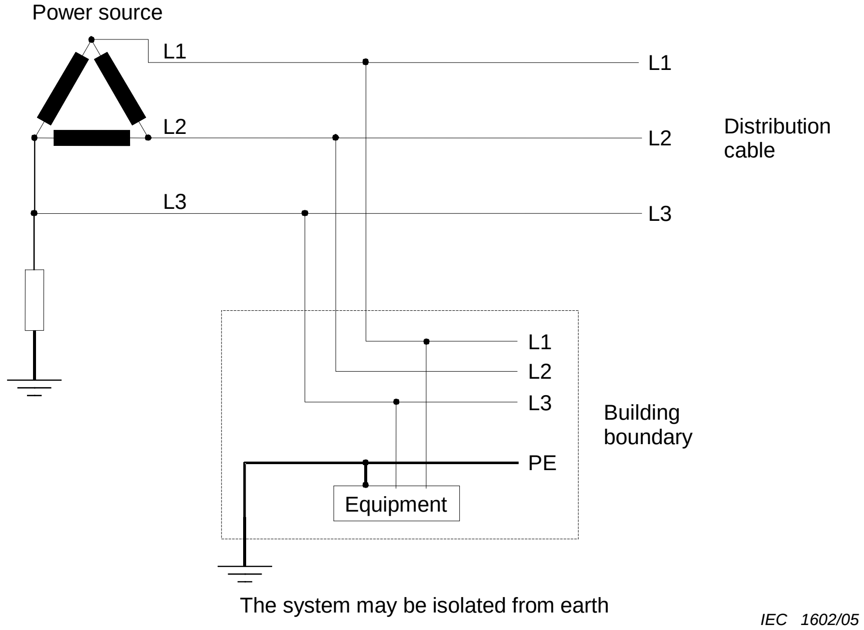


Figure V.8 – Example of three line IT power distribution system

Annex W
(informative)

Summation of touch currents

This annex explains the background to the requirements and tests in 5.1.8.2.

W.1 Touch current from electronic circuits

There are two quite different mechanisms that determine the current through a human body that touches an electronic circuit (or power bus), depending on whether or not the circuit is earthed. This distinction between earthed and unearthed (floating) circuits is not the same as between CLASS I EQUIPMENT and CLASS II EQUIPMENT. Floating circuits can exist in CLASS I EQUIPMENT and earthed circuits in CLASS II EQUIPMENT. Floating circuits are commonly, but not exclusively, used in telecommunication equipment and earthed circuits in data processing equipment, also not exclusively.

In order to consider the worst case, it will be assumed in this annex that TELECOMMUNICATION NETWORKS are floating and that the AC MAINS SUPPLY and human bodies (SERVICE PERSONS or USERS) are earthed. It should be noted that a SERVICE PERSON can touch some parts that are not USER-accessible. An "earthed" circuit means that the circuit is either directly earthed or in some way referenced to earth so that its potential with respect to earth is fixed.

W.1.1 Floating circuits

If the circuit is not earthed, the current (I_c) through the human body is "leakage" through stray or added capacitance (C) across the insulation in the mains transformer (see Figure W.1).

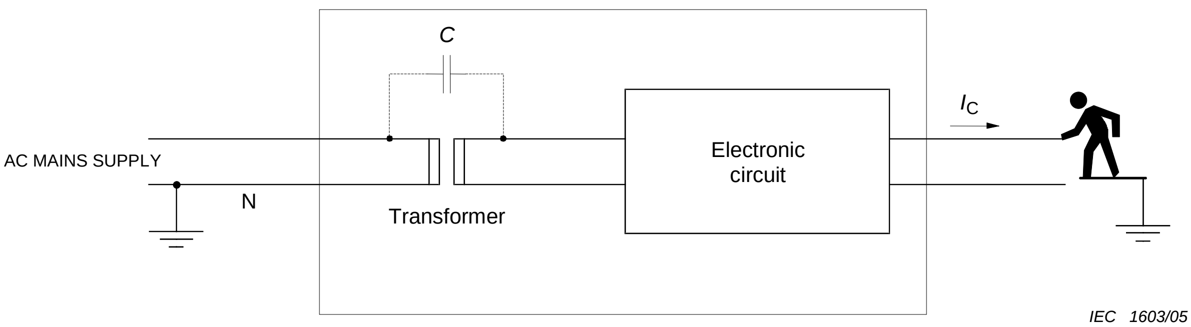


Figure W.1 – Touch current from a floating circuit

This current comes from a relatively high voltage, high impedance source, and its value is largely unaffected by the operating voltage on the electronic circuit. In this standard, the body current (I_c) is limited by applying a test using the measuring instrument in Annex D, which roughly simulates a human body.

W.1.2 Earthed circuits

If the electronic circuit is earthed, the current through the human body (I_V) is due to the operating voltage (V) of the circuit, which is a source of low impedance compared with the body (see Figure W.2). Any leakage current from the mains transformer (see W.1.1), will be conducted to earth and will not pass through the body.

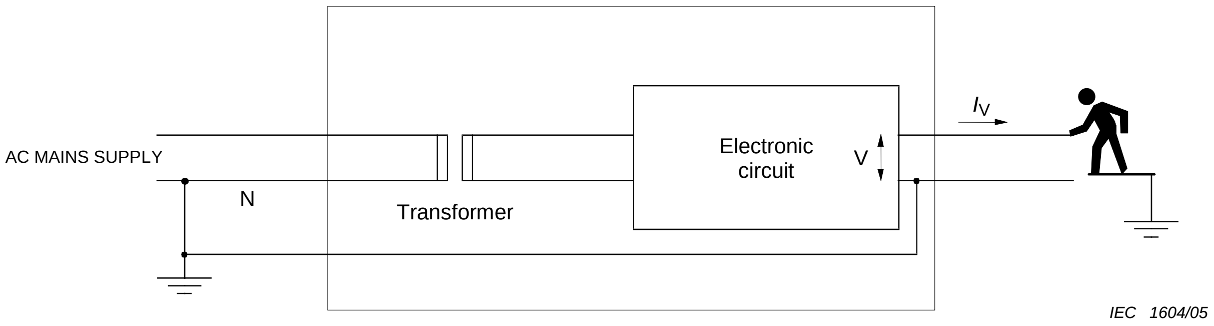


Figure W.2 – Touch current from an earthed circuit

In this standard, the body current (I_V) is limited by specifying maximum voltage values for the accessible circuit, which shall be an SELV CIRCUIT or (with restricted accessibility) a TNV CIRCUIT.

W.2 Interconnection of several equipments

It is a characteristic of information technology equipment, in particular in telecommunication applications, that many equipments may be connected to a single central equipment in a "star" topology. An example is telephone extensions or data terminals connected to a PABX, which may have tens or hundreds of ports. This example is used in the following description (see Figure W.3).

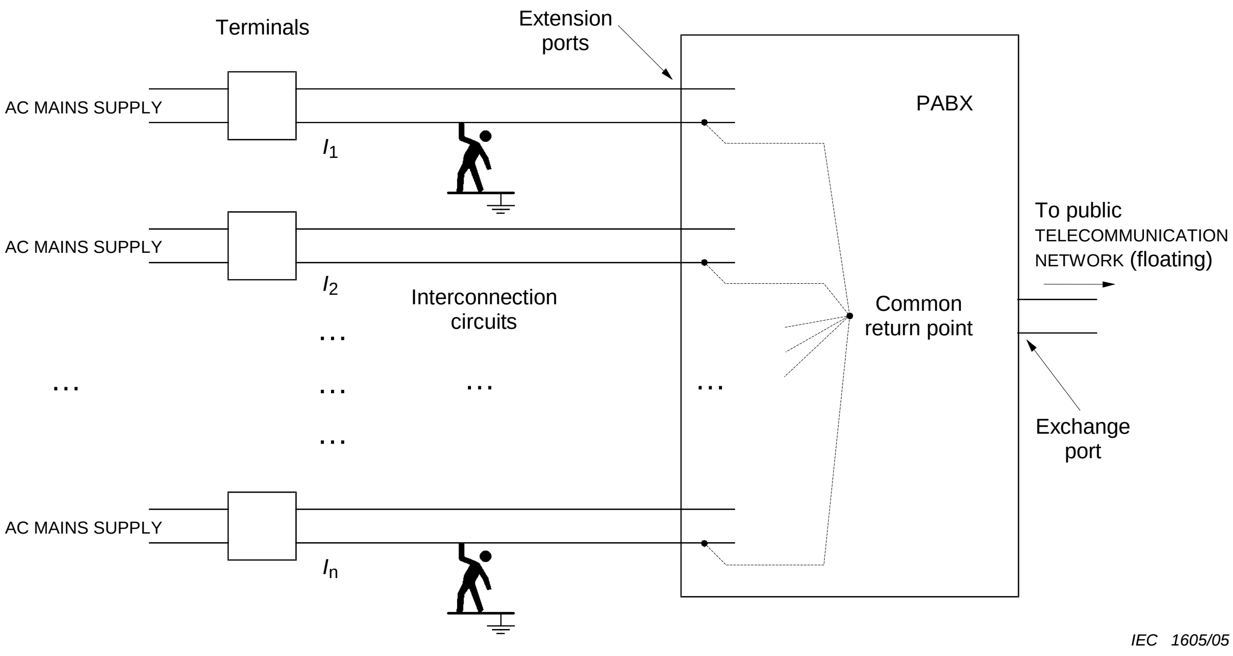


Figure W.3 – Summation of touch currents in a PABX

Each terminal equipment can deliver current to a human body touching the interconnecting circuit (I_1, I_2, etc.), added to any current coming from the PABX port circuitry. If several circuits are connected to a common point, their individual TOUCH CURRENTS will add together, and this represents a possible risk to an earthed human body that touches the interconnection circuit.

Various ways of avoiding this risk are considered in the following subclauses.

W.2.1 Isolation

Isolate all interconnection circuits from each other and from earth, and limit I_1, I_2, etc., as described in W.1.1. This implies either the use in the PABX of a separate power supply for each port, or the provision of an individual line (signal) transformer for each port. Such solutions may not be cost effective.

W.2.2 Common return, isolated from earth

Connect all interconnection circuits to a common return point that is isolated from earth. (Such connections to a common point may in any case be necessary for functional reasons.) In this case the total current from all interconnection circuits will pass through an earthed human body that touches either wire of any interconnection circuit. This current can only be limited by controlling the values I_1, I_2,... I_n in relation to the number of ports on the PABX. However, the value of the total current will probably be less than $I_1 + I_2 +... + I_n$ due to harmonic and other effects.

W.2.3 Common return, connected to protective earth

Connect all interconnection circuits to a common return point and connect that point to protective earth. The situation described in W.1.2 applies regardless of the number of ports. Since safety depends on the presence of the earth connection, it may be necessary to use high-integrity earthing arrangements, depending on the maximum value of the total current that could flow.

Annex X
(informative)

Maximum heating effect in transformer tests

(see Clause C.1)

Clause C.1 requires transformers to be loaded in such a way as to give the maximum heating effect. In this annex examples are given of various methods of producing this condition. Other methods are possible and compliance with Clause C.1 is not restricted to these examples.

X.1 Determination of maximum input current

The value of the input current at rated load is established. This is I_r, see step A of Table X.1. The value may be established by test or from manufacturer's data.

A load is applied to the output winding or to the output of the switch mode power supply unit while measuring the input current. The load is adjusted as quickly as possible to provide the maximum value of input current that can be sustained for approximately 10 s of operation. This is I_m, see step B of Table X.1. The test is then repeated according to step C and, if necessary, steps D to J of Table X.1. The input current at each step is then noted and maintained until either:

a) the temperature of the transformer stabilizes without the operation of any component or protective device (inherent protection) in which case no further testing is conducted; or

b) component or protective device operates, in which case the winding temperature is noted immediately and the test of Clause X.2 is then conducted depending on the type of protection.

If any component or protective device operates within 10 s after the application of the primary voltage, I_m is the value recorded just before the component or protective device operates.

In conducting the tests described in steps C to J of Table X.1, the variable load is adjusted to the required value as quickly as possible and readjusted, if necessary, 1 min after application of the primary voltage. The sequence of steps C to J may be reversed.

Table X.1 – Test steps

Steps	**Input current of the transformer or switch mode power supply unit**
A	Input current at rated load = I_r
B	Maximum value of input current after 10 s of operation = I_m
C	$I_r + 0,75\ (I_m - I_r)$
D	$I_r + 0,50\ (I_m - I_r)$
E	$I_r + 0,25\ (I_m - I_r)$
F	$I_r + 0,20\ (I_m - I_r)$
G	$I_r + 0,15\ (I_m - I_r)$
H	$I_r + 0,10\ (I_m - I_r)$
J	$I_r + 0,05\ (I_m - I_r)$

X.2 Overload test procedure

If the test of Clause X.1 results in condition X.1 b), the following applies depending on type of protection.

Electronic protection:	*The current is either reduced in steps of 5 % from the current of condition X.1 b) or increased in steps of 5 % from the rated load to find the maximum overload at which the temperature stabilizes without the operation of any electronic protection.*
Thermal protection:	*An overload is applied such that the operating temperature remains a few degrees below the rated opening temperature of the thermal protection.*
Overcurrent protection:	*An overload is applied such that a current flows in accordance with the current versus time trip curves of the overcurrent protective device.*

Annex Y
(normative)

Ultraviolet light conditioning test

(see 4.3.13.3)

Y.1 Test apparatus

Samples are exposed to ultraviolet light by using one of the following apparatus:

– *a twin enclosed carbon-arc, (see Y.3), with continuous exposure for a minimum of 720 h. The test apparatus shall operate with a black-panel temperature of 63 °C ± 3 °C in a relative humidity of (50 ~~%~~ ± 5)%; or*

– *a xenon-arc, (see Y.4) with continuous exposure for a minimum of 1 000 h. The test apparatus shall operate with a 6 500 W, water-cooled xenon-arc lamp, a spectral irradiance of 0,35 W/m^2 at 340 nm, a black-panel temperature of 63 °C ± 3 °C in a relative humidity of (50 ~~%~~ ± 5)%.*

Y.2 Mounting of test samples

The samples are mounted vertically on the inside of the cylinder of the light exposure apparatus, with the widest portion of the samples facing the arcs. They are mounted so that they do not touch each other.

Y.3 Carbon-arc light-exposure apparatus

The apparatus described in ISO 4892-4, or equivalent, is used in accordance with the procedures given in ISO 4892-1 and ISO 4892-4 using a type 1 filter, without water spray.

Materials tested with water spray are also considered acceptable.

Y.4 Xenon-arc light-exposure apparatus

The apparatus described in ISO 4892-2, or equivalent, is used in accordance with the procedures given in ISO 4892-1 and ISO 4892-2 using method A, without water spray.

Materials tested with water spray are also considered acceptable.

NOTE The wording "without water spray" indicates that the samples are not sprayed with water during the test. This should not be confused with water cooling which is necessary for operation of the apparatus.

Annex Z
(informative)

Overvoltage categories

(see 2.10.3.2 and Clause G.2)

The largest peak value of transient overvoltage likely to be experienced at the power input interface of equipment connected to a MAINS SUPPLY is known as the MAINS TRANSIENT VOLTAGE. In this standard, minimum CLEARANCES for insulation in PRIMARY CIRCUITS are based on the MAINS TRANSIENT VOLTAGE.

According to IEC 60664-1, the value of the MAINS TRANSIENT VOLTAGE of an AC MAINS SUPPLY depends on the AC MAINS SUPPLY voltage and the Overvoltage Category, I to IV, see also Table G.1.

The Overvoltage Category therefore has to be identified for each equipment intended to be connected to the AC MAINS SUPPLY.

The Overvoltage Category depends on the manner of connection of the equipment to the building power supply arrangements. It is normally considered to be as shown in Table Z.1. Where transient limiting measures are provided, such as external filters in the AC MAINS SUPPLY, the equipment can be used in a higher Overvoltage Category.

The term Overvoltage Category is not used in connection with DC MAINS SUPPLIES.

Table Z.1 – Overvoltage categories

Overvoltage Category	Equipment and its point of connection to the AC MAINS SUPPLY	Examples of equipment
IV	Equipment that will be connected to the point where the AC MAINS SUPPLY enters the building	Electricity meters Communications information technology equipment for remote electricity metering
III	Equipment that will be an integral part of the building wiring	Socket-outlets, fuse panels and switch panels Power monitoring equipment
II	PLUGGABLE or PERMANENTLY CONNECTED EQUIPMENT that will be supplied from the building wiring	Household appliances, portable tools, home electronics Most information technology equipment used in the building
I	Equipment that will be connected to a special AC MAINS SUPPLY in which measures have been taken to reduce transients	Information technology equipment supplied via an external filter or a motor driven generator

Annex AA
(normative)

Mandrel test
(see 2.10.5.8)

NOTE This test is based on IEC 61558-1 and will give the same results.

Three test samples, each individual sample consisting of three or more layers of non-separable thin sheet material forming REINFORCED INSULATION*, are used. One sample at a time is fixed to the mandrel of the test fixture (Figure AA.1) as shown in Figure AA.2.*

Dimensions in millimeters

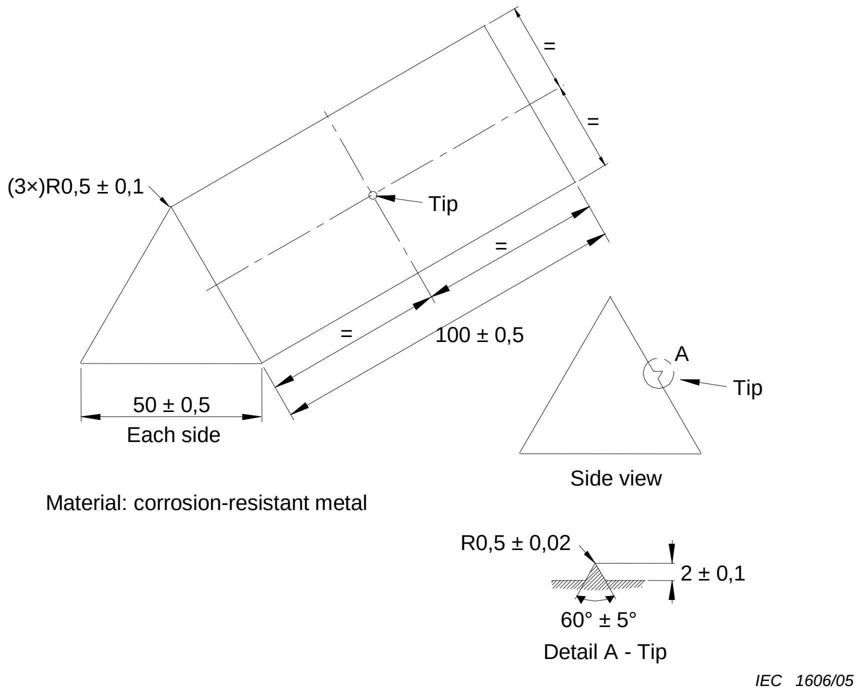
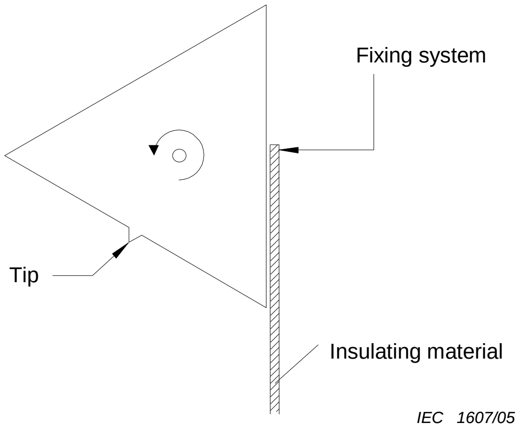
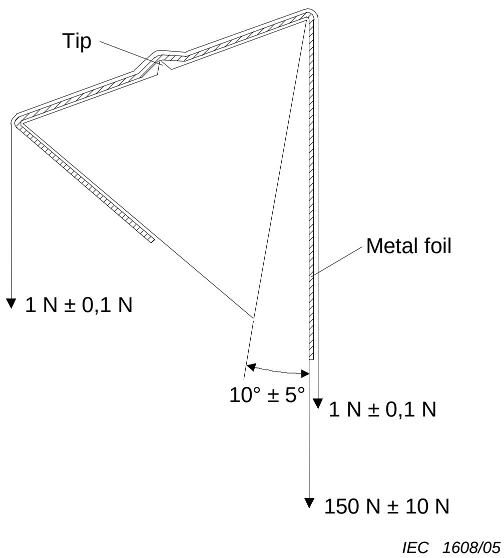


Figure AA.1 – Mandrel





The final position of the mandrel is rotated 230° ± 5° from the initial position

Figure AA.2 – Initial position of mandrel

Figure AA.3 – Final position of mandrel

A downward force of 150 N ± 10 N is applied to the free end of the sample (see Figure AA.3), using an appropriate clamping device. The mandrel is rotated

– *from the initial position (Figure AA.2) to the final position (Figure AA.3) and back;*

– *as above for a second time;*

– *from the initial position to the final position.*

If a sample breaks during rotation where it is fixed to the mandrel or to the clamping device, this does not constitute a failure. If a sample breaks at any other place, the test has failed.

After the above test, a sheet of metal foil, 0,035 mm ± 0,005 mm thick, at least 200 mm long, is placed along the surface of the sample, hanging down on each side of the mandrel (see Figure AA.3). The surface of the foil in contact with the sample shall be conductive, not oxidized or otherwise insulated. The foil is positioned so that its edges are not less than 18 mm from the edges of the sample (see Figure AA.4). The foil is then tightened by two equal weights, one at each end, using appropriate clamping devices.

Dimensions in millimeters

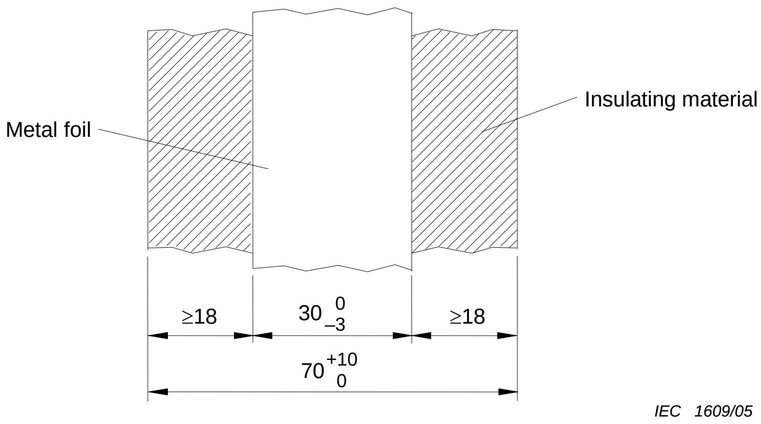


Figure AA.4 – Position of metal foil on insulating material

While the mandrel is in its final position, and within the 60 s following the final positioning, an electric strength test is applied between the mandrel and the metal foil in accordance with 5.2.2. The test voltage is 150 % of U_{test} *, but not less than 5 kV.* U_{test} *is the test voltage specified in 5.2.2 for* REINFORCED INSULATION.

The entire test procedure is repeated on the other two samples.

Annex BB
(informative)

Changes in the second edition

BB.1 Numbering changes table

The following subclause, annex, figure and table numbers have changed since the first edition of IEC 60950-1.

First Edition	Action	This edition
1.2.2.3	deleted	
	new	1.2.2.3
1.2.2.4	deleted	
1.2.2.5	deleted	
	new	1.2.5.3
1.2.5.3 to 5	renumbered	1.2.5.4 to 6
	new	1.2.8.3
1.2.8.3 to 13	renumbered	1.2.8.4 to 14
	new	1.2.9.7
1.2.9.7 to 10	renumbered	1.2.9.8 to 11
	new	1.2.10.4
	new	1.2.13.15
	new	1.2.13.16
	new	1.2.13.17
1.5.6, 1.5.7.2	replaced	1.5.6
1.5.7	replaced	1.5.7
	new	1.5.9
	new	1.7.2.1 to 3
1.7.10	renumbered	1.7.2.4
1.7.11	renumbered	1.7.10
1.7.12	deleted	
1.7.13 to 15	renumbered	1.7.11 to 13
1.7.16	renumbered	1.7.2.5
1.7.17	renumbered	1.7.14
	new	1.7.2.6
	new	2.1.1.8
	new	2.1.1.9
2.2.3.1	deleted	
2.2.3.2	deleted	
2.2.3.3	deleted	
	new	2.3.2.1 to 4
2.6.1 c)	combined with 2.6.1 b)	
2.6.1 d) to g)	renumbered	2.6.1 c) to f)
	new	2.9.4
2.10	replaced	2.10
	new	3.5.4
	new	4.5.1
4.5.1	renumbered	4.5.2
4.5.2	renumbered	4.5.5
	new	4.5.3
	new	4.5.4
	new	4.6.4.1 to 3
	new	5.1.2.1 to 3
	new	5.1.7.1 to 2
	new	5.3.6
5.3.6 to 5.3.8.2	renumbered	5.3.7 to 5.3.9.2
	new	7.1
7.1 to 7.2	renumbered	7.2 to 7.3
7.3.1 to 7.3.3	renumbered	7.4.1 to 7.4.3
	new	B.6.1 to 4
	new	B.7.1
B.7.1 to B.7.3	renumbered	B.7.2 to B.7.4
	new	G.1.1
G.1	renumbered	G.1.2

First Edition	Action	This edition
	new	G.2.3
	new	G.2.4
G.4 a)	renumbered	G.4.1
G.4 b)	renumbered	G.4.2
G.4 c)	renumbered	G.4.3
G.4 d)	renumbered	G.4.4
	new	Annex Q
Annex Q	renamed	Bibliography
	new	Annex Z
	new	Annex AA
	new	Annex BB
	new	Figure 2D
	new	Figure 2E.1 and Figure 2E.2
Figure 2D to Figure 2H	renumbered	Figure 2F to Figure 2K
Figure F.12	split and renumbered	Figures 2D and F.12
	new	Figure F.14 to F.18
	new	Figure AA.1 to AA.4
	new	Table 1B
	new	Table 1C
	new	Table 1D
	new	Table 2E
Table 2E to Table 2G	renumbered	Table 2F to Table 2H
	new	Table 2J
Table 2H to Table 2L	renumbered	Table 2K to Table 2N
	new	Table 2P
Table 2M	renumbered	Table 2R
Table 2N	renumbered	Table 2Q
Table 4B part 1	renumbered	Table 4B
Table 4B part 2	renumbered	Table 4C
Table 4C	renumbered	Table 4D
Table 4D	renumbered	Table 4E
	new	Table 5C
	new	Table 5D
	new	Table Z.1

Changes to this edition

The principal changes in this edition as compared with the first edition of IEC 60950-1 are as follows. Minor changes are not listed.

Audio amplifiers, requirements added for consistency with IEC 60065 (2.1.1.9, 4.5.1).

Ball pressure test, test procedure corrected, different at high ambients (4.5.5).

Batteries, requirements enhanced (4.3.8).

Bibliography moved to a new section after the Annexes

CABLE DISTRIBUTION SYSTEMS, voltage tests clarified (7.4.2, 7.4.3).

Cathode ray tubes, requirements aligned with IEC 60065 (4.2.8).

Connectors, lower minimum CLEARANCES and CREEPAGE DISTANCES (2.10.3.1, 2.10.4.3, G.6).

Data ports for additional equipment, requirements added to limit power output (3.5.4)

Definitions added:

- CHEESECLOTH (1.2.13.15);
- EQUIPMENT, PLUGGABLE (1.2.5.3);
- INSULATION, SOLID (1.2.10.4);
- RATING, PROTECTIVE CURRENT (1.2.13.17);
- SUPPLY, MAINS (1.2.8.3);
- TIME, RATED RESTING (1.2.2.3);
- TISSUE, WRAPPING (1.2.13.16);
- VOLTAGE, RMS WORKING (1.2.9.7).

DC MAINS SUPPLIES, more detailed requirements regarding:

- CLEARANCES [2.10.3.2 b) and c), 2.10.3.7, 2.10.3.9, G.2.2, G.2.3, G.4.1 c), G.5 a)];
- shock hazard (2.1.1.7, 2.1.1.8).

Distance through insulation, requirements clarified (2.10.5) in particular:

- optocouplers, aligned with IEC 60747 (2.10.5.4, Figure F.17);
- non-separable thin sheet material (2.10.5.8).

"Hiccup" mode of power supplies (2.2.3).

Insulation having starting pulses, requirements added (2.10.1.7, 2.10.2.1, 2.10.3.5).

Insulation in non-separable thin sheets, aligned with IEC 61558-1 (2.10.5.8, 2.10.5.9, Annex AA).

Insulation in wound components, requirements clarified (2.10.5.11, 2.10.5.14, Annex U) including:

- winding wire (2.10.5.12);
- solvent-based enamel on winding wire (2.10.5.1, 2.10.5.13).

Language for marking, requirement for local language removed (1.7.2.1 Note 3).

Limited power sources, tests clarified (2.5).

Mechanical strength, tests clarified (4.2.5, 4.2.6).

Motor test, alternative procedure added (B.6.3).

Non-continuous operation, requirements clarified (1.2.2, 1.7.3, 4.5.2, 5.3.8).

Overcurrent protective devices to be specified if required externally (1.7.2.3).

Overvoltage categories III and IV, requirements added or clarified (2.10.3.1, 5.2.2, G.1.1, Annex Z).

Pollution degrees 2 and 3, CLEARANCES modified to align with IEC 60664-1 (Table G.2).

PROTECTIVE BONDING CONDUCTORS, requirements and test procedure modified (2.6.3.3, 2.6.3.4).

Resistors, bridging insulation (1.5.7).

Ringing signals, test procedure for "Part 68" corrected and clarified (M.3).

Scope clarified, this standard can be used for:

- partial compliance of component subassemblies (1.1.1);
- electronic parts of certain other equipment (1.1.1 Note 2).

SELV CIRCUIT and TNV CIRCUIT requirements for separation aligned (2.3.2, 2.3.3, 2.9.4).

Single-pole isolators, rules clarified (3.4.6).

Starting pulses, requirements added (2.10.1.7, 2.10.2.1, 2.10.3.5).

Surge suppressors:

- VDRs in PRIMARY CIRCUITS, requirements clarified (1.5.9);
- more detail to determine minimum rated operating voltage (6.1.2.1).

Thermal classes of insulation, classes 200, 220 and 250 added in line with IEC 60085 (Tables 5D, B.1, B.2, C.1, U.2).

TRANSPORTABLE EQUIPMENT, requirements for openings in ENCLOSURES (4.6.4).

TOUCH CURRENT:

- test procedure clarified for equipment with multiple supply connections (5.1.2, 5.1.7.2);
- requirements extended for PLUGGABLE EQUIPMENT TYPE A (5.1.7.1).

Wall-mounted equipment, test procedure modified (4.2.10).

X and Y capacitors bridging insulation, applications clarified, aligned with IEC 60384-14 (1.5.6).

Annex CC
(normative)

Evaluation of integrated circuit (IC) current limiters

CC.1 Integrated circuit (IC) current limiters

IC current limiters (used for current limiting the output of a power source in accordance with the requirements of a limited power source, see 2.5) are not shorted from input to output if they comply with all of the following:

– CLEARANCES and CREEPAGE DISTANCES for REINFORCED INSULATION are provided between the input and output pins for the applicable WORKING VOLTAGE, except for IC current limiters in SELV CIRCUITS;

– the IC current limiters limit the current to the manufacturer's specified value (not to be more than 5 A) under normal operating conditions with any specified drift taken into account;

– the IC current limiters are entirely electronic and have no means for manual operation or reset;

– the IC current limiters shall limit the current to 5 A, taking into account the manufacturer's specified drift, as applicable, (an open circuit is considered an acceptable result) after each of the conditioning tests given in either of the test programs specified in CC.2, CC.3 or C.C.4. The IC current limiter need only meet one of the test programs.

NOTE The power source for the tests should be capable of delivering 250 VA minimum unless the IC current limiter is tested in the end product.

A different sample may be used for each test.

CC.2 Test program 1

Test program 1 consists of the following:

– *10 000 cycles of turning enable on and off with a 100 $\Omega \pm 5\ \Omega$ resistor and a 425 μF $\pm$ 10 μF capacitor in parallel with the output;*

– *10 000 cycles of turning enable on and off with an ferrite-core inductor having 0,35 mH $\pm$ 0,1 mH inductance at 1 kHz and a d.c. resistance not exceeding 1 Ω connected in the output circuit;*

– *10 000 cycles of turning enable on and off with the input connected to a capacitor rated 425 μF $\pm$ 1 μF and shorting the output;*

– *10 000 cycles of turning the input pin on and off with a capacitor rated 425 μF $\pm$ 10 μF connected to the input supply while keeping enable active and shorting the output;*

– *10 000 cycles of turning the input pin on and off with an ferrite-core inductor having 0,35 mH $\pm$ 0,1 mH inductance at 1 kHz and a d.c resistance not exceeding 1 Ω connected to the input supply and return while keeping enable active and shorting the output;*

– *50 cycles with the enable pin held active with the output open-circuited, each cycle consisting of shorting the output and then opening the output;*

– *50 cycles with the enable pin held active while applying a short to the output, each cycle consisting of turning the power on and off;*

– *50 cycles with the enable pin held active while power is applied, each cycle consisting of shorting the output, removing power, reapplying power, removing the short, followed by removal of power.*

CC.3 Test program 2

Test program 2 consists of the following:

- *50 cycles with the enable pin held active with the output open-circuited; each cycle consisting of shorting the output and then opening the output;*
- *50 cycles with the enable pin held active while applying a short to the output; each cycle consisting of turning the power on and off;*
- *50 cycles with the enable pin held active with the output loaded to maximum power, each cycle consisting of turning the power on and off;*
- *50 cycles with the enable pin held active while power is applied, each cycle consisting of shorting the output, removing power, reapplying power, removing the short, followed by removal of power;*
- *3 cycles of exposing the device (not energized) to 70 °C ± 2 °C for 24 h; followed by at least 1 h at room ambient; followed by at least 3 h at -30 °C ± 2 °C; followed by 3 h at room ambient;*
- *10 cycles of exposing the device (while energized) to 50 °C ± 2 °C for 10 min; followed by 10 min at 0 °C ± 2 °C with a 5 min period of transition from one state to the other;*
- *7 days with the output short-circuited and the device wrapped in a double layer of* CHEESECLOTH*. A fast blow 5 A fuse (complying with IEC 60127-1) kept in series with the output shall not open.*

CC.4 Test program 3

Test program 3 consists of the following:

- *H.17.1.4.2 of IEC 60730-1:1999;*
- *10 000 cycles of turning enable on and off with a 100 Ω resistor and 425 μF capacitor in parallel with the output;*
- *10 000 cycles of turning enable on and off with a ferrite-core inductor having 0,35 mH ± 0,1 mH inductance at 1 kHz and a d.c. resistance not exceeding 1 Ω connected in the output circuit;*
- *10 000 cycles of turning enable on and off while input connected to a capacitor rated 425 μF and shorting the output;*
- *10 000 cycles of turning input pin on and off while a capacitor rated 425 μF to the input supply keeping enable active and shorting the output;*
- *10 000 cycles of turning input pin on and off with a ferrite-core inductor having 0,35 mH inductance at 1 kHz and a d.c. resistance not exceeding 1 Ω connected to the input supply keeping enable active and shorting the output;*
- *50 cycles with enable pin held active and applying short to output with power on and off;*
- *50 cycles with enable pin held active and output loaded to maximum power with power on and off;*
- *50 cycles with enable pin held active and applying power, apply short to output; remove power, apply power, remove short, remove power;*
- *3 cycles of exposing the device (not energised) to 70 °C for 24 h; followed by at least 1 h at room ambient; followed by at least 3 h at − 30 °C; followed by 3 h at room ambient;*
- *10 cycles of exposing the device (while energised) to 49 °C for 10 min; followed by 10 min at 0 °C with a 5 min period of transition from one state to the other.*

CC.5 Compliance

After each of the tests in CC.2, CC.3 and CC.4, the device shall limit the current in accordance with its specification as applicable or the device shall become open circuit. An open-circuited device is replaced with a new sample and tests continued as applicable.

Annex DD
(normative)

Requirements for the mounting means of rack-mounted equipment

DD.1 General

These requirements apply to the mounting means of equipment having a mass exceeding 7 kg installed in a rack that can be extended away from the rack for installation, service and the like. This requirement does not apply to equipment fixed in place and provided with equipment subassemblies or racks having a top installation position less than 1 m in height from the supporting surface.

For the purpose of these requirements, the mechanical mounting means for such equipment will be referred to as slide rails. These requirements are intended to reduce the likelihood of injury by retaining the equipment in a safe position and not allowing the slide rails to buckle, the means of attachment to break, or the equipment to slide past the end of the slide rails.

NOTE 1 Slide rails include bearing slides, friction slides or other equivalent mounting means.

NOTE 2 Slide rail constructions of integrated parts/units of the end product (for example, pullout paper trays in copiers/printers) are not considered to be rack-mounted equipment.

Slide rails shall have end stops that prevent the equipment from unintentionally sliding off the mounting means.

DD.2 Mechanical strength test, variable *N*

The slide rails shall be installed in a rack with the equipment, or equivalent setup, in accordance with the manufacturer's instructions. With the equipment in its extended position, a force in addition to the weight of the equipment is to be applied downwards through the centre of gravity for 1 min by means of a suitable test apparatus providing contact over a circular plane surface of 30 mm in diameter. If applying this force could damage the equipment, a metal plate or other means to distribute the force may be placed under the test apparatus. The total force shall be calculated based on the mass of the equipment plus an additional mass as determined below.

NOTE This additional force is intend to take into account other items or devices that may be stacked on top of the installed rack-mounted equipment while in the extended position during installation of other equipment.

For slide-rail mounted equipment, where the slide rails are mounted horizontally on each side of the equipment, the total force applied to the slide rails shall be equal to the greater of the following two values:

– *150 % of the equipment mass plus 330 N,*

– *150 % of the equipment mass, plus an additional mass, where the additional mass is equal to the equipment mass or 530 N, whichever is less.*

For slide rail mounted equipment where the slide rails are mounted vertically on the top and bottom of the equipment in the rack, the total force applied to the slide rails shall be 150 % of the equipment mass, with a minimum force of 250 N and a maximum force of 530 N.

If the supporting surface is intended to be a shelf, then the distribution of force over a metal plate under the test apparatus does not apply. The manufacturer shall specify the maximum load intended to be placed on the shelf in order to determine the force that needs to be applied to the shelf. A marking shall be provided on the shelf to indicate the maximum weight that can be added to the shelf. The force test shall be conducted at 125 % of the maximum weight stated by the manufacturer. The force is to be applied directly by means of the test apparatus providing contact over a circular plane surface of 30 mm in diameter.

DD.3 Mechanical strength test, 250 N, including end stops

The slide rail mounted equipment is installed in a rack in accordance with the manufacturer's instructions. A 250 N static force is applied to the slide rail mounted equipment, in every direction except upward to include the most unfavourable position of the slide rail mounted equipment, for a period of 1 min. The force is applied to the slide rail mounted equipment in its fully extended (service) position as well as its normally recessed (operating) position by means of a suitable test instrument providing contact over a circular plane surface of 30 mm in diameter. The force is applied with the complete flat surface of the test instrument in contact with the equipment. The test instrument need not be in full contact with uneven surfaces (for example corrugated or curved surfaces).

NOTE Additional requirements for a dynamic force test on the end stops are under consideration.

DD.4 Compliance

Compliance is checked by inspection and available manufacturer's data. If data is not available, then the tests according to DD.2 and DD.3 are conducted.

The equipment and its associated slide rails shall remain secure during the tests. One complete cycle of travel of the equipment on the slide rails shall be performed after completion of each test. If the mounting means is not able to perform one complete cycle without binding, a force of 100 N shall be applied horizontally to the front centre point of the equipment with the intent to completely retract the equipment into the rack. Should the equipment fail to fully retract, the mounting means shall not bend or buckle to any extent that could introduce an injury. End stops shall retain the equipment in a safe position and shall not allow the equipment to slide past the end of the slide rails.

Annex EE
(normative)

Household and home/office document/media shredders

EE.1 General

HOUSEHOLD AND HOME/OFFICE DOCUMENT/MEDIA SHREDDERS shall additionally comply with the requirements of this annex.

EE.2 Markings and instructions

For HOUSEHOLD AND HOME/OFFICE DOCUMENT/MEDIA SHREDDERS, markings or symbols alerting the USER to the following considerations shall be provided adjacent to the document/media feed opening:

– this equipment is not intended for use by children (the product is not a toy);
– avoid touching the document/media feed opening with the hands;
– avoid clothing touching the document/media feed opening;
– avoid hair touching the document/media feed opening; and
– keep aerosol products away [for equipment incorporating a universal (brush) motor only].

Additionally, the symbol  (ISO 7000-0434) and the symbol  (ISO 7000-1641) (or a combination of the two) shall be marked adjacent to the document/media feed opening to alert the USER to the presence of important operating, maintenance and/or servicing instructions in the USER instructions accompanying the product, and the symbols required above shall be explained in the instructions.

The markings shall be permanent and easily discernible on the equipment when ready for use.

EE.3 Inadvertent reactivation

With the HOUSEHOLD AND HOME/OFFICE DOCUMENT/MEDIA SHREDDER held in any position, including being removed from any waste container, it shall not be possible to defeat any SAFETY INTERLOCK or switch that provides protection against the activation of the shredder mechanism by means of the test finger of Figure 2A.

NOTE In Canada, Japan and the United States, a different test finger is used for determining compliance with EE.3 and EE.5.

Compliance is checked by inspection and, where necessary, by a test with the test finger of Figure 2A.

EE.4 Disconnection of power to hazardous moving parts

An isolating switch complying with 3.4.2 shall be provided to disconnect power to hazardous moving parts. This switch may be a two-position (single-purpose) switch or a multi-position (multi-function) switch (for example, a slide switch). This switch shall be located where it is easily accessible to a USER whose body part or clothing may be caught at the feed opening.

The “ON” and “OFF” positions of a two-position switch shall be marked in accordance with 1.7.8.

For a multi-position switch, the “OFF” position of the switch shall be marked in accordance with 1.7.8, and the other positions shall be marked with appropriate words or symbols. If symbols are used, they shall be explained in the USER instructions.

Compliance is checked by inspection.

EE.5 Protection against hazardous moving parts

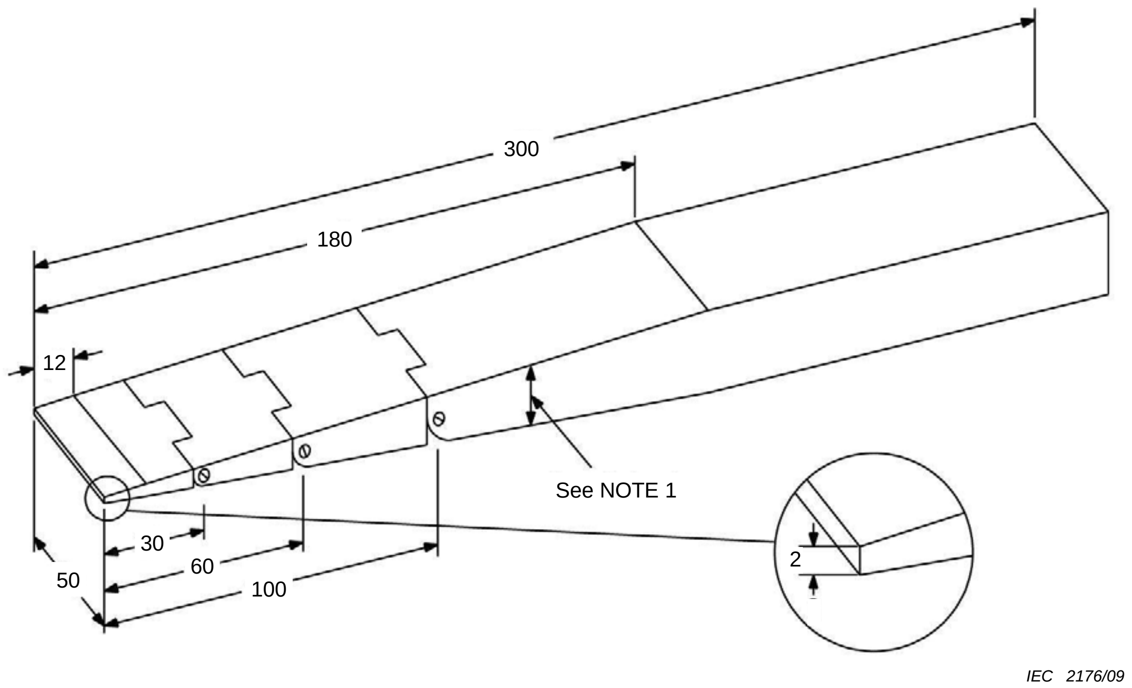
For HOUSEHOLD AND HOME/OFFICE DOCUMENT/MEDIA SHREDDERS contact with hazardous moving parts shall be prevented. A warning statement shall not be used in lieu of construction features that prevent access to hazardous moving parts.

Compliance is checked by the following.

The test finger in Figure 2A shall be inserted into each opening in the MECHANICAL ENCLOSURE, without appreciable force. The test finger shall not contact hazardous moving parts. This consideration applies to all sides of the MECHANICAL ENCLOSURE when the HOUSEHOLD AND HOME/OFFICE DOCUMENT/MEDIA SHREDDERS is mounted as intended in accordance with the manufacturer's instructions for use. In some cases, operation of the equipment may be necessary to determine accessibility (for example, where a guard or cover is only opened after the unit is energized and ready for use) when applying both the test finger and wedge probe.

The wedge probe, illustrated in Figure EE.1 and Figure EE.2, shall be inserted into each feed opening in the MECHANICAL ENCLOSURE. A force not exceeding 45 N for strip-cut type HOUSEHOLD AND HOME/OFFICE DOCUMENT/MEDIA SHREDDERS and not exceeding 90 N for cross-cut type HOUSEHOLD AND HOME/OFFICE DOCUMENT/MEDIA SHREDDERS shall be applied to the wedge probe in any direction relative to the opening. The mass of the wedge probe is to be factored into the overall applied force. Before application of the wedge probe, any MECHANICAL ENCLOSURES or guards that are removable without the use of a TOOL shall be removed. The wedge probe shall not contact hazardous moving parts, including the shredding rollers/mechanisms.

Dimensions in millimeters



NOTE 1 The thickness of the probe varies linearly, with slope changes at the following points along the probe:

Distance from probe tip, mm	Probe thickness, mm
0	2
12	4
180	24

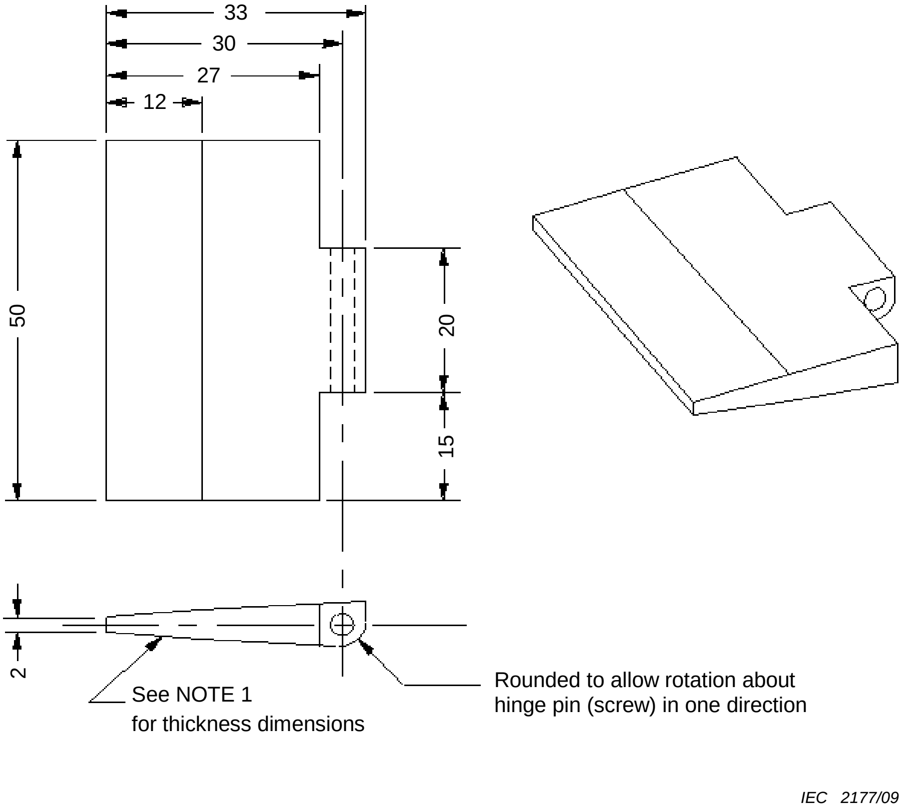
NOTE 2 Tolerances on linear dimensions without specific tolerances:

≤ 25 mm ± 0,13 mm;

> 25 mm ± 0,3 mm.

Figure EE.1 – Wedge probe (overall view)

Dimensions in millimeters



NOTE 1 The thickness of the probe varies linearly, with slope changes at the following points along the probe:

Distance from probe tip, mm	Probe thickness, mm
0	2
12	4
180	24

NOTE 2 Tolerances on linear dimensions without specific tolerances:

≤ 25 mm ± 0,13 mm;

> 25 mm ± 0,3 mm.

Figure EE.2 – Wedge probe (tip detail)

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This Bibliography contains information about documents referred to in notes and informative annexes in the standard. Further information on the listed documents, including how to obtain copies, can be found on the following internet sites:

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http://www.cie.co.at
http://www.icrp.org and (to obtain copies: http://www.elsevier.nl/locate/icrp)
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INDEX

This index is for information only and does not purport to be a complete guide to the use of this standard. The inclusion or omission of items in the index does not imply any particular importance.

Location references are clause or subclause numbers or annex letters.

In the standard, table numbers and figure numbers are linked to the clause or annex in which they are found,for example:

– Table 2A is the first Table in Clause 2;
– Figure F.2 is the second Figure in Annex F.

Principal references are printed in **bold** type.

If a term is defined in 1.2 of this standard, its definition is indicated in the index by an asterisk, for example:

– RATED VOLTAGE 1.2.1.1*.

This index is also used to explain some abbreviations, for example:

– EUT EQUIPMENT UNDER TEST.

Country notes are listed, but the contents of country notes are not indexed.

Bib is an abbreviation for Bibliography, which precedes this Index.

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COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

MATÉRIELS DE TRAITEMENT DE L'INFORMATION – SÉCURITÉ –

Partie 1: Exigences générales

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Cette version consolidée de la CEI 60950-1 comprend la deuxième édition (2005) [documents 108/135A/FDIS et 108/147/RVD], son corrigendum 1 (2006), son amendement 1 (2009) [documents 108/350/FDIS et 108/357/RVD] et son corrigendum (2012), et son amendement 2 (2013) [documents 108/507/FDIS et 108/510/RVD]. Elle porte le numéro d'édition 2.2.

Le contenu technique de cette version consolidée est donc identique à celui de l'édition de base et à ses amendements; cette version a été préparée par commodité pour l'utilisateur. Une ligne verticale dans la marge indique où la publication de base a été modifiée par les amendements 1 et 2. Les ajouts et les suppressions apparaissent en rouge, les suppressions sont barrées.

La Norme internationale CEI 60950-1 a été établie par le comité d'études 108 de la CEI: Sécurité des appareils électroniques dans le domaine de l'audio, de la vidéo, du traitement de l'information et des technologies de la communication.

La CEI 60950-1 comporte les exigences fondamentales pour la sécurité des matériels de traitement de l'information.

Des parties complémentaires de la CEI 60950-1 couvriront des exigences de sécurité spécifiques pour les matériels de traitement de l'information ayant des applications limitées ou des caractéristiques spéciales, comme suit:

Partie 21: Téléalimentation (publiée);

Partie 22: Matériels installés à l'extérieur (prévue);

Partie 23: Matériels de grande taille pour le stockage des données (prévue);

A l'exception des notes, les textes donnés à l'intérieur d'une figure normative ou d'une cellule sous un tableau normatif ont également une valeur normative. Lorsqu'un texte est accompagné d'une référence en exposant, il est lié à un point particulier du tableau. Les autres textes figurant dans une cellule sous un tableau s'appliquent à l'ensemble du tableau.

Les annexes informatives et les textes commençant par le mot "NOTE" n'ont pas de valeur normative. Ces annexes et ces textes ne sont indiqués que pour donner des informations complémentaires.

Les notes "par pays" sont également informatives mais attirent l'attention sur des exigences qui ont une valeur normative dans les pays concernés.

Dans la présente norme, les caractères d'imprimerie suivants sont employés:

- Exigences proprement dites et annexes normatives: caractères romains.
- Critères de conformité et modalités d'essais: caractères italiques.
- Notes dans le corps du texte et dans les tableaux: petits caractères romains.
- Termes définis en 1.2: PETITES CAPITALES.

Le comité a décidé que le contenu de la publication de base et de ses amendements ne sera pas modifié avant la date de stabilité indiquée sur le site web de la CEI sous "http://webstore.iec.ch" dans les données relatives à la publication recherchée. A cette date, la publication sera

- reconduite,
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INTRODUCTION

0 Principes de sécurité

Les principes suivants ont été adoptés par le comité d'études 108 dans la mise au point de la présente norme.

Ces principes ne prennent pas en compte les performances ou les caractéristiques fonctionnelles des matériels.

Les mots imprimés en PETITES MAJUSCULES sont des termes définis en 1.2 de la présente norme.

0.1 Principes généraux de sécurité

Il est essentiel que les concepteurs comprennent les principes directeurs des exigences de sécurité, de façon à pouvoir réaliser un matériel sûr.

Ce qui suit ne constitue pas une variante aux exigences détaillées de la présente norme, mais a pour but de fournir aux concepteurs une appréciation des principes sur lesquels ces exigences sont fondées. Lorsque les matériels impliquent des technologies, des composants et des matériaux ou des méthodes de construction qui ne sont pas explicitement prises en compte, il convient que la conception de ces matériels apporte un niveau de sécurité qui ne soit jamais inférieur à ceux décrits dans les présents principes de sécurité.

NOTE Il convient de porter rapidement à l'attention du comité compétent le besoin en exigences supplémentaires détaillées pour faire face à une situation nouvelle.

Les concepteurs doivent prévoir non seulement les conditions de fonctionnement normales du matériel mais aussi les conditions probables de défaut, les défauts qui en sont la conséquence, un mauvais usage prévisible et les influences externes comme la température, l'altitude, la pollution, l'humidité et les surtensions sur le RESEAU D'ALIMENTATION et sur un RESEAU DE TELECOMMUNICATIONS ou un SYSTEME DE DISTRIBUTION PAR CABLES. Il convient que le dimensionnement des espacements d'isolation tienne compte des réductions éventuelles liées aux tolérances de fabrication ou lorsqu'une déformation peut se produire au cours des manipulations, en cas de choc et de vibrations susceptibles de se produire au cours de la fabrication, du transport et de l'usage normal.

Il convient de respecter les priorités suivantes pour déterminer les méthodes de conception à adopter:

– quand cela est possible, spécifier les critères de conception qui élimineront, réduiront les dangers ou protégeront contre ceux-ci;

– quand la mesure ci-dessus n'est pas applicable parce que le fonctionnement du matériel en serait restreint, spécifier l'emploi de moyens de protection indépendants du matériel, comme un matériel personnel de protection (qui n'est pas spécifié dans cette norme);

– quand aucune des mesures ci-dessus n'est utilisable dans la pratique, ou bien en supplément de ces mesures, spécifier l'application d'étiquettes de marquages et d'instructions concernant les risques résiduels.

Il existe deux types de personnes dont la sécurité est à examiner, les UTILISATEURS (ou OPERATEURS) et le PERSONNEL DE MAINTENANCE.

UTILISATEUR est le terme appliqué à toute personne autre que le PERSONNEL DE MAINTENANCE. Il convient que les exigences de protection supposent que les UTILISATEURS ne sont pas formés pour identifier les dangers, mais qu'ils n'agissent pas non plus intentionnellement dans le but de créer une situation dangereuse. En conséquence, les exigences assureront la protection des agents chargés du nettoyage et des visiteurs occasionnels aussi bien que des

UTILISATEURS proprement dits. En général, il convient que les UTILISATEURS n'aient pas accès aux parties dangereuses et, pour ce faire, il convient que de telles parties soient situées seulement dans les ZONES D'ACCES POUR LA MAINTENANCE ou dans des matériels situés dans des LOCAUX A ACCES RESTREINT.

Lorsque les UTILISATEURS sont admis dans les ZONES A ACCES RESTREINT, ils doivent être informés de manière adéquate.

Les membres du PERSONNEL DE MAINTENANCE sont censés utiliser leur formation et leur habileté pour éviter pour eux-mêmes et pour des tiers les blessures pouvant résulter de dangers évidents qui existent dans les ZONES D'ACCES POUR LA MAINTENANCE des matériels ou dans des matériels situés dans des EMPLACEMENTS A ACCES RESTREINT. Toutefois, il convient que le PERSONNEL DE MAINTENANCE soit protégé contre des dangers inattendus. Cela peut se faire, par exemple, en plaçant les parties qui nécessitent d'être accessibles pour la maintenance à des emplacements ne présentant pas de dangers électriques et mécaniques, en fournissant des écrans pour éviter les contacts accidentels avec les parties dangereuses, et en fournissant des étiquettes ou des instructions pour avertir le personnel des risques résiduels.

Les informations sur les dangers potentiels peuvent être marquées sur le matériel ou fournies avec celui-ci, en fonction de la probabilité d'accident et de sa sévérité, ou tenues à la disposition du PERSONNEL DE MAINTENANCE. En général, les UTILISATEURS ne doivent pas être exposés à des dangers susceptibles de causer des blessures, et il convient que les informations fournies aux UTILISATEURS visent principalement à éviter les mauvais usages et les situations susceptibles de créer des dangers, comme un branchement à la mauvaise source de puissance et un remplacement de fusibles par des types incorrects.

Le MATERIEL MOBILE est considéré comme présentant un risque de choc légèrement plus élevé en raison d'une contrainte supplémentaire possible sur le câble d'alimentation, pouvant conduire à la rupture du conducteur de terre. Avec le MATERIEL PORTATIF, ce risque est augmenté, une usure du câble est plus probable et des dangers ultérieurs peuvent survenir en cas de chute du matériel. Le MATERIEL TRANSPORTABLE introduit un risque supplémentaire parce qu'il peut être employé et transporté dans n'importe quelle orientation; si un objet métallique rentre par une ouverture dans l'ENVELOPPE, il peut se déplacer à l'intérieur du matériel en risquant de provoquer un danger.

0.2 Dangers

L'application d'une norme de sécurité a pour but de réduire les risques de blessures ou de dommages dus aux dangers suivants:

- choc électrique;
- dangers liés à l'énergie;
- incendie;
- dangers thermiques;
- dangers mécaniques;
- rayonnements;
- dangers chimiques.

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0.2.1 Choc électrique

Un choc électrique est dû au passage d'un courant à travers le corps humain. Les effets physiologiques qui en résultent dépendent de la valeur et de la durée du courant et du chemin emprunté à travers le corps humain. La valeur du courant est fonction de la tension appliquée, de l'impédance de la source et de l'impédance du corps humain. L'impédance du corps humain, elle, dépend de la surface de contact, de la présence d'humidité sur la surface de contact et des tensions et fréquences appliquées. Des courants de l'ordre du demimilliampère peuvent provoquer une réaction chez des sujets en bonne santé et peuvent provoquer indirectement des blessures du fait d'une réaction involontaire. Des courants plus importants peuvent avoir des effets plus directs tels qu'une brûlure, une tétanisation musculaire provoquant une incapacité à s'éloigner ou une fibrillation ventriculaire.

Les tensions permanentes jusqu'à 42,4 V en valeur de crête ou 60 V en tension continue ne sont généralement pas considérées comme dangereuses en condition sèche si elles sont touchées sur une surface équivalente à celle d'une main. Il convient que les parties nues qui doivent être touchées ou manipulées soient au potentiel de terre ou convenablement isolées.

Certains matériels seront reliés à des réseaux téléphoniques et à d'autres réseaux extérieurs. Quelques RESEAUX DE TELECOMMUNICATIONS fonctionnent avec des signaux comme la voix et la sonnerie superposées à une tension d'alimentation continue permanente. Au total, cela peut dépasser les valeurs données ci-dessus pour des tensions permanentes. Pour le PERSONNEL DE MAINTENANCE, manipuler des parties de tels circuits à mains nues est une pratique courante. Cela ne donne pas lieu à des blessures sérieuses grâce à l'usage de signaux de sonnerie cadencés et parce que la zone de contact avec les conducteurs nus normalement manipulés par le PERSONNEL DE MAINTENANCE est limitée. Cependant, il convient que la surface de contact d'une partie accessible à l'UTILISATEUR, et la probabilité que la partie soit touchée, soient encore plus limitées (par exemple par la forme ou la localisation de cette partie).

Il est normal de fournir deux niveaux de protection pour les UTILISATEURS afin de prévenir un choc électrique. En conséquence, le fonctionnement du matériel dans les conditions normales et après un premier défaut, y compris tout défaut qui en résulte, ne doit pas créer un danger de choc électrique. Toutefois, des mesures de protection supplémentaires, telles qu'une protection par mise à la terre ou une ISOLATION SUPPLEMENTAIRE, ne sont pas considérées comme remplaçant une ISOLATION PRINCIPALE correctement conçue, ou l'en dispensant.

Des dommages peuvent résulter de:	**Exemples de mesures à prendre pour réduire les risques:**
Contacts avec des parties nues normalement sous TENSION DANGEREUSE.	Empêcher l'accès de l'UTILISATEUR aux parties portées à une TENSION DANGEREUSE par des couvercles fixés ou fermés, des VERROUILLAGES DE SECURITE, etc. Décharger les condensateurs accessibles sous TENSION DANGEREUSE.
Défaillances de l'isolation entre des parties normalement sous TENSION DANGEREUSE et des parties conductrices accessibles.	Fournir une ISOLATION PRINCIPALE et relier à la terre les parties conductrices accessibles et les circuits de façon que l'exposition à la tension pouvant apparaître reste limitée par la protection de surintensité qui déconnectera dans un temps spécifié les parties présentant des défauts à basse impédance; ou alors prévoir entre les parties un écran métallique relié à la terre de protection, ou fournir une DOUBLE ISOLATION ou une ISOLATION RENFORCEE entre ces parties, de façon qu'une défaillance vers la partie accessible ne soit pas susceptible de se produire.
Contacts avec des circuits reliés aux RESEAUX DE TELECOMMUNICATIONS qui dépassent 42,4 V en valeur de crête ou 60 V en tension continue.	Limiter l'accessibilité et la zone de contact de tels circuits et les séparer des parties non reliées à la terre auxquelles l'accès n'est pas limité.

Défaillances de l'isolation accessible à l'UTILISATEUR.

Il convient que l'isolation qui est accessible à l'OPERATEUR présente des résistances mécaniques et électriques adéquates pour réduire le risque de contact avec des TENSIONS DANGEREUSES.

COURANTS DE CONTACT (courant de fuite) entre des parties sous TENSION DANGEREUSE et les parties accessibles ou défaut d'une connexion de terre de protection. Le COURANT DE CONTACT peut comprendre le courant dû aux filtres d'anti-parasitage connectés entre CIRCUITS PRIMAIRES et parties accessibles.

Limiter le COURANT DE CONTACT à une valeur spécifiée, ou prévoir une connexion de terre de protection de grande fiabilité.

0.2.2 Dangers liés à l'énergie

Des blessures ou un incendie peuvent résulter d'un court-circuit entre des pôles adjacents de sources d'énergie à courant élevé ou de circuits à haute capacité et peuvent provoquer:

- des brûlures;
- des formations d'arcs;
- des émissions de métal fondu.

Même les circuits dont les tensions sont sûres peuvent être dangereux à ce point de vue.

Exemples de mesures à prendre pour réduire les risques:

- la séparation;
- la mise en place d'écrans;
- la mise en place de VERROUILLAGES DE SÉCURITÉ.

0.2.3 Incendie

Des risques d'incendie peuvent résulter de températures excessives soit dans les conditions de fonctionnement normal, soit à cause de surcharges, d'une défaillance d'un composant, d'une rupture de l'isolation ou de connexions desserrées. Il convient qu'un incendie prenant naissance dans un matériel ne s'étende pas au-delà du voisinage immédiat de la source d'incendie et ne provoque pas de dommages à l'entourage du matériel.

Exemples de mesures à prendre pour réduire les risques:

- la fourniture d'une protection contre les surintensités;
- l'utilisation de matériaux de construction ayant des caractéristiques d'inflammabilité appropriées;
- le choix des parties, composants et matériaux inflammables pour éviter une température élevée susceptible de provoquer l'inflammation;
- la limitation de la quantité de matériaux combustibles utilisés;
- la mise en place d'écrans ou la séparation des matériaux combustibles des sources possibles d'inflammation;
- l'utilisation d'ENVELOPPES ou de barrières pour limiter la propagation du feu à l'intérieur du matériel;
- l'utilisation de matériaux appropriés pour les ENVELOPPES de façon à réduire le risque d'extension du feu à l'extérieur du matériel.

0.2.4 Dangers thermiques

Des blessures peuvent résulter de hautes températures dans les conditions de fonctionnement normal, provoquant:

- des brûlures dues au contact avec des parties chaudes accessibles;
- une dégradation de l'isolation et de composants critiques pour la sécurité;

– une inflammation de liquides inflammables.

Exemples de mesures à prendre pour réduire les risques:

– la prise de mesures pour éviter des températures élevées sur les parties accessibles;
– le fait d'éviter des températures supérieures au point d'inflammation des liquides;
– la mise en place de marquages pour avertir les UTILISATEURS aux endroits où l'accès aux parties à haute température est inévitable.

0.2.5 Dangers mécaniques

Des blessures peuvent résulter:

– d'arêtes et de coins tranchants;
– de parties mobiles qui peuvent causer des blessures;
– de l'instabilité du matériel;
– d'une projection de particules lors d'implosions de tubes cathodiques ou d'explosions de lampes à haute pression.

Exemples de mesures à prendre pour réduire les risques:

– l'arrondissement des arêtes et des coins tranchants;
– l'installation de protections;
– la mise en place de VERROUILLAGES DE SECURITE;
– des mesures assurant une stabilité suffisante aux matériels auto-stables;
– la sélection des tubes cathodiques et des lampes à haute pression résistant respectivement aux implosions et aux explosions;
– la mise en place de marquages pour avertir les UTILISATEURS aux endroits où l'accès est inévitable.

0.2.6 Rayonnements

Des blessures touchant les UTILISATEURS et le PERSONNEL DE MAINTENANCE peuvent résulter de différentes formes de rayonnements émis par le matériel. Il peut s'agir de fréquences acoustiques, de fréquences radioélectriques, de rayons infrarouges, ultraviolets et ionisants et de lumières de haute intensité visibles et cohérentes (lasers).

Exemples de mesures à prendre pour réduire les risques:

– la limitation du niveau d'énergie des sources de rayonnements;
– l'écrantage des sources de rayonnements;
– la mise en place de VERROUILLAGES DE SECURITE;
– la mise en place de marquages pour avertir les UTILISATEURS aux endroits où l'exposition au danger de rayonnement est inévitable.

0.2.7 Risques chimiques

Des blessures peuvent résulter du contact avec certaines substances chimiques ou de l'inhalation de leurs vapeurs et de leurs fumées.

Exemples de mesures à prendre pour réduire les risques:

– éviter l'utilisation de matériaux de construction ou de consommables susceptibles de causer des dommages par contact ou inhalation dans les conditions normales et pré-visibles d'utilisation.
– éviter les conditions susceptibles de causer des fuites ou des vaporisations;
– mettre des marquages en place pour avertir les UTILISATEURS des dangers.

0.3 Matériaux et composants

Il convient de choisir et de disposer les matériaux et les composants utilisés dans la construction des matériels de façon qu'on puisse espérer qu'ils assureront leur fonction de manière sûre pour la durée de vie prévisible du matériel, sans créer de danger et qu'ils ne contribueront pas de façon significative à la propagation d'un danger d'incendie sérieux. Il convient de choisir les composants de façon à ce qu'ils restent dans la plage des caractéristiques spécifiées par leur fabricant en conditions normales, et qu'ils ne créent pas de danger dans les conditions de défaut.

MATÉRIELS DE TRAITEMENT DE L'INFORMATION – SÉCURITÉ –

Partie 1: Exigences générales

1 Généralités

1.1 Domaine d'application

1.1.1 Matériels couverts par la présente norme

La présente norme est applicable aux matériels de traitement de l'information alimentés par le réseau ou alimentés par batteries, y compris les matériels de bureau électriques et les matériels associés, de TENSION ASSIGNEE maximale égale à 600 V.

La présente norme est aussi applicable aux matériels de traitement de l'information suivants:

– conçus pour être utilisés comme équipements terminaux de télécommunications et matériels d'infrastructure de RESEAUX DE TELECOMMUNICATIONS, quelle que soit la source d'alimentation;
– conçus et prévus pour être connectés directement à un SYSTEME DE DISTRIBUTION PAR CABLES, ou pour y être utilisés comme matériels d'infrastructure quelle que soit la source d'alimentation;
– destinés à utiliser le RESEAU D'ALIMENTATION EN COURANT ALTERNATIF comme moyen de transmission de télécommunications (voir Article 6, Note 4 et 7.1, Note 4).

La présente partie de la CEI 60950 est également applicable:

- aux composants et sous-ensembles destinés à être intégrés dans ces matériels~~de traitement de l'information~~. ~~Il n'est pas attendu que~~ De tels composants et sous-ensembles ne doivent pas nécessairement être conformes à chaque exigence de la norme, sous réserve que le matériel complet ~~de technologie de l'information~~, qui intègre de tels composants et sous-ensembles, soit conforme.
- aux sources d'alimentation externes destinées à alimenter d'autres matériels entrant dans le domaine d'application de la présente partie de la CEI 60950;
- aux accessoires destinés à être utilisés avec des matériels entrant dans le domaine d'application de la présente partie de la CEI 60950.

NOTE 1 Parmi les exemples d'aspects auxquels des composants, des sous-ensembles et des accessoires non installés peuvent ne pas être conformes, on peut citer le marquage des caractéristiques assignées et l'accès aux parties dangereuses.

NOTE 2 La présente norme peut être appliquée aux parties électroniques du matériel même si le matériel n'entre pas complètement dans le domaine d'application de la norme, par exemple gros systèmes de conditionnement de l'air, systèmes de détection incendie et systèmes d'extinction d'incendie. Des exigences différentes peuvent être nécessaires pour certaines applications.

La présente norme spécifie les exigences prévues pour réduire les risques de feu, de chocs électriques ou de blessures pour l'OPERATEUR et le personnel non spécialisé qui peut entrer en contact avec le matériel et, lorsque c'est indiqué spécifiquement, pour le PERSONNEL DE MAINTENANCE.

Le but de la présente norme est de réduire de tels risques concernant le matériel installé, qu'il se compose d'un système d'unités interconnectées ou d'unités indépendantes, sous réserve que le matériel soit installé, utilisé et entretenu de la manière prescrite par le fabricant.

Comme exemples de matériels entrant dans le domaine d'application de la présente norme, on peut citer:

Type générique de produit	Exemples spécifiques pour un type générique
matériels bancaires	matériels de traitement de l'argent y compris les distributeurs automatiques de billets (DAB)
machines de traitement de texte et de données et leurs matériels associés	matériels de préparation de données, matériels de traitement de données, matériels de stockage de données, ordinateurs personnels, traceurs, imprimantes, matériels de numérisation, matériels de traitement de texte, écrans de visualisation
matériels de réseaux de données	passerelles de réseaux, matériels de terminaison de circuits de données, terminaux informatiques, routeurs,
matériels électriques et électroniques du commerce de détail	caisses enregistreuses, terminaux points de vente y compris les balances électroniques associées
machines électriques et électroniques de bureau	calculatrices, photocopieuses, dictaphones, broyeurs de documents, duplicateurs, effaceuses, matériels micrographiques, classeurs à moteur, machines à papier (perforatrices, massicots, trieuses), machines débitrices de papier, taille-crayons, agrafeuses, machines à écrire
autres matériels de traitement de l'information	matériels de photo impression, terminaux publics d'information, matériels multimédias
matériels pour le service postal	machines à traiter le courrier, machines à affranchir
matériels d'infrastructure de réseau de télécommunications	matériels de facturation, multiplexeurs, matériels d'alimentation de réseau, matériels de terminaison de réseau, stations de base radio, répéteurs, matériels de transmission, matériels de commutation des télécommunications
terminaux de télécommunications	télécopieurs, systèmes de téléphone à touches, modems, PABX, appareils de messagerie, répondeurs téléphoniques, postes téléphoniques (avec ou sans cordon)

NOTE 3 Les exigences de la CEI 60065 peuvent également être utilisées pour satisfaire aux exigences de sécurité des matériels multimédias. Voir le Guide CEI 112*, Guide pour la sécurité des matériels multimédias*.

Cette liste n'est pas exhaustive et les matériels qui ne sont pas cités ne sont pas nécessairement exclus du Domaine d'application.

Les matériels satisfaisant aux exigences appropriées de la présente norme sont considérés comme pouvant être utilisés avec les matériels de commande de processus, les matériels d'essais automatiques et les systèmes analogues nécessitant des dispositifs pour le traitement de l'information. Toutefois, la présente norme ne comprend pas les exigences concernant l'aptitude à la fonction ou les caractéristiques de fonctionnement du matériel.

1.1.2 Exigences complémentaires

Des exigences complémentaires à celles qui sont spécifiées dans la présente norme peuvent être nécessaires pour:

– les matériels destinés à fonctionner dans des environnements spéciaux, (par exemple en présence de températures extrêmes, de poussières, d'humidité ou de vibrations excessives, de gaz inflammables ou d'atmosphères corrosives ou explosives);

– les applications électromédicales avec contact physique avec le patient;

– les matériels destinés à être utilisés sur des véhicules, à bord de navires ou d'aéronefs, dans les pays tropicaux ou à des altitudes supérieures à 2 000 m;

– les matériels destinés à être utilisés dans des endroits où la pénétration de l'eau est possible; pour connaître les lignes directrices et les essais applicables, se reporter à l'Annexe T.

NOTE Il convient également de noter que les autorités de certains pays imposent des exigences supplémentaires.

1.1.3 Exclusions

La présente norme ne s'applique pas:

– aux systèmes d'alimentation en énergie qui ne font pas partie intégrante du matériel, tels que groupes convertisseurs, batteries de secours et transformateurs de distribution;

– à l'installation électrique des bâtiments;

– aux dispositifs fonctionnant sans puissance électrique.

1.2 Définitions

Pour les besoins de la présente Norme internationale, les définitions suivantes s'appliquent. Lorsque les termes "tension" et "courant" sont utilisés, il s'agit, sauf spécification contraire, des valeurs efficaces.

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UTILISATEUR 1.2.13.6
VERROUILLAGE DE SECURITE 1.2.7.6
ZONE D'ACCES DE L'OPERATEUR 1.2.7.1
ZONE D'ACCES POUR LA MAINTENANCE 1.2.7.2

1.2.1 Caractéristiques électriques des matériels

1.2.1.1
TENSION ASSIGNEE
tension d'alimentation ~~(pour un RESEAU D'ALIMENTATION EN COURANT ALTERNATIF triphasée, tension entre phases)~~ à partir de laquelle le matériel doit être mis en fonctionnement, telle déclarée par le fabricant

1.2.1.2
PLAGE ASSIGNEE DE TENSIONS
plage de tensions d'alimentation déclarée par le fabricant, exprimée par les TENSIONS ASSIGNEES inférieure et supérieure

1.2.1.3
COURANT ASSIGNE
courant absorbé par le matériel, déclaré par le fabricant

1.2.1.4
FREQUENCE ASSIGNEE
fréquence d'alimentation déclarée par le fabricant

1.2.1.5
PLAGE ASSIGNEE DE FREQUENCES
plage de fréquences d'alimentation déclarée par le fabricant, exprimée par les FREQUENCES ASSIGNEES inférieure et supérieure

1.2.2 Conditions de fonctionnement

1.2.2.1
CHARGE NORMALE
mode de fonctionnement, utilisé à des fins d'essais, qui représente le plus fidèlement possible les conditions les plus sévères de fonctionnement normal qui peuvent être raisonnablement attendues

Si les conditions d'emploi réelles peuvent être à l'évidence plus sévères que les conditions de charge maximale recommandées par le fabricant, y compris la DUREE ASSIGNEE DE FONCTIONNEMENT et la DUREE ASSIGNEE DE REPOS, un mode de fonctionnement représentatif de ces conditions plus sévères est utilisé.

NOTE Les conditions de CHARGE NORMALE pour quelques types de matériels sont données à l'Annexe L.

1.2.2.2

DUREE ASSIGNEE DE FONCTIONNEMENT

durée de fonctionnement maximale assignée au matériel par le fabricant

1.2.2.3

DUREE ASSIGNEE DE REPOS

durée minimale, assignée par le fabricant, pendant laquelle le matériel est déconnecté ou fonctionne à vide entre des périodes de DUREE ASSIGNEE DE FONCTIONNEMENT

1.2.3 Mobilité des matériels

1.2.3.1

MATERIEL MOBILE

matériel qui est:

– soit de masse inférieure ou égale à 18 kg et non installé à poste fixe;
– soit équipé de roues, roulettes ou autres moyens qui en facilitent le déplacement par l'OPERATEUR lorsque cela est nécessaire pour assurer sa fonction

1.2.3.2

MATERIEL PORTATIF (A MAIN)

MATERIEL MOBILE, ou partie d'un matériel, qui est prévu pour être tenu à la main en usage normal

1.2.3.3

MATERIEL TRANSPORTABLE

MATERIEL MOBILE qui est destiné à être transporté de manière habituelle par un UTILISATEUR

NOTE Par exemple ordinateurs personnels portables, ordinateurs bloc-notes à stylet et leurs accessoires portables tels qu'imprimantes et lecteurs de CD-ROM.

1.2.3.4

MATERIEL FIXE

matériel qui n'est pas un MATERIEL MOBILE

1.2.3.5

MATERIEL A ENCASTRER

matériel destiné à être installé dans un logement prévu à cet effet, par exemple dans une paroi, ou dans des conditions analogues

NOTE En général, le MATERIEL A ENCASTRER n'a pas d'ENVELOPPE sur tous les côtés car certains côtés seront protégés après l'installation.

1.2.3.6

MATERIEL ENFICHABLE DIRECTEMENT

matériel destiné à être utilisé sans câble d'alimentation; la fiche de prise de courant forme une partie intégrante de l'ENVELOPPE du matériel si bien que le poids du matériel est supporté par le socle de prise de courant

1.2.4 Classes de matériels – Protection contre les chocs électriques

NOTE Certains matériels de traitement de l'information ne peuvent être identifiés comme conformes à l'une des classes suivantes.

1.2.4.1

MATERIEL DE LA CLASSE I

matériel dans lequel la protection contre les chocs électriques est obtenue

– au moyen d'une ISOLATION PRINCIPALE et aussi
– en fournissant un moyen de raccorder au CONDUCTEUR DE PROTECTION de l'installation du bâtiment les parties conductrices qui sont autrement capables d'être portées à des TENSIONS DANGEREUSES en cas de défaillance de l'ISOLATION PRINCIPALE

NOTE Le MATERIEL DE LA CLASSE I peut avoir des parties à DOUBLE ISOLATION ou à ISOLATION RENFORCEE.

1.2.4.2

APPAREIL DE LA CLASSE II

matériel dans lequel la protection contre les chocs électriques ne repose pas uniquement sur l'ISOLATION PRINCIPALE, mais dans lequel des précautions supplémentaires de sécurité ont été prises, telles qu'une ISOLATION DOUBLE ou une ISOLATION RENFORCEE, celles-ci ne dépendant pas de la mise à la terre de protection

1.2.4.3

APPAREIL DE LA CLASSE III

matériel dans lequel la protection contre les chocs électriques repose sur l'alimentation à partir de CIRCUITS TBTS et dans lequel ne sont pas engendrées de TENSIONS DANGEREUSES

NOTE Pour les MATERIELS DE LA CLASSE III, bien qu'il n'y ait pas d'exigences pour la protection contre les chocs électriques, toutes les autres exigences de la norme s'appliquent.

1.2.5 Raccordement au réseau

1.2.5.1

MATERIEL DU TYPE A RACCORDE PAR PRISE DE COURANT

matériel destiné à être relié à un RESEAU D'ALIMENTATION par une prise de courant et un socle de prise non industriels ou un connecteur non industriel ou les deux

1.2.5.2

MATERIEL DU TYPE B RACCORDE PAR PRISE DE COURANT

matériel destiné à être relié à un RESEAU D'ALIMENTATION par une prise de courant et un socle de prise industriels ou par un connecteur, ou par les deux, conformes à la CEI 60309 ou à une norme nationale similaire

1.2.5.3

MATERIEL ENFICHABLE

matériel qui est soit un MATERIEL DE TYPE A RACCORDE PAR PRISE DE COURANT soit un MATERIEL DE TYPE B RACCORDE PAR PRISE DE COURANT

1.2.5.4

MATERIEL RELIE A DEMEURE

matériel destiné à être relié à l'installation électrique des bâtiments au moyen de bornes à vis ou par d'autres moyens fiables

1.2.5.5

CABLE D'ALIMENTATION NON FIXE A DEMEURE

câble souple d'alimentation destiné à être relié au matériel par un connecteur approprié

1.2.5.6

CABLE D'ALIMENTATION FIXE A DEMEURE

câble souple d'alimentation fixé ou monté sur l'appareil

Ce câble peut être:

Ordinaire: câble souple qui peut être facilement remplacé sans préparation spéciale du câble ni l'aide d'OUTILS spéciaux; ou

Spécial: câble souple qui est spécialement préparé ou qui ne peut être remplacé sans dommage pour le matériel, ou dont le remplacement nécessite des OUTILS spécialement conçus.

L'expression «spécialement préparé» comprend, par exemple, la présence d'un dispositif de garde faisant partie intégrante du câble, l'utilisation de cosses, la confection d'œillets, etc., mais non la remise en forme d'un conducteur avant son introduction dans une borne ni le retoronnage des brins d'une âme câblée pour consolider l'extrémité.

1.2.6 Enveloppes

1.2.6.1
ENVELOPPE
partie du matériel assurant une ou plusieurs des fonctions décrites en 1.2.6.2, 1.2.6.3 ou 1.2.6.4

NOTE Une ENVELOPPE d'un type peut être incluse dans une ENVELOPPE d'un autre type, (par exemple une ENVELOPPE ELECTRIQUE dans une ENVELOPPE CONTRE LE FEU ou UNE ENVELOPPE CONTRE LE FEU dans une ENVELOPPE ELECTRIQUE). Une ENVELOPPE unique peut avoir plusieurs fonctions (par exemple les fonctions d'ENVELOPPE ELECTRIQUE et d'ENVELOPPE CONTRE LE FEU).

1.2.6.2
ENVELOPPE CONTRE LE FEU
partie d'un matériel destinée à minimiser l'extension du feu ou des flammes provenant de l'intérieur

1.2.6.3
ENVELOPPE MECANIQUE
partie du matériel destinée à réduire le risque de blessures dues à des dangers mécaniques ou autres dangers physiques

1.2.6.4
ENVELOPPE ELECTRIQUE
partie du matériel destinée à limiter l'accès à des parties qui peuvent être à des TENSIONS DANGEREUSES ou à des NIVEAUX D'ENERGIE DANGEREUX ou qui sont dans des CIRCUITS TRT

1.2.6.5
PARTIE DECORATIVE
partie du matériel, à l'extérieur de l'ENVELOPPE, qui n'a pas de fonction de sécurité

1.2.7 Accès

1.2.7.1
ZONE D'ACCES DE L'OPERATEUR
partie du matériel à laquelle, dans les conditions normales de fonctionnement, une des conditions suivantes s'applique:

- il est possible d'avoir accès sans l'aide d'un OUTIL;
- le moyen d'accès est délibérément fourni à l'OPERATEUR;
- l'OPERATEUR a des instructions pour accéder, qu'il ait besoin ou non d'un OUTIL pour le faire

Les termes «accès» et «accessible» sans qualificatif s'appliquent à la ZONE D'ACCES DE L'OPERATEUR telle qu'elle est définie ci-dessus.

1.2.7.2
ZONE D'ACCES POUR LA MAINTENANCE
partie du matériel, autre qu'une ZONE D'ACCES DE L'OPERATEUR, à laquelle il est nécessaire que le PERSONNEL DE MAINTENANCE ait accès même lorsque le matériel est sous tension

1.2.7.3
EMPLACEMENT A ACCES RESTREINT
emplacement pour le matériel dans lequel les deux alinéas suivants s'appliquent:

- l'accès n'est possible qu'au PERSONNEL DE MAINTENANCE et aux UTILISATEURS qui ont reçu des instructions au sujet des raisons pour lesquelles il y a des restrictions d'accès à l'emplacement et au sujet des précautions qui doivent être prises; et
- l'accès nécessite l'usage d'un OUTIL ou d'un verrou avec une clé, ou de tout autre moyen de sécurité, et il est contrôlé par l'autorité responsable de l'emplacement

NOTE Les exigences pour les matériels destinés à être installés dans des EMPLACEMENTS A ACCES RESTREINT sont les mêmes que pour les ZONES D'ACCES DE L'OPERATEUR à l'exception de ce qui est indiqué en 1.7.14, 2.1.3, 4.5.4, 4.6.2 et 5.1.7.

1.2.7.4
OUTIL

tournevis ou tout autre objet qui peut être utilisé pour manœuvrer une vis, un loquet ou des moyens de fixation similaires

1.2.7.5
MASSE

toutes les parties conductrices accessibles, les axes des poignées, boutons, manettes et organes analogues, et une feuille métallique en contact avec toutes les surfaces accessibles en matière isolante

1.2.7.6
VERROUILLAGE DE SECURITE

moyen d'empêcher l'accès à une partie dangereuse jusqu'à suppression du danger, ou de supprimer automatiquement la condition dangereuse en cas d'accès

1.2.8 Circuits et caractéristiques des circuits

1.2.8.1
RESEAU D'ALIMENTATION EN COURANT ALTERNATIF

système extérieur de distribution de l'alimentation en courant alternatif alimentant les matériels en courant alternatif

Ces sources de courant comprennent les alimentations publiques ou privées et, sauf indication contraire dans la norme (par exemple 1.4.5), des sources équivalentes telles que des motogénérateurs et des alimentations sans interruption.

NOTE Voir l'Annexe V pour des exemples typiques de systèmes de distribution de l'alimentation en courant alternatif.

1.2.8.2
RESEAU D'ALIMENTATION EN COURANT CONTINU

système de distribution de l'alimentation en courant continu extérieur au matériel, équipé ou non de batteries, fournissant l'alimentation en courant continu au matériel, à l'exclusion de ce qui suit:

- des sources à courant continu fournissant l'énergie par le câblage du RESEAU DE TELECOMMUNICATIONS à un matériel distant;
- des sources à puissance limitée (voir 2.5) dont la tension en circuit ouvert est inférieure ou égale à 42,4 V en courant continu;
- des sources à courant continu dont la tension en circuit ouvert est supérieure à 42,4 V et inférieure ou égale à 60 V et dont la puissance disponible est inférieure à 240 VA

Les circuits connectés à un RESEAU D'ALIMENTATION EN COURANT CONTINU sont considérés comme des CIRCUITS SECONDAIRES au sens de cette norme (par exemple un CIRCUIT TBTS, un CIRCUIT TRT ou un CIRCUIT SECONDAIRE A TENSION DANGEREUSE).

NOTE Voir la Recommandation UIT-T K.27 pour les configurations de liaisons équipotentielles et de mise à la terre dans les bâtiments de télécommunications.

1.2.8.3
RESEAU D'ALIMENTATION

système de distribution de l'alimentation qui est soit un RESEAU D'ALIMENTATION EN COURANT ALTERNATIF soit un RESEAU D'ALIMENTATION EN COURANT CONTINU

1.2.8.4
CIRCUIT PRIMAIRE

circuit qui est directement connecté au RESEAU D'ALIMENTATION EN COURANT ALTERNATIF

Cela comprend, par exemple, les moyens de connexion au RESEAU D'ALIMENTATION EN COURANT ALTERNATIF, les enroulements primaires des transformateurs, les moteurs et les autres dispositifs absorbant de l'énergie.

NOTE Les parties conductrices d'un CABLE D'INTERCONNEXION peuvent faire partie d'un CIRCUIT PRIMAIRE comme indiqué en 1.2.11.6.

1.2.8.5
CIRCUIT SECONDAIRE
circuit qui n'est pas relié directement à un CIRCUIT PRIMAIRE et qui est alimenté par l'intermédiaire d'un transformateur, d'un convertisseur ou d'un dispositif d'isolement équivalent ou par l'intermédiaire d'une batterie

NOTE Les parties conductrices d'un CABLE D'INTERCONNEXION peuvent faire partie d'un CIRCUIT SECONDAIRE comme indiqué en 1.2.11.6.

1.2.8.6
TENSION DANGEREUSE
tension supérieure à 42,4 V en valeur de crête ou à 60 V en tension continue, présente dans un circuit non conforme aux exigences relatives soit à un CIRCUIT A LIMITATION DE COURANT, soit à un CIRCUIT TRT

1.2.8.7
CIRCUIT TBT
CIRCUIT SECONDAIRE avec des tensions entre deux conducteurs quelconques du circuit, et entre un tel conducteur et la terre (voir 1.4.9), ne dépassant pas 42,4 V en valeur de crête ou 60 V en tension continue, dans les conditions normales de fonctionnement, qui est séparé des TENSIONS DANGEREUSES par une ISOLATION PRINCIPALE, et qui n'est ni conforme à toutes les exigences pour un CIRCUIT TBTS ni conforme à toutes les exigences pour les CIRCUITS A LIMITATION DE COURANT

1.2.8.8
CIRCUIT TBTS
CIRCUIT SECONDAIRE conçu et protégé de telle manière que, dans des conditions normales et dans des conditions de premier défaut, les tensions ne soient pas supérieures à une valeur sûre

NOTE 1 Les valeurs limites des tensions en fonctionnement normal et dans des conditions de premier défaut (voir 1.4.14) sont spécifiées en 2.2. Voir aussi le Tableau 1A.

NOTE 2 Cette définition du CIRCUIT TBTS diffère du terme «système TBTS» tel qu'il est utilisé dans la CEI 61140.

1.2.8.9
CIRCUIT A LIMITATION DE COURANT
circuit conçu et protégé de façon que, en fonctionnement normal et dans des conditions de premier défaut, le courant que peut débiter la source ne soit pas dangereux

NOTE Les valeurs limites des courants en fonctionnement normal et dans des conditions de premier défaut (voir 1.4.14) sont spécifiées en 2.4.

1.2.8.10
NIVEAU D'ENERGIE DANGEREUX
niveau de puissance disponible supérieur ou égal à 240 VA pour une durée supérieure ou égale à 60 s, ou niveau de l'énergie emmagasinée supérieur ou égal à 20 J (par exemple à partir d'un ou plusieurs condensateurs), à un potentiel supérieur ou égal à 2 V

1.2.8.11
CIRCUIT TRT
circuit qui est dans le matériel et dont la surface de contact accessible est limitée et qui est conçu et protégé de telle manière que, dans les conditions normales de fonctionnement et dans les conditions de premier défaut (voir 1.4.14), les tensions ne dépassent pas les valeurs limites spécifiées

Un CIRCUIT TRT est considéré comme étant un CIRCUIT SECONDAIRE au sens de la présente norme.

NOTE 1 Les valeurs limites spécifiées des tensions dans les conditions normales de fonctionnement et dans les conditions de premier défaut (voir 1.4.14) sont données en 2.3.1. Les exigences concernant l'accessibilité aux CIRCUITS TRT sont données en 2.1.1.1.

NOTE 2 Les parties conductrices d'un CABLE D'INTERCONNEXION peuvent faire partie d'un CIRCUIT TRT comme indiqué en 1.2.11.6.

Les CIRCUITS TRT sont classés comme CIRCUITS TRT-1, CIRCUITS TRT-2 et CIRCUITS TRT-3 comme défini en 1.2.8.12, 1.2.8.13 et 1.2.8.14.

NOTE 3 Les relations de tension entre les CIRCUITS TBTS et TRT sont indiquées dans le Tableau 1A.

Tableau 1A – Plages de tensions des circuits TBTS et TRT

		Tensions normales de fonctionnement	
Surtensions venant des RESEAUX DE TELECOMMUNICATIONS possibles ?	**Surtensions venant des SYSTEMES DE DISTRIBUTION PAR CABLES possibles ?**	**A l'intérieur des limites des CIRCUITS TBTS**	**Dépassant les limites des CIRCUITS TBTS mais à l'intérieur des limites des CIRCUITS TRT**
Oui	Oui	CIRCUIT TRT-1	CIRCUIT TRT-3
Non	Non applicable	CIRCUIT TBTS	CIRCUIT TRT-2

1.2.8.12
CIRCUIT TRT-1

CIRCUIT TRT

- dont les tensions normales de fonctionnement ne dépassent pas les limites pour un CIRCUIT TBTS dans les conditions normales de fonctionnement et
- sur lequel des surtensions venant des réseaux de télécommunications et des systèmes de distribution par câbles sont possibles

1.2.8.13
CIRCUIT TRT-2

CIRCUIT TRT

- dont les tensions normales de fonctionnement dépassent les limites pour un CIRCUIT TBTS dans les conditions normales de fonctionnement et
- qui n'est pas sujet à des surtensions venant des RESEAUX DE TELECOMMUNICATIONS

1.2.8.14
CIRCUIT TRT-3

CIRCUIT TRT

- dont les tensions normales de fonctionnement dépassent les limites pour un CIRCUIT TBTS dans les conditions normales de fonctionnement et
- sur lequel des surtensions venant des réseaux de télécommunications et des systèmes de distribution par câbles sont possibles

1.2.9 Isolation

1.2.9.1
ISOLATION FONCTIONNELLE

isolation nécessaire seulement pour le fonctionnement correct du matériel

NOTE L'ISOLATION FONCTIONNELLE, par définition, ne protège pas contre les chocs électriques. Elle peut cependant minimiser l'exposition à l'inflammation ou au feu.

1.2.9.2
ISOLATION PRINCIPALE

isolation pour assurer la protection principale contre les chocs électriques

1.2.9.3

ISOLATION SUPPLEMENTAIRE

isolation indépendante appliquée en plus de l'ISOLATION PRINCIPALE afin de réduire le risque de choc électrique en cas de défaut survenant dans l'ISOLATION PRINCIPALE

1.2.9.4

DOUBLE ISOLATION

isolation comprenant à la fois une ISOLATION PRINCIPALE et une ISOLATION SUPPLEMENTAIRE

1.2.9.5

ISOLATION RENFORCEE

système d'isolation unique qui procure, dans les conditions spécifiées dans la présente norme, un degré de protection contre les chocs électriques équivalant à une DOUBLE ISOLATION

NOTE L'expression «système d'isolation» n'implique pas que l'isolation doit être homogène. Elle peut comprendre plusieurs couches qui ne peuvent pas être essayées séparément comme une ISOLATION PRINCIPALE et une ISOLATION SUPPLEMENTAIRE.

1.2.9.6

TENSION DE SERVICE

tension maximale à laquelle sont, ou peuvent être soumis l'isolation ou le composant considérés lorsque le matériel est alimenté dans les conditions d'utilisation normale

Les surtensions dont l'origine est à l'extérieur du matériel ne sont pas prises en compte.

1.2.9.7

TENSION DE SERVICE EFFICACE

valeur efficace de la TENSION DE SERVICE, y compris toute composante continue

NOTE Pour la détermination de la TENSION DE SERVICE EFFICACE, ce sont les règles de 2.10.2.2 qui s'appliquent et, le cas échéant, celles de 1.4.8.

1.2.9.8

TENSION DE SERVICE CRETE

valeur de crête de la tension de service, y compris toute composante continue et toute impulsion de crête répétitive générée dans le matériel

Lorsque l'ondulation de crête à crête dépasse 10 % de la valeur moyenne, les exigences relatives aux tensions de crête et alternatives sont applicables.

NOTE Pour la détermination des TENSIONS DE SERVICE DE CRETE, ce sont les règles de 2.10.2.3 qui s'appliquent et, le cas échéant, celles de 1.4.8.

1.2.9.9

TENSION DE TENUE PRESCRITE

tension de crête que l'isolation considérée doit supporter

1.2.9.10

TENSION TRANSITOIRE SUR LE RESEAU

valeur la plus élevée de la tension de crête prévisible à l'entrée du matériel, provenant de transitoires externes sur le RESEAU D'ALIMENTATION

1.2.9.11

TENSION TRANSITOIRE SUR LE RESEAU DE TELECOMMUNICATIONS

valeur la plus élevée de la tension de crête prévisible à l'entrée RESEAU DE TELECOMMUNICATIONS du matériel, provenant de transitoires externes sur le réseau

NOTE L'effet des transitoires provenant des SYSTEMES DE DISTRIBUTION PAR CABLES n'est pas pris en compte.

1.2.10 Propriétés de l'isolation

1.2.10.1
DISTANCE DANS L'AIR
plus petite distance entre deux parties conductrices, ou entre une partie conductrice et la SURFACE FRONTIERE du matériel, mesurée dans l'air

1.2.10.2
LIGNE DE FUITE
plus petite distance entre deux parties conductrices, ou entre une partie conductrice et la SURFACE FRONTIÈRE du matériel, mesurée le long de la surface de l'isolant

1.2.10.3
SURFACE FRONTIERE
surface externe de l'ENVELOPPE ELECTRIQUE considérée comme si une feuille de métal était appliquée sur les surfaces accessibles en matière isolante

1.2.10.4
ISOLATION SOLIDE
matériau qui assure une isolation électrique entre deux surfaces opposées, pas le long d'une surface extérieure

NOTE Les propriétés requises pour l'ISOLATION SOLIDE sont spécifiées soit comme

– la distance minimale réelle à travers l'isolation (voir 2.10.5.2), soit par
– d'autres exigences et essais dans la présente norme à la place d'une distance minimale.

1.2.11 Composants

1.2.11.1
THERMOSTAT
dispositif de commande thermosensible à action cyclique destiné à maintenir une température entre deux valeurs particulières dans les conditions normales de fonctionnement et qui peut être prévu pour être réglé par l'OPERATEUR

1.2.11.2
LIMITEUR DE TEMPERATURE
dispositif de commande thermosensible destiné à maintenir une température en dessous ou au-dessus d'une valeur particulière dans les conditions de fonctionnement normal et qui peut être prévu pour être réglé par l'OPERATEUR

NOTE Un LIMITEUR DE TEMPERATURE peut être à réenclenchement automatique ou à réenclenchement manuel.

1.2.11.3
COUPE-CIRCUIT THERMIQUE
dispositif de commande thermosensible destiné à fonctionner dans les conditions de fonctionnement anormal et dont le réglage ne peut pas être effectué par l'OPERATEUR

NOTE Un COUPE-CIRCUIT THERMIQUE peut être à réenclenchement automatique ou à réenclenchement manuel.

1.2.11.4
COUPE-CIRCUIT THERMIQUE A REENCLENCHEMENT AUTOMATIQUE
COUPE-CIRCUIT THERMIQUE qui rétablit automatiquement le courant après que la partie correspondante du matériel s'est suffisamment refroidie

1.2.11.5
COUPE-CIRCUIT THERMIQUE A REENCLENCHEMENT MANUEL
COUPE-CIRCUIT THERMIQUE qui nécessite un réenclenchement manuel, ou le remplacement d'un élément, pour le rétablissement du courant

1.2.11.6
CABLE D'INTERCONNEXION
câble utilisé pour

– connecter électriquement un accessoire à une unité du matériel de traitement de l'information,
– interconnecter des unités à l'intérieur d'un système, ou
– connecter une unité à un RÉSEAU DE TÉLÉCOMMUNICATIONS ou à un SYSTEME DE DISTRIBUTION PAR CABLES

Un tel câble peut transporter n'importe quel type de circuit d'une unité à une autre.

NOTE Un cordon d'alimentation utilisé pour la connexion au réseau d'alimentation n'est pas un CABLE D'INTERCONNEXION.

1.2.12 Inflammabilité

1.2.12.1
CLASSIFICATION DES MATERIAUX VIS-A-VIS DE L'INFLAMMABILITE
moyens de reconnaître le comportement des matériaux vis-à-vis de la combustion et leur capacité à s'éteindre s'ils sont enflammés

Les matériaux sont classés comme indiqué de 1.2.12.2 à 1.2.12.14, lorsqu'ils sont essayés conformément aux normes suivantes: CEI 60695-11-10, CEI 60695-11-20, ISO 9772 ou ISO 9773

NOTE 1 Lors de l'application des exigences de la présente norme, les MATERIAUX PLASTIQUES CELLULAIRES de CLASSE HF-1 sont considérés comme meilleurs que ceux de CLASSE HF-2 et les MATERIAUX de CLASSE HF-2 meilleurs que ceux de CLASSE HBF.

NOTE 2 De même, le MATERIAU de CLASSE 5VA est considéré comme meilleur que celui de CLASSE 5VB, les MATERIAUX de CLASSE 5VB meilleurs que ceux de CLASSE V-0, les MATERIAUX de CLASSE V0 meilleurs que ceux de CLASSE V-1, les MATERIAUX de CLASSE V-1 meilleurs que ceux de CLASSE V-2, LES MATERIAUX de CLASSE V-2 meilleurs que ceux de classe HB40 et LES MATERIAUX de CLASSE HB40 meilleurs que ceux de classe HB75.

NOTE 3 De même, les MATERIAUX de CLASSE VTM-0 sont considérés comme meilleurs que ceux de CLASSE VTM-1 et ceux de CLASSE VTM-1 meilleurs que ceux de CLASSE VTM-2.

NOTE 4 Les matériaux de CLASSE D'INFLAMMABILITE VTM-0, VTM-1 et VTM-2 sont considérés comme équivalents aux matériaux de CLASSE D'INFLAMMABILITE V-0, V-1 et V-2 respectivement, mais uniquement pour leurs propriétés d'inflammabilité. Leurs propriétés électriques et mécaniques ne sont pas nécessairement équivalentes.

NOTE 5 Certaines classes d'inflammabilité ont remplacé les classes utilisées dans les éditions précédentes de cette norme. Les équivalences entre les anciennes classes et les nouvelles classes sont données dans le Tableau 1B.

Tableau 1B – Equivalence entre classes d'inflammabilité

Ancienne classe	Nouvelle classe	Equivalence
–	5VA (1.2.12.5)	La classe 5VA n'est pas demandée dans cette norme.
5V	5VB (1.2.12.6)	Les matériaux qui satisfont aux essais pour la classe 5V de l'Article A.9 des éditions précédentes de cette norme sont équivalents à ceux de la classe 5VB ou sont meilleurs.
HB	HB40 (1.2.12.10)	Les échantillons des matériaux d'une épaisseur de 3 mm qui satisfont aux essais de l'Article A.8 des éditions précédentes de cette norme (propagation maximale de la flamme de 40 mm/min, pendant l'essai) sont équivalents à la classe HB40.
	HB75 (1.2.12.11)	Les échantillons des matériaux d'une épaisseur de 3 mm qui satisfont aux essais de l'Article A.8 des éditions précédentes de cette norme (propagation maximale de la flamme de 75 mm/min, pendant l'essai) sont équivalents à la classe HB75.

1.2.12.2
MATERIAU DE CLASSE V-0
matériau essayé dans la plus faible épaisseur significative utilisée et classé V-0 selon la CEI 60695-11-10

1.2.12.3
MATERIAU DE CLASSE V-1
matériau essayé dans la plus faible épaisseur significative utilisée et classé V-1 selon la CEI 60695-11-10

1.2.12.4
MATERIAU DE CLASSE V-2
matériau essayé dans la plus faible épaisseur significative utilisée et classé V-2 selon la CEI 60695-11-10

1.2.12.5
MATERIAU DE CLASSE 5VA
matériau essayé dans la plus faible épaisseur significative utilisée et classé 5VA selon la CEI 60695-11-20

1.2.12.6
MATERIAU DE CLASSE 5VB
matériau essayé dans la plus faible épaisseur significative utilisée et classé 5VB selon la CEI 60695-11-20

1.2.12.7
MATERIAU PLASTIQUE CELLULAIRE DE CLASSE HF-1
matériau essayé dans la plus faible épaisseur significative utilisée et classé HF-1 selon l'ISO 9772

1.2.12.8
MATERIAU PLASTIQUE CELLULAIRE DE CLASSE HF-2
matériau essayé dans la plus faible épaisseur significative utilisée et classé HF-2 selon l'ISO 9772

1.2.12.9
MATERIAU PLASTIQUE CELLULAIRE DE CLASSE HBF
matériau essayé dans la plus faible épaisseur significative utilisée et classé HBF selon l'ISO 9772

1.2.12.10
MATERIAU DE CLASSE HB40
matériau essayé dans la plus faible épaisseur significative utilisée et classé HB40 selon la CEI 60695-11-10

1.2.12.11
MATERIAU DE CLASSE HB75
matériau essayé dans la plus faible épaisseur significative utilisée et classé HB75 selon la CEI 60695-11-10

1.2.12.12
MATERIAU DE CLASSE VTM-0
matériau essayé dans la plus faible épaisseur significative utilisée et classé VTM-0 selon l'ISO 9773

1.2.12.13
MATERIAU DE CLASSE VTM-1
matériau essayé dans la plus faible épaisseur significative utilisée et classé VTM-1 selon l'ISO 9773

1.2.12.14
MATERIAU DE CLASSE VTM-2
matériau essayé dans la plus faible épaisseur significative utilisée et classé VTM-2 selon l'ISO 9773

1.2.12.15
LIMITE D'EXPLOSION
plus faible concentration d'une matière combustible dans un mélange contenant: des gaz, des vapeurs, des brouillards ou des poussières, dans lequel une flamme est capable de se propager après enlèvement de la source d'inflammation

1.2.13 Divers

1.2.13.1
ESSAI DE TYPE
essai effectué sur un échantillon représentatif du matériel pour déterminer si ce matériel, tel qu'il est conçu et fabriqué, peut satisfaire aux exigences de la présente norme

1.2.13.2
ESSAI SUR PRELEVEMENT
essai effectué sur un certain nombre d'échantillons prélevés de manière aléatoire dans un lot

1.2.13.3
ESSAI INDIVIDUEL DE SERIE
essai auquel chaque échantillon est soumis en cours ou en fin de fabrication pour s'assurer qu'il satisfait à certains critères

1.2.13.4
TENSION CONTINUE
valeur moyenne d'une tension ayant une ondulation de crête à crête ne dépassant pas 10 % de la valeur moyenne

NOTE Lorsque l'ondulation de crête à crête dépasse 10 % de la valeur moyenne, les exigences relatives à la tension de crête sont applicables.

1.2.13.5
PERSONNEL DE MAINTENANCE
personne ayant une formation technique appropriée et l'expérience nécessaire pour être consciente des dangers auxquels elle peut être exposée en effectuant une tâche et des mesures à prendre pour minimiser les risques pour elle-même ou d'autres personnes

1.2.13.6
UTILISATEUR
toute personne autre que le PERSONNEL DE MAINTENANCE

Le terme UTILISATEUR dans la présente norme est le même que le terme OPERATEUR et les deux termes peuvent s'utiliser indifféremment.

1.2.13.7
OPERATEUR
voir UTILISATEUR (1.2.13.6).

1.2.13.8

RESEAU DE TELECOMMUNICATIONS

moyen de transmission à terminaison métallique destiné à la communication entre matériels qui peuvent être placés dans des bâtiments différents, à l'exclusion:

- des réseaux de production, transport et distribution de l'énergie électrique utilisés comme vecteur de transmission pour les télécommunications;
- des systèmes de distribution par câbles;
- des CIRCUITS TBTS connectant les unités d'un matériel de traitement de l'information

NOTE 1 L'expression RESEAU DE TELECOMMUNICATIONS est définie en termes de sa fonctionnalité, non de ses caractéristiques électriques. Un RESEAU DE TELECOMMUNICATIONS n'est pas lui-même défini comme étant soit un CIRCUIT TBTS soit un CIRCUIT TRT. Seuls les circuits à l'intérieur du matériel sont classés ainsi.

NOTE 2 Un RESEAU DE TELECOMMUNICATIONS peut être:

- public ou privé;
- soumis à des surtensions transitoires dues à des décharges atmosphériques et à des défauts dans les systèmes de distribution de l'énergie;
- soumis à des tensions longitudinales (mode commun) induites par les lignes d'énergie ou les lignes de traction électrique dans le voisinage.

NOTE 3 Exemples de RESEAUX DE TELECOMMUNICATIONS:

- un réseau téléphonique public commuté;
- un réseau de données public;
- un Réseau Numérique à Intégration de Services (RNIS);
- un réseau privé avec des caractéristiques d'interface électriques similaires à celles des réseaux ci-dessus.

1.2.13.9

MISE A LA TERRE FONCTIONNELLE

mise à la terre d'un point d'un matériel ou d'un système, nécessaire dans un autre but que la sécurité

1.2.13.10

CONDUCTEUR DE MISE A LA TERRE DE PROTECTION

conducteur dans l'installation de câblage du bâtiment, ou dans le câble d'alimentation électrique, reliant la borne principale de mise à la terre de protection du matériel à un point de terre du bâtiment

NOTE Dans certains pays, le terme «conducteur de terre» est utilisé au lieu de «CONDUCTEUR DE MISE A LA TERRE DE PROTECTION».

1.2.13.11

CONDUCTEUR DE LIAISON A LA TERRE DE PROTECTION

conducteur dans le matériel, ou une combinaison de parties conductrices du matériel, reliant la borne principale de mise à la terre de protection à une partie du matériel qu'il est nécessaire de mettre à la terre pour des raisons de sécurité

1.2.13.12

COURANT DE CONTACT

courant électrique traversant le corps humain lorsqu'il est en contact avec une ou plusieurs parties accessibles

NOTE Le COURANT DE CONTACT était précédemment inclus dans le terme «courant de fuite».

1.2.13.13

COURANT DANS LE CONDUCTEUR DE PROTECTION

courant circulant dans le CONDUCTEUR DE MISE A LA TERRE DE PROTECTION dans les conditions d'utilisation normale

NOTE Le COURANT DANS LE CONDUCTEUR DE PROTECTION était précédemment inclus dans le terme «courant de fuite».

1.2.13.14
SYSTEMES DE DISTRIBUTION PAR CABLES
moyen de transmission à terminaison métallique utilisant du câble coaxial principalement destiné à la transmission des signaux vidéo et/ou audio entre des bâtiments séparés ou entre une antenne extérieure et des bâtiments, à l'exclusion:

– des systèmes d'alimentation, de transmission et de distribution du réseau électrique, s'ils sont utilisés comme vecteur de transmission de communication;
– des RESEAUX DE TELECOMMUNICATIONS;
– des CIRCUITS TBTS connectant les unités d'un matériel de traitement de l'information

NOTE 1 Exemples de SYSTEMES DE DISTRIBUTION PAR CABLES:

– des réseaux câblés locaux, par exemple des systèmes de réseaux communautaires de télévision et des systèmes d'antennes collectives fournissant une distribution de signaux audio et vidéo;
– des antennes extérieures, y compris les paraboles satellites, les antennes de réception et d'autres dispositifs similaires.

NOTE 2 Les SYSTEMES DE DISTRIBUTION PAR CABLES peuvent être soumis à des transitoires plus importants que ceux des RESEAUX DE TELECOMMUNICATIONS (voir 7.4.1)

1.2.13.15
ETAMINE
tissu de coton blanchi d'environ 40 g/m^2

1.2.13.16
PAPIER MOUSSELINE
papier d'emballage mince, souple et résistant de grammage compris généralement entre 12 g/m^2 et 30 g/m^2, essentiellement destiné à l'emballage, à la protection ou à la présentation des objets fragiles et des cadeaux

[ISO 4046-4:2002, définition 4.215]

1.2.13.17
CARACTERISTIQUES ASSIGNEES DU COURANT DE PROTECTION
caractéristiques assignées d'un dispositif de protection contre les intensités qui est en place ou réputé être en place pour protéger un circuit

NOTE Les règles de détermination de la valeur des CARACTERISTIQUES ASSIGNEES DU COURANT DE PROTECTION sont données en 2.6.3.3.

1.2.13.18
DECHIQUETEUSE (DOCUMENTS/SUPPORTS, A USAGE DOMESTIQUE ET DE BUREAU/MAISON)
matériel avec une configuration de prise de courant associée à un MATERIEL DE TYPE A RACCORDE PAR PRISE DE COURANT, ou matériel fonctionnant sur batterie, destiné à déchiqueter le papier ou autres formes de supports selon les instructions du fabricant

NOTE 1 Les exemples d'autres formes de supports comprennent – sans que cela soit exhaustif – les disques vidéonumériques, les disques compacts, les mémoires flash, les cartes à bande magnétique, les disques magnétiques ou éléments similaires.

NOTE 2 Les DECHIQUETEUSES DE DOCUMENTS/SUPPORTS A USAGE DOMESTIQUE ET DE MAISON/BUREAU sont classiquement identifiées comme étant soit à coupe en bandes, soit à coupe croisée. Une DECHIQUETEUSE DE DOCUMENTS/SUPPORTS A USAGE DOMESTIQUE ET DE BUREAU/MAISON à coupe en bandes déchiquette le papier en longues bandes à l'aide d'un mécanisme déchiqueteur à moteur. Une DECHIQUETEUSE DE DOCUMENTS/SUPPORTS à coupe croisée déchiquette le papier de deux ou plusieurs façons en minuscules particules, classiquement à l'aide d'un moteur plus puissant et d'un mécanisme déchiqueteur plus complexe.

NOTE 3 Une déchiqueteuse de documents/supports est considérée comme n'étant pas à usage domestique ou comme n'étant pas de bureau/maison si la déchiqueteuse de documents/supports est pourvue d'une configuration de prise de courant associée à un MATERIEL DE TYPE B RACCORDE PAR PRISE DE COURANT, ou est un MATERIEL RELIE A DEMEURE.

1.3 Exigences générales

1.3.1 Application des exigences

Les exigences détaillées dans la présente norme ne doivent s'appliquer que si la sécurité est impliquée.

Afin d'établir si la sécurité est impliquée ou non, les circuits et la construction doivent être soigneusement analysés, afin de tenir compte des conséquences des défaillances possibles.

1.3.2 Conception et construction du matériel

Le matériel doit être conçu et construit de façon que, dans toutes les conditions d'utilisation normale ou dans des conditions de premier défaut (voir 1.4.14) ou d'emploi anormal vraisemblable, la protection soit assurée pour réduire les risques de blessures aux personnes provoqués par un choc électrique ou par tout autre danger, et contre l'extension de feux prenant naissance à l'intérieur du matériel.

La vérification est effectuée par examen et par les essais applicables.

1.3.3 Tension d'alimentation

Le matériel doit être conçu pour être sûr à toutes les tensions auxquelles il est destiné à être relié.

La vérification est effectuée par examen et par les essais applicables de la présente norme en utilisant une tension d'alimentation telle que spécifiée dans le paragraphe correspondant. Si le paragraphe ne spécifie par de tension d'alimentation (explicitement ou par référence à 1.4.5), alors la valeur de la TENSION ASSIGNEE *ou toute valeur dans la* PLAGE ASSIGNEE DE TENSIONS *doit être utilisée.*

1.3.4 Constructions non spécifiquement couvertes

Lorsque le matériel implique des technologies et des matériaux ou des méthodes de construction qui ne sont pas spécifiquement couverts dans cette norme, le matériel doit procurer un niveau de sécurité au moins égal au niveau généralement garanti par la présente norme et les principes de sécurité qu'elle contient.

NOTE Il convient de porter rapidement à l'attention du comité compétent le besoin en exigences supplémentaires détaillées pour faire face à une situation nouvelle.

1.3.5 Matériaux équivalents

Lorsque la norme spécifie une isolation d'un niveau particulier, l'utilisation d'une isolation d'un niveau supérieur est permise. De la même façon, lorsque la norme prescrit un matériau d'une CLASSE D'INFLAMMABILITE particulière, l'utilisation d'une classe ayant de meilleures performances est permise.

1.3.6 Orientation pendant le transport et l'utilisation

Lorsqu'il est clair que l'orientation du matériel est susceptible d'avoir une influence significative sur l'application des exigences ou sur les résultats des essais, toutes les orientations en fonctionnement autorisées dans les instructions d'installation ou le mode d'emploi doivent être prises en compte. Pour un MATERIEL TRANSPORTABLE, toutes les orientations pour le transport et l'utilisation doivent être prises en compte.

NOTE Le texte ci-dessus est applicable pour 4.1, 4.2, 4.3.8, 4.5, 4.6 et 5.3.

1.3.7 Choix des critères

Quand la norme autorise un choix entre différents critères de conformité, ou entre différentes méthodes ou conditions d'essai, le choix est spécifié par le fabricant.

1.3.8 Exemples cités dans la norme

Quand des exemples de matériels, pièces détachées, méthodes de construction, techniques de conception et défauts sont donnés dans la norme, et qu'ils sont précédés de «par exemple» ou «tel que», d'autres exemples de situations et de solutions ne sont pas exclus.

1.3.9 Liquides conducteurs

Pour les exigences électriques de la présente norme, les liquides conducteurs doivent être traités comme des parties conductrices.

1.4 Conditions générales d'essai

1.4.1 Application des essais

Les essais détaillés dans la présente norme ne doivent s'appliquer que si la sécurité est impliquée.

Si la conception et la construction du matériel montrent de façon évidente qu'un essai particulier n'est pas applicable, cet essai n'est pas effectué.

Sauf indication contraire, il n'est pas nécessaire que le matériel soit en état de fonctionner à l'issue des essais.

1.4.2 Essais de type

Sauf indication contraire, les essais spécifiés dans la présente norme sont des ESSAIS DE TYPE.

1.4.3 Echantillons d'essai

Sauf indication contraire, l'échantillon ou les échantillons à l'essai doivent être représentatifs du matériel que l'UTILISATEUR recevrait ou doivent être le véritable matériel prêt à être expédié à l'UTILISATEUR.

Comme variante à l'exécution des essais sur le matériel complet, des essais peuvent être effectués séparément sur des circuits, des composants ou des sous-ensembles à l'extérieur du matériel, à condition qu'un examen du matériel et des dispositions des circuits montre que le résultat de tels essais sera représentatif des résultats de l'essai du matériel assemblé. Si l'un quelconque de ces essais montre qu'il y a un risque de non-conformité dans le matériel complet, l'essai doit être répété dans le matériel.

Si un essai spécifié dans la présente norme risque d'être destructif, il est permis d'utiliser un modèle pour représenter la condition à évaluer.

NOTE 1 Il convient d'effectuer les essais dans l'ordre suivant:

- présélection des composants et des matériaux;
- essais au banc des composants et des sous-ensembles;
- essais pour lesquels le matériel n'est pas mis sous tension;
- essais sous tension:
  - dans les conditions normales de fonctionnement;
  - dans les conditions de fonctionnement anormal;
  - risquant de provoquer une destruction.

NOTE 2 Compte tenu de l'importance des frais engagés dans les essais et afin de minimiser le gaspillage, l'étude du programme d'essais, des échantillons et des séquences d'essais par toutes les parties concernées est recommandée.

1.4.4 Paramètres de fonctionnement pour les essais

A moins que des conditions particulières d'essais ne soient indiquées ailleurs dans la présente norme, et lorsqu'il est clair que cela a un impact significatif sur les résultats de l'essai, les essais doivent être effectués suivant la combinaison la plus défavorable des paramètres suivants, dans les limites des spécifications de fonctionnement du fabricant:

– tension d'alimentation; (voir 1.4.5);
– fréquence d'alimentation; (voir 1.4.6);
– température de fonctionnement (voir 1.4.12);
– emplacement physique du matériel et position des parties mobiles;
– mode de fonctionnement;
– réglage des THERMOSTATS, des dispositifs de régulation ou des dispositifs de commande similaires situés dans les ZONES D'ACCÈS DE L'OPÉRATEUR et qui sont:
– réglables sans l'aide d'un OUTIL, ou
– réglables par un moyen tel qu'une clé ou un OUTIL délibérément fourni à l'OPERATEUR.

1.4.5 Tension d'alimentation pour les essais

En déterminant la tension la plus défavorable pour l'alimentation d'un matériel pour un essai, il doit être tenu compte des variables suivantes:

– tensions assignées multiples;
– tolérances sur la TENSION ASSIGNEE comme indiqué ci-dessous;
– limites des plages assignées de tensions.

Si le matériel est prévu pour une connexion directe à un RESEAU D'ALIMENTATION EN COURANT ALTERNATIF, les valeurs de +6 % et –10 % doivent être prises comme tolérances sur la TENSION ASSIGNEE, à moins que:

– la TENSION ASSIGNEE soit 230 V en monophasé ou 400 V en triphasé, auquel cas la tolérance doit être prise comme +10 % et –10 %; ou
– une tolérance plus large soit déclarée par le fabricant, auquel cas la tolérance doit être prise comme cette valeur plus large.

Si le matériel est prévu uniquement pour une connexion à une source équivalant à un réseau en courant alternatif, tel qu'un motogénérateur ou une alimentation sans interruption (voir 1.2.8.1) ou à une source autre qu'un RESEAU D'ALIMENTATION, les tolérances sur la TENSION ASSIGNEE doivent être déclarées par le fabricant.

Si le matériel est prévu pour une connexion à un RESEAU D'ALIMENTATION EN COURANT CONTINU, les tolérances doivent être prises entre +20 % et –15 %, à moins que le fabricant ne déclare d'autres valeurs.

Lors de l'essai d'un matériel conçu uniquement pour le courant continu, l'influence possible de la polarité doit être prise en compte.

1.4.6 Fréquence de l'alimentation pour les essais

En déterminant la fréquence la plus défavorable pour l'alimentation d'un matériel à l'essai, différentes FREQUENCES ASSIGNEES à l'intérieur de la PLAGE ASSIGNEE DE FRÉQUENCES doivent être prises en compte (par exemple 50 Hz et 60 Hz) mais il n'est pas, normalement, nécessaire de prendre en considération la tolérance sur une FREQUENCE ASSIGNEE (par exemple 50 Hz ± 0,5 Hz).

1.4.7 Appareils de mesure électriques

Les appareils de mesure électriques doivent avoir une largeur de bande appropriée afin de fournir des lectures précises prenant en compte toutes les composantes (courant continu, fréquence du RESEAU D'ALIMENTATION EN COURANT ALTERNATIF, haute fréquence et harmoniques) du paramètre à mesurer. Si la valeur efficace est mesurée, on doit s’assurer que les appareils de mesure fournissent la valeur efficace vraie aussi bien en présence d'ondes non sinusoïdales que d'ondes sinusoïdales.

1.4.8 Tensions normales de fonctionnement

Dans le but de:

– déterminer les TENSIONS DE SERVICE (voir 1.2.9.6); et de

– classer les circuits dans un matériel comme CIRCUITS TBT, CIRCUITS TBTS, CIRCUITS TRT-1, CIRCUITS TRT-2, CIRCUITS TRT-3, ou circuits à TENSIONS DANGEREUSES,

on doit considérer les tensions suivantes:

– les tensions normales de fonctionnement produites à l’intérieur du matériel, y compris les pointes de tension répétitives comme celles associées aux alimentations à découpage;

– les tensions normales de fonctionnement produites à l’extérieur du matériel, y compris les tensions de sonnerie reçues des RESEAUX DES TELECOMMUNICATIONS.

A ces fins, les tensions transitoires non désirées, non répétitives, produites à l’extérieur (par exemple les TENSIONS TRANSITOIRES SUR LE RESEAU et les TENSIONS TRANSITOIRES SUR LES RESEAUX DE TELECOMMUNICATIONS) induites par les commutations des systèmes d’alimentation et les transitoires dus à la foudre ne doivent pas être prises en compte:

– lors de la détermination des TENSIONS DE SERVICE, ces transitoires ayant été prises en compte dans les procédures pour déterminer les DISTANCES DANS L’AIR minimales (voir 2.10.3 et Annexe G);

– lors de la classification des circuits dans un matériel, excepté lorsque l’on fait la distinction entre les CIRCUITS TBTS et les CIRCUITS TRT-1 et entre les CIRCUITS TRT-2 et les CIRCUITS TRT-3 (voir 1.2.8.11, Tableau 1A).

NOTE 1 Les effets des tensions permanentes non désirées produites à l’extérieur du matériel (par exemple les différences de potentiel de terre et les tensions induites sur les RESEAUX DE TELECOMMUNICATIONS par les systèmes de traction électrique) sont contrôlés par les pratiques d’installation ou par une isolation appropriée dans le matériel. De telles mesures dépendent de l’application et ne sont pas traitées dans cette norme.

NOTE 2 Au Canada et aux Etats-Unis, des exigences supplémentaires pour la protection contre les surtensions s'appliquent (voir Article 6, Note 5).

1.4.9 Mesure de la tension par rapport à la terre

Lorsque la norme spécifie une tension entre une partie conductrice et la terre, toutes les parties suivantes mises à la terre sont considérées:

– la principale borne de mise à la terre de protection (si c’est applicable); et

– toute autre partie conductrice qui nécessite la connexion à la terre de protection (voir, par exemple, 2.6.1); et

– toute partie conductrice qui est mise à la terre à l'intérieur du matériel pour des raisons fonctionnelles.

Les parties qui seront mises à la terre dans l'application par connexion à d'autres matériels mais qui ne sont pas mises à la terre dans le matériel comme essayées doivent être connectées à la terre au point par lequel la plus haute tension est obtenue. Lors de la mesure d’une tension entre la terre et un conducteur dans un circuit qui ne sera pas mis à la terre dans l'application prévue du matériel, une résistance non inductive de 5 000 Ω ± 10 % doit être branchée en parallèle sur l'appareil de mesure de la tension.

La chute de tension dans le CONDUCTEUR DE MISE A LA TERRE DE PROTECTION du câble d'alimentation, ou dans un conducteur mis à la terre dans un autre câblage externe, n'est pas incluse dans les mesures.

1.4.10 Configuration de la charge du matériel à l'essai

Lors de la détermination du courant absorbé (voir 1.6.2) et lorsque d'autres résultats d'essai peuvent être affectés, les variables suivantes doivent être prises en considération et combinées pour donner les résultats les plus défavorables:

– les charges dues aux différentes configurations possibles, offertes ou fournies par le fabricant pour l'inclusion dans ou avec le matériel à l'essai;
– les charges dues à d'autres unités du matériel qui selon le fabricant utiliseront de l'énergie à partir du matériel à l'essai;
– les charges susceptibles d'être reliées à tous les socles de prise de courant normalisés situés dans les ZONES D'ACCÈS DE L'OPÉRATEUR sur le matériel, jusqu'à la valeur indiquée dans le marquage prescrit en 1.7.5.

Il est permis d'utiliser des charges artificielles pour simuler de telles charges pendant les essais.

1.4.11 Puissance venant d'un réseau de télécommunications

Dans le cadre de la présente norme, la puissance disponible provenant d'un RESEAU DE TELECOMMUNICATIONS est considérée comme limitée à 15 VA.

1.4.12 Conditions de mesure des températures

1.4.12.1 Généralités

Les températures mesurées sur le matériel soumis aux essais doivent satisfaire à 1.4.12.2 ou 1.4.12.3, selon ce qui est applicable, toutes les températures étant exprimées en degrés Celsius (°C), où:

T est la température de la partie concernée mesurée dans les conditions d'essai prescrites;

T_{max} est la température maximale spécifiée pour la conformité à l'essai;

T_{amb} est la température de l'air ambiant pendant l'essai;

T_{ma} est la température maximale de l'air ambiant autorisée par les spécifications du fabricant ou 25 °C, suivant la valeur la plus élevée.

1.4.12.2 Matériels dépendant de la température

Pour les matériels dans lesquels l'échauffement ou le refroidissement sont conçus pour dépendre de la température (par exemple le matériel comporte un ventilateur dont la vitesse est plus élevée à haute température), la mesure de la température est effectuée à la température ambiante la plus défavorable dans la plage de fonctionnement spécifiée par le fabricant. Dans ce cas,

T ne doit pas dépasser T_{max}.

NOTE 1 Afin de trouver la valeur la plus élevée de T pour chaque composant, il peut être nécessaire d'effectuer plusieurs essais à différentes valeurs de T_{amb}.

NOTE 2 La valeur la plus défavorable de T_{amb} peut être différente pour des composants différents.

1.4.12.3 Matériels ne dépendant pas de la température

Pour les matériels dans lesquels l'échauffement ou le refroidissement ne sont pas conçus pour dépendre de la température ambiante, il est permis d'utiliser la méthode spécifiée en 1.4.12.2. En variante, l'essai est effectué à une valeur quelconque de T_{amb} dans la plage de fonctionnement spécifiée par le fabricant. Dans ce cas,

T ne doit pas dépasser ($T_{max} + T_{amb} - T_{ma}$).

Il convient que, pendant les essais, T_{amb} ne dépasse pas T_{ma} à moins d'un accord entre toutes les parties concernées.

1.4.13 Méthodes de mesure des températures

A moins qu'une méthode particulière ne soit spécifiée, les températures des enroulements doivent être déterminées soit par la méthode des couples thermoélectriques soit par la méthode de variation de la résistance (voir Annexe E). Les températures des parties autres que les enroulements doivent être déterminées par la méthode des couples thermo-électriques. Il est aussi permis d'utiliser toute autre méthode appropriée de mesure de température qui n'influence pas de façon sensible le bilan thermique et qui donne une précision suffisante pour montrer la conformité. Le choix et la position des sondes thermiques doivent être tels qu'ils aient une influence minimale sur la température de la partie à l'essai.

1.4.14 Défauts simulés et conditions anormales

Lorsqu'il est prescrit d'appliquer des défauts simulés ou des conditions de fonctionnement anormales, ceux-ci doivent être appliqués un par un et l'un après l'autre. Les défauts qui sont la conséquence directe d'un défaut simulé ou d'une condition de fonctionnement anormal sont considérés comme une partie de ce défaut simulé ou de la condition de fonctionnement anormal.

Lors de l'application de défauts simulés ou de conditions de fonctionnement anormal, les accessoires, fournitures, produits consommables, supports et matériels d'enregistrement doivent être mis en place s'il est vraisemblable qu'ils ont un effet sur le résultat de l'essai.

Lorsqu'il est fait référence spécifiquement à un premier défaut, le premier défaut est constitué d'une seule défaillance d'une isolation (à l'exception d'une DOUBLE ISOLATION ou d'une ISOLATION RENFORCEE) ou d'une seule défaillance d'un composant (à l'exception des composants avec une DOUBLE ISOLATION ou une ISOLATION RENFORCEE). La défaillance de l'ISOLATION FONCTIONNELLE n'est simulée que si cela est requis en 5.3.4 c).

Le matériel, les schémas et les spécifications concernant les composants sont étudiés pour déterminer quelles conditions de défaut peuvent raisonnablement se produire. Les exemples comprennent:

– les courts-circuits et circuits ouverts des dispositifs à semi-conducteur et condensateurs;
– les défauts provoquant une dissipation continue dans les résistances prévues pour une dissipation intermittente;
– les défauts internes dans les circuits intégrés provoquant une dissipation excessive;
– la défaillance de l'ISOLATION PRINCIPALE entre les parties du CIRCUIT PRIMAIRE transportant le courant et
  • les parties conductrices accessibles;
  • les écrans métalliques mis à la terre (voir l'Article C.2);
  • les parties de CIRCUITS TBTS;
  • les parties de CIRCUITS A LIMITATION DE COURANT.

1.4.15 Vérification par examen des données applicables

Lorsque dans cette norme la vérification des matériaux, des composants ou des sous-ensembles est effectuée par examen ou par essai des propriétés, il est permis de confirmer la conformité par l'examen de toute donnée applicable ou des résultats de l'essai précédent qui seraient disponibles, au lieu d'effectuer les ESSAIS DE TYPE spécifiés.

1.5 Composants

1.5.1 Généralités

Lorsque la sécurité est concernée, les composants doivent être conformes soit aux exigences de la présente norme ou, lorsque cela est spécifié dans un article d'exigences, ~~soit~~ aux aspects de sécurité des normes de la CEI applicables à ces composants.

NOTE ~~1~~ Une norme de composant de la CEI est considérée comme applicable uniquement lorsque le composant en question fait clairement partie de son domaine d'application.

~~NOTE 2 En Suède, les contacteurs contenant du mercure ne sont pas autorisés.~~

~~NOTE 3 En Suisse, les contacteurs contenant du mercure tels les THERMOSTATS, les relais et les régulateurs de niveau ne sont pas autorisés.~~

Les composants et sous-ensembles qui sont conformes à la CEI 62368-1 sont acceptables, en tant que partie intégrante d'un matériel traité dans la présente norme, sans évaluation autre que celle visant à prendre en considération l'utilisation appropriée du composant ou du sous-ensemble dans le produit fini.

1.5.2 Evaluation et essais des composants

Lorsque l'utilisation d'une norme de composants de la CEI est autorisée ci-dessus, l'évaluation et les essais des composants doivent être effectués comme suit:

– *un composant doit être vérifié pour déterminer si son application et son utilisation sont conformes à ses caractéristiques assignées;*

– *un composant qui a été démontré conforme à une norme harmonisée avec la norme de composants correspondante de la CEI doit être ~~vérifié pour déterminer si son application et son utilisation sont conformes à ses caractéristiques assignées. Il doit être~~ soumis, en tant que partie intégrante du matériel, aux essais applicables de la présente norme, à l'exception des essais qui font partie de la norme de composants correspondante de la CEI;*

– *un composant qui n'a pas été démontré conforme à une norme ~~correspondante~~ applicable comme ci-dessus doit être ~~vérifié pour déterminer si son application et son utilisation sont conformes à ses caractéristiques assignées. Il doit être~~ soumis aux essais applicables de la présente norme, en tant que partie intégrante du matériel, et aux essais applicables de la norme de composants dans les conditions se présentant dans le matériel;*

NOTE L'essai applicable de conformité à une norme de composant est, en général, effectué séparément.

– *~~lorsqu'il n'existe pas de norme de composant correspondante à la CEI, ou~~ lorsque les composants sont utilisés dans des circuits dans des conditions qui ne sont pas en accord avec leurs caractéristiques assignées spécifiées, les composants doivent être soumis aux essais dans les conditions se présentant dans le matériel. Le nombre d'échantillons exigés pour l'essai est, en général, le même que le nombre exigé par une norme équivalente.*

La vérification de la conformité est effectuée par examen et par les essais ou données applicables.

1.5.3 Dispositifs de commande thermiques

Les dispositifs de commande thermiques doivent être essayés conformément à l'Annexe K.

1.5.4 Transformateurs

Les transformateurs doivent satisfaire aux exigences applicables de la présente norme, y compris celles de l'Annexe C.

1.5.5 Câbles d'interconnexion

Les CABLES D'INTERCONNEXION fournis comme une partie du matériel doivent satisfaire aux exigences applicables de la présente norme et ne doivent pas représenter un danger au sens de la présente norme, qu'ils soient détachables ou non.

Pour les CABLES D'INTERCONNEXION fournis séparément (par exemple câbles d'imprimantes), il est permis d'appliquer les exigences du présent paragraphe au choix du fabricant.

Il est permis de traiter les câbles, ou les parties des câbles, qui se trouvent à l'intérieur de l'ENVELOPPE d'un matériel soit comme des CABLES D'INTERCONNEXION soit comme un câblage interne.

1.5.6 Condensateurs en parallèle sur l'isolation

Un condensateur connecté entre deux conducteurs de ligne d'un CIRCUIT PRIMAIRE ou entre un conducteur de ligne et le conducteur neutre ou entre le CIRCUIT PRIMAIRE et la terre de protection doit être conforme à l'une des sous-classes de la CEI 60384-14 et doit être utilisé conformément à leurs caractéristiques assignées. Cette exigence s'applique également à un condensateur qui est en parallèle sur une DOUBLE ISOLATION ou une ISOLATION RENFORCEE à un autre endroit dans le matériel. Les détails concernant l'essai continu de chaleur humide spécifié en 4.12 de la CEI 60384-14 doivent être les suivants:

– Température: 40 °C ± 2 °C;
– Humidité: (93 ~~%~~ ± 3)% d'humidité relative;
– Durée de l’essai: 21 jours.

NOTE 1 Les condensateurs qui ont été soumis à une durée d'essai supérieure à 21 jours sont considérés avoir rempli les critères de durée d'essai.

L'exigence ci-dessus ne s'applique pas dans le cas d'un condensateur connecté entre un CIRCUIT SECONDAIRE SOUS TENSION DANGEREUSE et la terre de protection lorsque seule une ISOLATION PRINCIPALE est requise.

NOTE 2 L'essai de 5.2.2 s'applique encore entre le CIRCUIT SECONDAIRE SOUS TENSION DANGEREUSE et la terre de protection.

La sous-classe de condensateurs appropriée doit être choisie parmi celles données au Tableau 1C conformément aux règles d'application du tableau.

Tableau 1C – Caractéristiques des condensateurs selon la CEI 60384-14

Sous-classe de condensateurs selon la CEI 60384-14	TENSION ASSIGNEE du condensateur V efficace	Tension d’impulsion de l'ESSAI DE TYPE du condensateur kV crête	Tension efficace de l'ESSAI DE TYPE du condensateur kV efficace
Y1	Jusqu’à 500 inclus	8	4
Y2	De 150 à 300 inclus	5	1,5
Y4	Jusqu’à 150 inclus	2,5	0,9
X1	Jusqu'à 760 inclus	4 [a]	-
X2	Jusqu'à 760 inclus	2,5 [a]	-

Règles pour l'application du Tableau 1C 1 Les condensateurs utilisés en parallèle sur l'ISOLATION PRINCIPALE, l'ISOLATION SUPPLEMENTAIRE ou l'ISOLATION RENFORCEE doivent être de la classe Y mais il est autorisé de mettre un condensateur de la classe X EN PARALLELE SUR l'ISOLATION PRINCIPALE d'un CIRCUIT SECONDAIRE. 2 Pour un seul condensateur monté en parallèle sur une ISOLATION FONCTIONNELLE, une ISOLATION PRINCIPALE, une ISOLATION SUPPLEMENTAIRE ou une ISOLATION RENFORCEE, les caractéristiques assignées du condensateur unique doivent être au moins égales à la VALEUR EFFICACE DE LA TENSION DE SERVICE à travers l'isolation totale, la détermination étant réalisée selon 2.10.2.2 3 Pour un seul condensateur monté en parallèle sur une ISOLATION FONCTIONNELLE, une ISOLATION PRINCIPALE ou une ISOLATION SUPPLEMENTAIRE, - la tension d'essai d'impulsion de l'ESSAI DE TYPE du condensateur unique ne doit pas être inférieure à la valeur de crête de la tension d'essai (pas la tension efficace) du Tableau 5B pour l'ISOLATION PRINCIPALE, ou à la valeur de crête de la tension d'essai du Tableau 5C pour l'ISOLATION PRINCIPALE, le cas échéant; - les tensions efficaces de l'ESSAI DE TYPE du condensateur unique ne doivent pas être inférieures à la tension d'essai efficace exigée du Tableau 5B pour l'ISOLATION PRINCIPALE, ou à la tension d'essai efficace équivalente (pas la tension de crête) du Tableau 5C pour l'ISOLATION PRINCIPALE, le cas échéant. 4 Pour un seul condensateur monté en parallèle sur une DOUBLE ISOLATION ou une ISOLATION RENFORCEE, - la tension d'impulsion de l'ESSAI DE TYPE du condensateur unique ne doit pas être inférieure à la valeur de crête de la tension d'essai (pas la tension efficace) du Tableau 5B pour l'ISOLATION RENFORCEE, ou à la valeur de crête de la tension d'essai du Tableau 5C pour l'ISOLATION RENFORCEE, le cas échéant; - la tension efficace de l'ESSAI DE TYPE des condensateurs uniques ne doit pas être inférieure à la tension d'essai efficace exigée du Tableau 5B pour l'ISOLATION RENFORCEE, ou à la tension d'essai efficace équivalente (pas la tension de crête) du Tableau 5C pour l'ISOLATION RENFORCEE, le cas échéant; 5 Il est autorisé d'utiliser un condensateur de qualité supérieure à celle spécifiée, comme suit: - sous-classe Y1 si la sous-classe Y2 est spécifiée; - sous-classe Y1 ou Y2 si la sous-classe Y4 est spécifiée; - sous-classe Y1 ou Y2 si la sous-classe X1 est spécifiée; - sous-classe X1, Y1 ou Y2 si la sous-classe X2 est spécifiée. 6 Il est autorisé d'utiliser deux ou plus de deux condensateurs en série à la place du condensateur unique spécifié, avec les configurations suivantes: - sous-classe Y1 ou Y2 si la sous-classe Y1 est spécifiée; - sous-classe Y2 ou Y4 si la sous-classe Y2 est spécifiée; - sous-classe X1 ou X2 si la sous-classe X1 est spécifiée. 7 Dans le cas où deux ou plus de deux condensateurs sont utilisés en série, tous les éléments suivants s'appliquent: - dans les conditions de premier défaut, la tension sur chacun des condensateurs individuels restants ne doit pas dépasser les caractéristiques assignées de tension du condensateur individuel correspondant; - pour l'ISOLATION PRINCIPALE ou l'ISOLATION SUPPLEMENTAIRE, la somme des tensions d'essai d'impulsion de crête de l'ESSAI DE TYPE de tous les condensateurs ne doit pas être inférieure à la valeur de crête de la tension d'essai (pas la tension efficace) du Tableau 5B, ou à la valeur de crête de la tension d'essai du Tableau 5C, le cas échéant; - pour l'ISOLATION PRINCIPALE ou l'ISOLATION SUPPLEMENTAIRE, la somme des tensions d'essai efficaces de l'ESSAI DE TYPE de tous les condensateurs ne doit pas être inférieure à la tension d'essai efficace exigée du Tableau 5B ou à la tension d'essai efficace équivalente (pas la tension de crête) du Tableau 5C, le cas échéant; - pour l'ISOLATION RENFORCEE, la somme des tensions d'essai d'impulsion de crête de l'ESSAI TYPE de tous les condensateurs ne doit pas être inférieure à la valeur de crête de la tension d'essai (pas la tension efficace) du Tableau 5B, ou à la valeur de crête de la tension du Tableau 5C, le cas échéant; - pour l'ISOLATION RENFORCEE, la somme des tensions d'essai efficaces de l'ESSAI DE TYPE de tous les condensateurs ne doit pas être inférieure à la tension d'essai efficace exigée du Tableau 5B ou la tension d'essai efficace équivalente (pas la tension de crête) du Tableau 5C, le cas échéant; - ils doivent être conformes aux autres règles ci-dessus.
[a] Pour les valeurs de capacité de plus de 1 µF, cette tension d'essai est réduite selon un facteur égal à $\sqrt{C}$, où *C* est la valeur de la capacité en µF.

Le Tableau 1D donne un certain nombre d'exemples à titre informatif pour l'application des condensateurs choisis conformément au Tableau 1C. D'autres exemples sont possibles.

Tableau 1D – Exemples informatifs d'application de condensateurs

~~TENSION DU RESEAU D'ALIMENTATION EN COURANT ALTERNATIF jusqu'à et y compris V efficace~~	~~Catégorie de surtension~~	~~TENSION TRANSITOIRE DU RESEAU kV~~	~~Isolation « pontée » par un condensateur~~	~~Type de condensateur~~	~~Nombre de condensateurs~~
~~150~~	~~II~~	~~1,5~~	~~B ou S~~	~~Y4~~	~~1~~
	~~II~~	~~1,5~~	~~D ou R~~	~~Y2~~	~~1~~
	~~II~~	~~1,5~~	~~D ou R~~	~~Y4~~	~~2~~
	~~III~~	~~2,5~~	~~F~~	~~X2~~	~~1~~
	~~III~~	~~2,5~~	~~B ou S~~	~~Y4~~	~~1~~
	~~III~~	~~2,5~~	~~D ou R~~	~~Y1~~	~~1~~
	~~IV~~	~~4,0~~	~~F~~	~~X1~~	~~1~~
	~~IV~~	~~4,0~~	~~B ou S~~	~~Y2~~	~~1~~
	~~IV~~	~~4,0~~	~~D ou R~~	~~Y1~~	~~1~~
~~250~~	~~II~~	~~2,5~~	~~F~~	~~X2~~	~~1~~
~~300~~	~~II~~	~~2,5~~	~~B ou S~~	~~Y2~~	~~1~~
	~~II~~	~~2,5~~	~~D ou R~~	~~Y1~~	~~1~~
	~~II~~	~~2,5~~	~~D ou R~~	~~Y2~~	~~2~~
~~250~~	~~III~~	~~4,0~~	~~F~~	~~X1~~	~~1~~
~~300~~	~~III~~	~~4,0~~	~~D ou R~~	~~Y1~~	~~1~~
	~~III~~	~~4,0~~	~~D ou R~~	~~Y2~~	~~2~~
	~~IV~~	~~6,0~~	~~B ou S~~	~~Y1~~	~~1~~
	~~IV~~	~~6,0~~	~~D ou R~~	~~Y1~~	~~2~~
~~500~~	~~II~~	~~4,0~~	~~B ou S~~	~~Y1~~	~~1~~
	~~II~~	~~4,0~~	~~D ou R~~	~~Y1~~	~~1~~
	~~III~~	~~6,0~~	~~B ou S~~	~~Y1~~	~~1~~
	~~III~~	~~6,0~~	~~D ou R~~	~~Y1~~	~~2~~
	~~IV~~	~~8,0~~	~~B ou S~~	~~Y1~~	~~1~~
	~~IV~~	~~8,0~~	~~D ou R~~	~~Y1~~	~~2~~
~~Les valeurs du tableau s'appliquent à l'ISOLATION FONCTIONNELLE (F), l'ISOLATION PRINCIPALE (B), l'ISOLATION SUPPLEMENTAIRE (S), l'ISOLATION DOUBLE (D) et à l'ISOLATION RENFORCEE (R).~~					

Tension du RESEAU D'ALIMENTATION EN COURANT ALTERNATIF Jusques et y compris V efficace	Catégorie de surtension	TENSION TRANSITOIRE DU RESEAU kV	Isolation « pontée »	Type de condensateur	Nombre de condensateurs	
					En utilisant le Tableau 5B	En utilisant le Tableau 5C
150	II	1,5	B ou S	Y2	1	1
	II	1,5	D ou R	Y2	2	2
	II	1,5	D ou R	Y1	1	1
	II	1,5	F	X2	1	1
	III	2,5	F	X2	-	1
	III	2,5	B ou S	Y2	-	2
	III	2,5	D ou R	Y1	-	1
	IV	4,0	F	X1	-	1
	IV	4,0	B ou S	Y1	-	1
	IV	4,0	B ou S	Y2	-	2
	IV	4,0	D ou R	Y1	-	2
250	II	2,5	F	X2	1	1
	III	4,0	F	X1	-	1
300	II	2,5	B ou S	Y2	1	2
	II	2,5	D ou R	Y1	1	1
	II	2,5	D ou R	Y2	2	3
	III	4,0	B ou S	Y1	-	1
	III	4,0	B ou S	Y2	-	2
	III	4,0	D ou R	Y1	-	2
	III	4,0	D ou R	Y2	-	4
	IV	6,0	F	X1	-	2
	IV	6,0	B ou S	Y1	-	2
	IV	6,0	D ou R	Y1	-	3
500	II	4,0	F	X1	1	1
	II	4,0	B ou S	Y1	1	1
	II	4,0	D ou R	Y1	1	2
	III	6,0	F	X1	-	2
	III	6,0	B ou S	Y1	-	2
	III	6,0	D ou R	Y1	-	3
	IV	8,0	F	X1	-	2
	IV	8,0	B ou S	Y1	-	2
	IV	8,0	D ou R	Y1	-	3

Les valeurs du tableau s'appliquent à l'ISOLATION FONCTIONNELLE (F), à l'ISOLATION PRINCIPALE (B), à l'ISOLATION SUPPLEMENTAIRE (S), à la DOUBLE ISOLATION (D) et à l'ISOLATION RENFORCEE (R).

NOTE Le Tableau 5B est utilisé uniquement pour les catégories de surtensions I et II.

Si une partie conductrice accessible ou un circuit, est séparé d'une autre partie par une DOUBLE ISOLATION ou une ISOLATION RENFORCEE, et que un ou plusieurs condensateurs sont montés en parallèle entre ces parties ou circuit, la partie accessible ou le circuit doit être conforme aux exigences pour un CIRCUIT A LIMITATION DE COURANT de 2.4. Cette exigence s'applique après l'essai de rigidité diélectrique de l'isolation avec le ou les condensateurs de court-circuit en place.

NOTE 3 Un circuit est un CIRCUIT A LIMITATION DE COURANT si le courant à travers les composants montés en parallèle est conforme à 2.4 et que les autres exigences de 2.4 sont satisfaites.

La vérification est effectuée par examen et par des mesures.

1.5.7 Résistances en parallèle sur l'isolation

1.5.7.1 Résistances montées en parallèle sur une isolation fonctionnelle, une isolation principale ou une isolation supplémentaire

Il n'existe pas d'exigences spécifiques pour les résistances montées en parallèle sur une ISOLATION FONCTIONNELLE, UNE ISOLATION PRINCIPALE OU UNE ISOLATION SUPPLEMENTAIRE, mais les exigences de 2.10.3 (ou de l'Annexe G) et de 2.10.4 s'appliquent et, dans certains cas, celles de 2.4.

NOTE En Finlande, en Norvège et en Suède, il faut que les résistances montées en parallèle sur une ~~isolation de base~~ ISOLATION PRINCIPALE dans le MATERIEL DE LA CLASSE I DE TYPE A RACCORDE PAR PRISE DE COURANT soient conformes aux exigences de ~~1.5.7.2~~ 1.5.7.1. En outre, lorsqu'une seule résistance est utilisée, celle-ci doit supporter l'essai de résistance de 1.5.7.2.

1.5.7.2 Résistances montées en parallèle sur une double isolation ou une isolation renforcée entre l'alimentation réseau en courant alternatif et les autres circuits

Il est autorisé de mettre en parallèle sur une DOUBLE ISOLATION ou une ISOLATION RENFORCEE une résistance ou un groupe de deux ou plus de deux résistances en série, dans les conditions suivantes. Pour les conditions applicables aux circuits connectés à une antenne ou un câble coaxial, voir 1.5.7.3.

La résistance ou le groupe de résistances doit être conforme aux DISTANCES DANS L'AIR minimales de 2.10.3 ou de l'Annexe G et aux LIGNES DE FUITE minimales de 2.10.4 pour l'ISOLATION RENFORCEE pour la TENSION DE SERVICE totale à travers la résistance ou le groupe de résistances. Dans le cas d'un groupe de résistances, voir aussi la Figure F.13.

Si une résistance unique est utilisée, elle doit passer avec succès l'essai de résistance ci-dessous.

Si un groupe de résistances est utilisé, la distance dans l'air et la ligne de fuite sont évaluées comme si chaque résistance était court-circuitée tour à tour, sauf si le groupe passe avec succès l'essai de résistance ci-dessous.

Si une partie conductrice accessible ou un circuit est séparé(e) d'une autre partie par une DOUBLE ISOLATION ou une ISOLATION RENFORCEE en parallèle de laquelle sont câblées une ou plusieurs résistances, la partie accessible ou le circuit doit être conforme aux exigences pour un CIRCUIT A LIMITATION DE COURANT de 2.4 entre la partie conductrice accessible ou le circuit et la terre. Si un groupe de résistances est utilisé, la mesure du courant de 2.4.2 est réalisée avec chaque résistance court-circuitée tour à tour, sauf si le groupe passe avec succès l'essai de résistance ci-dessous. ~~Ce courant est mesuré après l'essai de rigidité diélectrique de l'isolation avec la résistance ou le groupe de résistances en place.~~ Lors de la mesure du CIRCUIT A LIMITATION DE COURANT, l'ampèremètre est placé entre le côté charge des composants montés en parallèle et toute partie accessible à l'UTILISATEUR, y compris la terre.

La vérification est effectuée par examen et par des mesures et, si cela est spécifié ci-dessus, par l'essai de résistance suivant sur dix échantillons. Un échantillon est une résistance unique utilisée seule ou un groupe de résistances en série.

Essai de résistance

Avant l'essai, la résistance de chaque échantillon est mesurée.

Les échantillons sont soumis à l'essai de chaleur humide de la CEI 60068-2-78 avec les conditions suivantes:

– *Température: 40 °C ± 2 °C;*

– *Humidité: (93 ~~%~~ ± 3) % d'humidité relative;*

– *Durée de l'essai: 21 jours.*

NOTE Les résistances qui ont été soumises à une durée d'essai supérieure à 21 jours sont considérées avoir rempli les critères de durée d'essai.

Chaque échantillon est ensuite soumis à dix impulsions de polarité alternée, en utilisant la référence 2 de générateur d'impulsions d'essai du Tableau N.1. L'intervalle entre impulsions successives est de 60 s, et U_c est égale à la TENSION DE TENUE PRESCRITE *applicable.*

A l'issue de l'essai, la valeur de la résistance de chaque échantillon ne doit pas s'être modifiée de plus de 10 %.

Aucune défaillance n'est autorisée.

1.5.7.3 Résistances montées en parallèle sur la double isolation ou l'isolation renforcée entre le réseau d'alimentation en courant alternatif et les circuits connectés à une antenne ou un câble coaxial

Les exigences et les essais de 1.5.7.2 s'appliquent à l'exception du générateur d'impulsions d'essai qui est comme spécifié à la référence 3 du Tableau N.1 si le circuit n'est pas connecté à une antenne ou comme spécifié à la référence 1 du Tableau N.1 si le circuit est connecté à un câble coaxial.

A l'issue de l'essai, la résistance de chaque échantillon ne doit pas s'être modifiée de plus de 20 % et aucune défaillance n'est autorisée.

NOTE Si une résistance ou un groupe de résistances est connecté entre le CIRCUIT PRIMAIRE et un SYSTEME DE DISTRIBUTION PAR CABLES, 7.4 s'applique aussi.

1.5.8 Composants dans les matériels pour schémas d'alimentation IT

Pour les matériels destinés à être raccordés à des schémas d'alimentation IT, les composants connectés entre phase et terre doivent pouvoir supporter les contraintes dues à la tension entre phases. Cependant, les condensateurs marqués pour la tension ligne-neutre applicable sont autorisés pour de telles applications s'ils sont conformes à la CEI 60384-14, sous-classe Y1, Y2 ou Y4.

NOTE 1 Les condensateurs ci-dessus subissent un essai d'endurance à 170 % la tension assignée du condensateur.

NOTE 2 En Norvège, du fait du système d'alimentation IT utilisé (voir Annexe V, Figure V.7), il est prescrit que les condensateurs doivent être spécifiés pour la tension entre phases applicable (230 V).

La conformité est vérifiée par examen.

1.5.9 Parasurtenseurs

1.5.9.1 Généralités

Dans un CIRCUIT SEDONDAIRE, il est autorisé d'utiliser n'importe quel type de parasurtenseur, y compris une résistance dépendant de la tension (voltage dependent resistor – VDR).

Si un parasurtenseur est utilisé dans un CIRCUIT PRIMAIRE, il doit s'agir d'une VDR qui doit être conforme à l'Annexe Q.

NOTE 1 Une VDR est parfois désignée sous le terme varistance ou varistance à oxyde métallique (metal oxide varistor – MOV). Dans la présente norme, les dispositifs tels que les tubes à décharge, les plaquettes de carbone et les dispositifs à semiconducteurs avec caractéristiques de courant/tension non linéaires ne sont pas considérés comme des VDR.

NOTE 2 La présente norme n'exige pas la conformité avec une norme de composants spécifiques pour les parasurtenseurs utilisés dans les CIRCUITS SECONDAIRES. Toutefois, l'attention est attirée sur la série de normes CEI 61643, en particulier:

- CEI 61643-21 (parafoudres dans les applications de télécommunications)
- CEI 61643-311 (tubes à décharge dans un gaz)
- CEI 61643-321 (diodes à avalanche)
- CEI 61643-331 (varistances à oxyde métallique).

La conformité est vérifiée par examen et par l'application de l'Annexe Q, selon ce qui est approprié.

1.5.9.2 Protection des VDR

Pour la protection contre

– les surtensions temporaires supérieures à la tension continue maximale,

– la surcharge thermique due au courant de fuite à l'intérieur de la VDR, et

– la combustion et l'éclatement de la VDR en cas de défaut de court-circuit,

un moyen d'interruption présentant une capacité de coupure adéquate doit être connecté en série avec la VDR. Cette exigence ne s'applique pas à une VDR dans un CIRCUIT A LIMITATION DE COURANT.

NOTE 1 Pour des surtensions temporaires provenant du RESEAU D'ALIMENTATION EN COURANT ALTERNATIF, voir la CEI 60664-1.

NOTE 2 Au cours de la durée de vie d'une VDR, le courant de fuite augmente avec le nombre de cycles de commutation dans cette VDR. Ce courant de fuite cause une contrainte de température permanente et en augmentation continue, qui peut provoquer la combustion ou l'éclatement de la VDR.

La conformité est vérifiée par examen et, si nécessaire pour déterminer que le circuit est un CIRCUIT A L'IMITATION DE COURANT, par des mesures et des essais.

1.5.9.3 VDR mise en parallèle sur une isolation fonctionnelle

Il est autorisé de câbler une VDR en parallèle sur une ISOLATION FONCTIONNELLE.

La conformité est vérifiée par examen.

1.5.9.4 VDR mise en parallèle sur une isolation principale

Il est autorisé de câbler en parallèle sur une ISOLATION PRINCIPALE une VDR conforme aux exigences de l'Annexe Q, avec ou sans éclateur à gaz en série, si un côté ~~de la VDR~~ du circuit est relié à la terre conformément à 2.6.1 a).

Le matériel avec une telle VDR montée en parallèle sur l'ISOLATION PRINCIPALE doit être de l'un des types suivants:

– MATERIEL DU TYPE B RACCORDE PAR PRISE DE COURANT; ou

– MATERIEL RELIE A DEMEURE; ou

– matériels équipés d'un CONDUCTEUR DE MISE A LA TERRE DE PROTECTION fixé à demeure et munis d'instructions pour l'installation de ce conducteur.

NOTE En Finlande, en Norvège et en Suède, le troisième tiret ne s'applique qu'aux équipements tels qu'ils sont définis dans la Note de 6.1.2.2.

Pour tous les autres matériels, il est autorisé de mettre en parallèle sur une ISOLATION PRINCIPALE une VDR en série avec un éclateur à gaz, si:

- la VDR est conforme aux exigences de l'Annexe Q; et
- l'éclateur à gaz est conforme:
  - à l'essai de rigidité diélectrique pour l'ISOLATION PRINCIPALE; et
  - aux exigences de DISTANCES DANS L'AIR et de LIGNES DE FUITE externes relatives à l'ISOLATION PRINCIPALE.

La vérification de la conformité est effectuée par examen et, si nécessaire, par des mesures et des essais.

1.5.9.5 VDR montée en parallèle sur une isolation supplémentaire, une double isolation ou une isolation renforcée

Il n'est pas autorisé de câbler une VDR en parallèle sur une ISOLATION SUPPLEMENTAIRE, une DOUBLE ISOLATION ou une ISOLATION RENFORCEE.

La conformité est vérifiée par examen.

1.6 Adaptation au réseau

1.6.1 Schémas d'alimentation en courant alternatif

Les schémas d'alimentation en courant alternatif sont classifiés TN-C, TN-C-S, TN-S, TT ou IT (voir Annexe V).

1.6.2 Courant absorbé

Le courant absorbé en régime permanent par le matériel ne doit pas dépasser le COURANT ASSIGNE de plus de 10 % sous la CHARGE NORMALE.

NOTE Voir aussi 1.4.10.

La vérification est effectuée par la mesure du courant absorbé par le matériel sous la CHARGE NORMALE dans les conditions suivantes:

– *lorsqu'un matériel a plus d'une TENSION ASSIGNEE, le courant absorbé est mesuré pour chaque TENSION ASSIGNEE;*

– *lorsque le matériel a une ou plusieurs PLAGES ASSIGNEES DE TENSIONS, le courant absorbé est mesuré à chaque extrémité de chaque PLAGE ASSIGNEE DE TENSIONS. Lorsqu'une seule valeur de COURANT NOMINAL est marquée (voir 1.7.1), elle est comparée avec la valeur de courant absorbé la plus élevée mesurée dans la plage de tensions associée. Lorsque deux valeurs de COURANT ASSIGNE sont marquées, séparées par un trait d'union, elles sont comparées aux deux valeurs mesurées dans la plage de tensions associée.*

Dans chaque cas, les lectures sont effectuées après stabilisation du courant absorbé. Si le courant varie pendant le cycle de fonctionnement normal, le courant absorbé en régime permanent est pris comme la valeur moyenne, mesurée sur un ampèremètre enregistreur, pendant une période représentative.

1.6.3 Limite de tension du matériel portatif (à main)

La TENSION ASSIGNEE du MATERIEL PORTATIF ne doit pas dépasser 250 V.

La conformité est vérifiée par examen.

1.6.4 Conducteur neutre

Le conducteur neutre, s'il existe, doit être isolé de la terre et de la MASSE dans tout le matériel comme s'il était un conducteur de ligne. Les composants connectés entre le neutre et la terre doivent avoir des caractéristiques assignées correspondant à la tension entre phase et neutre (cependant, voir aussi 1.5.8).

La conformité est vérifiée par examen.

1.7 Marquages et instructions

NOTE Des exigences supplémentaires pour les marquages et instructions figurent dans les paragraphes suivants:

2.1.1.2	Compartiments pour piles ou batteries	4.3.3	Dispositifs de commande réglables
~~2.1.1.8~~	~~Dangers liés à l' de transfert d'énergie~~	4.3.5	Fiches et socles
2.3.2.3	Protection par mise à la terre	4.3.13.4	Rayonnements UV
2.6.1	Parties non mises à la terre	4.3.13.5	Lasers
2.6.2	MISE A LA TERRE FONCTIONNELLE	4.4.2	Parties mobiles dangereuses
2.6.3.4 c)	Conducteurs de liaison à la terre	4.4.5.2	Protection contre les ventilateurs pour les UTILISATEURS
2.6.5.1	Conducteurs de liaison à la terre	4.4.5.3	Protection contre les ventilateurs pour le personnel de maintenance
2.7.1	Dispositifs de protection externes	~~4.5.3~~ 4.5.4 Tableau 4C	Marquage des parties chaudes
2.7.6	Fusible sur le neutre	4.5.4	Températures de contact
2.10.3.2	Catégories de surtensions	4.6.2	Matériel sur des sols non combustibles
3.2.1.2	RESEAU D'ALIMENTATION EN COURANT CONTINU	4.6.3	Portes et couvercles amovibles
3.3.7	Groupement des bornes pour les conducteurs	5.1.7.1	COURANT DE CONTACT dépassant 3,5 mA
3.4.3	Dispositifs de sectionnement	5.1.8.2	Sommation des COURANTS DE CONTACT
3.4.6	Dispositifs de sectionnement bi-polaires	6.1.1 et 6.1.2.2	Mise à la terre pour un RESEAU DE TELECOMMUNICATIONS
3.4.7	Dispositifs de sectionnement quadripolaire	7.2 et 7.4.1	Mise à la terre pour un SYSTEME DE DISTRIBUTION PAR CABLES
3.4.9	Fiches comme dispositifs de sectionnement	G.2.1	Matériel dans les catégories de surtension III et IV
3.4.10	Matériels interconnectés	DD.2	Charge d'étagère maximale
3.4.11	Alimentations multiples	EE.2	Avertissement concernant la déchiqueteuse
4.1	Stabilité du matériel	EE.4	Déconnexion de l'alimentation de la déchiqueteuse
4.2.5	Essai de choc		

La vérification de chaque paragraphe de 1.7 est effectuée par examen, sauf spécification contraire (voir 1.7.11).

1.7.1 Marquages de l'identification et des caractéristiques assignées de l'alimentation

~~Le matériel doit comporter un marquage des caractéristiques assignées dont l'objet est de spécifier les conditions correctes d'alimentation en tension et en fréquence ainsi qu'en capacité de passage de courant.~~

~~Si une unité ne comporte pas de moyens de raccordement direct à un RESEAU D'ALIMENTATION, il n'est pas nécessaire qu'elle porte l'indication de caractéristiques électriques telles que sa TENSION ASSIGNEE, son COURANT ASSIGNE ou sa FREQUENCE ASSIGNEE.~~

~~Pour un matériel destiné à être installé par un OPERATEUR, le marquage doit être facilement visible dans une ZONE D'ACCES DE L'OPERATEUR, en incluant toute zone directement visible seulement après l'ouverture d'une porte ou d'un couvercle par un OPERATEUR. Si un sélecteur manuel de tension n'est pas accessible à l'OPERATEUR, le marquage doit indiquer la TENSION ASSIGNEE pour laquelle ce matériel est configuré lors de sa fabrication. Un marquage temporaire est autorisé à cet effet. Le marquage est autorisé sur toute surface extérieure du~~

~~matériel, sauf sur le fond d'un matériel de masse supérieure à 18 kg. De plus, sur un MATERIEL FIXE, le marquage doit être visible après l'installation du matériel pour un usage normal.~~

~~Pour le matériel destiné à être installé par le PERSONNEL DE MAINTENANCE, et si le marquage se trouve dans une ZONE D'ACCES POUR LA MAINTENANCE, l'emplacement du marquage permanent doit être indiqué dans les instructions d'installation ou par un avertissement visible sur le matériel. Il est permis d'utiliser un avertissement temporaire dans ce cas.~~

~~Le marquage doit comprendre les indications suivantes:~~

- ~~la ou les tensions assignées, ou la ou les plages assignées de tensions, en volts.~~
  - ~~les TENSIONS ASSIGNEES minimale et maximale de la plage de tensions doivent être séparées par un trait d'union (-) et si des TENSIONS assignées multiples ou des PLAGES ASSIGNEES DE TENSIONS multiples sont données, elles doivent être séparées par une barre oblique (/).~~

~~NOTE 1 Quelques exemples de marquages de TENSIONS ASSIGNEES sont indiqués ci-dessous:~~

- ~~PLAGE ASSIGNEE DE TENSIONS: 220-240 V. Cela signifie que le matériel est conçu pour être relié à un RESEAU D'ALIMENTATION EN COURANT ALTERNATIF ayant une tension comprise entre 220 V et 240 V.~~
- ~~TENSIONS ASSIGNEES multiples: 120/230/240 V. Cela signifie que le matériel est conçu pour être relié à un RESEAU D'ALIMENTATION EN COURANT ALTERNATIF ayant une tension égale à 120 V ou 230 V ou 240 V, généralement après un réglage interne.~~

  - ~~si le matériel est destiné à être relié aux deux conducteurs de ligne et au conducteur de neutre d'un schéma d'alimentation monophasé à trois conducteurs, le marquage doit indiquer la tension ligne-neutre et la tension entre lignes séparées par une barre oblique (/) avec l'indication supplémentaire «Trois conducteurs plus terre de protection», «3W + PE» ou l'équivalent.~~

~~NOTE 2 Quelques exemples de marquage pour le système ci-dessus sont indiqués ci-après:~~

~~120/240 V: 3 conducteurs + PE~~

~~120/240 V; 3W + ⏚ (60417-IEC-5019)~~

~~100/200 V: 2 W + N + PE~~

- ~~le symbole de la nature du courant, pour courant continu seulement;~~
- ~~la FREQUENCE ASSIGNEE ou la PLAGE ASSIGNEE DE FREQUENCES, en hertz, à moins que le matériel ne soit conçu pour courant continu seulement;~~
- ~~le COURANT ASSIGNE, en milliampères ou en ampères;~~
  - ~~pour le matériel à TENSIONS ASSIGNEES multiples, les COURANTS ASSIGNES correspondants doivent être indiqués en séparant les différentes caractéristiques assignées de courant par une barre oblique (/) et en faisant apparaître clairement la relation entre TENSION ASSIGNEE et COURANT ASSIGNE associé;~~
  - ~~le matériel avec une PLAGE ASSIGNEE DE TENSIONS doit être marqué soit du COURANT ASSIGNE maximal soit de la plage de courants;~~
  - ~~le marquage du COURANT ASSIGNE d'un groupe d'unités ayant une seule connexion à l'alimentation doit être placé sur l'unité qui est directement reliée à un RESEAU D'ALIMENTATION. Le COURANT ASSIGNE indiqué sur cette unité doit être le courant total maximal qui peut être en circuit en même temps, et il doit inclure les courants combinés de toutes les unités du groupe qui peuvent être alimentées simultanément par l'intermédiaire de cette unité et qui peuvent être mises en fonctionnement simultanément.~~

~~NOTE 3 Quelques exemples de marquages de COURANT ASSIGNES sont indiqués ci-dessous:~~

- ~~pour les matériels avec TENSIONS ASSIGNEES MULTIPLES:~~

~~120/240 V; 2,4/1,2 A~~

- ~~pour les matériels avec une PLAGE ASSIGNEE DE TENSIONS:~~

~~100-240 V; 2,8 A~~

~~100-240 V; 2,8-1,4 A~~

~~— 100-120 V; 2,8 A~~

~~— 200-240 V; 1,4 A~~

~~Il est reconnu que dans certaines régions, il est habituel d'utiliser un point (.) comme marqueur décimal à la place d'une virgule.~~

~~– le nom du fabricant ou la marque de fabrique ou la marque d'identification;~~

~~– le numéro de modèle ou la référence du type;~~

~~– le symbole ▣ (IEC 60417-5172 (DB:2003-02)), pour le matériel de CLASSE II uniquement, à l'exception des cas où cela est interdit par 2.6.2.~~

~~Des marquages supplémentaires sont permis, pourvu qu'ils ne soient pas source de confusion.~~

~~Lorsqu'il est fait usage de symboles, ceux-ci doivent être conformes à l'ISO 7000 ou à la CEI 60417, lorsque les symboles appropriés existent.~~

1.7.1.1 Marquage des caractéristiques assignées de l'alimentation

Le matériel doit comporter un marquage des caractéristiques assignées dont l'objet est de spécifier les conditions correctes d'alimentation en tension et en fréquence ainsi qu'en capacité de passage de courant.

Si le matériel ne comporte pas de moyens de raccordement direct à un RESEAU D'ALIMENTATION, il n'est pas nécessaire qu'il porte l'indication de caractéristiques électriques telles que sa TENSION ASSIGNEE, son COURANT ASSIGNE ou sa FREQUENCE ASSIGNEE.

Si le matériel, ou un système, comporte des connexions d'ALIMENTATION multiples, chaque caractéristique électrique assignée du RESEAU D'ALIMENTATION doit être marquée, à moins qu'elles ne soient identiques, mais il n'est pas nécessaire que l'ensemble des caractéristiques électriques du matériel ou du système soient marquées. Si les connexions d'ALIMENTATION multiples sont identiques, il est permis de les marquer, par exemple, comme suit: "caractéristique électrique du RESEAU D'ALIMENTATION x N", où N est le nombre de connexions d'ALIMENTATION identiques.

Pour un matériel destiné à être installé par un OPERATEUR, le marquage des caractéristiques assignées de l'alimentation, s'il est requis, doit être facilement visible dans toute ZONE D'ACCES DE L'OPERATEUR. Si un sélecteur manuel de tension n'est pas accessible à l'OPERATEUR, le marquage des caractéristiques assignées de l'alimentation doit indiquer la TENSION ASSIGNEE pour laquelle ce matériel est configuré lors de sa fabrication; un avertissement temporaire est permis dans ce cas. Le marquage des caractéristiques assignées de l'alimentation est autorisé sur toute surface extérieure du matériel, sauf sur le fond d'un matériel de masse supérieure à 18 kg.

Pour le MATERIEL FIXE, le marquage des caractéristiques assignées de l'alimentation doit être visible après l'installation du matériel pour un usage normal.

Pour le matériel destiné à être installé par le PERSONNEL DE MAINTENANCE et si le marquage des caractéristiques assignées de l'alimentation se trouve dans une ZONE D'ACCES POUR LA MAINTENANCE, l'emplacement du marquage permanent doit être indiqué dans les instructions d'installation ou par un avertissement visible sur le matériel. Il est permis d'utiliser un avertissement temporaire dans ce cas.

Le marquage des caractéristiques assignées de l'alimentation doit comporter ce qui suit:

- TENSION(S) ASSIGNEE(S) ou PLAGE(S) ASSIGNEE(S) DE TENSIONS, en volts;
  — les TENSIONS ASSIGNEES minimale et maximale de la plage de tensions doivent être séparées par un trait d'union (-) et si des TENSIONS ASSIGNEES multiples ou des PLAGES

ASSIGNEES DE TENSIONS multiples sont données, elles doivent être séparées par une barre oblique (/);

NOTE 1 Des exemples de marquages de TENSION ASSIGNEE sont:

- PLAGE ASSIGNEE DE TENSIONS: 220-240 V. Cela signifie que le matériel est conçu pour être relié à un RESEAU D'ALIMENTATION EN COURANT ALTERNATIF ayant une tension comprise entre 220 V et 240 V.
- TENSIONS ASSIGNEES multiples: 120/230/240 V. Cela signifie que le matériel est conçu pour être relié à un RESEAU D'ALIMENTATION EN COURANT ALTERNATIF ayant une tension égale à 120 V ou 230 V ou 240 V, généralement après un réglage interne.

— si le matériel est destiné à être relié aux deux conducteurs de ligne et au conducteur de neutre d'un schéma d'alimentation monophasé à trois conducteurs, le marquage des caractéristiques assignées de l'alimentation doit indiquer la tension ligne-neutre et la tension entre lignes séparées par une barre oblique (/) avec l'indication supplémentaire « Trois conducteurs plus terre de protection », « 3W + PE » ou l'équivalent ;

NOTE 2 Quelques exemples de marquage pour le système ci-dessus sont indiqués ci-après:

120 /240 V; 3 conducteurs + PE ;

120 /240 V; 3W + ⏚ (60417-IEC-5019) ;

100/ 200 V; 2W + N + PE;

100-120/200-240 V; 2W + N + PE.

- le symbole de la nature du courant, pour courant continu seulement;
- FREQUENCE ASSIGNEE ou PLAGE ASSIGNEE DE FREQUENCES, en hertz, à moins que le matériel soit conçu pour courant continu seulement;
- COURANT ASSIGNE, en milliampères ou en ampères;

— pour le matériel à TENSIONS ASSIGNEES multiples, les COURANTS ASSIGNES correspondants doivent être indiqués en séparant les différentes caractéristiques assignées de courant par une barre oblique (/) et en faisant apparaître clairement la relation entre TENSION ASSIGNEE et COURANT ASSIGNE associé;

— le matériel avec une PLAGE ASSIGNEE DE TENSIONS doit être marqué soit du COURANT ASSIGNE maximal, soit de la plage de courants;

— le marquage des caractéristiques assignées de l'alimentation pour le COURANT ASSIGNE d'un groupe d'unités ayant une seule connexion à l'alimentation doit être placé sur l'unité qui est directement reliée à un RESEAU D'ALIMENTATION. Le COURANT ASSIGNE indiqué sur cette unité doit être le courant total maximal qui peut être en circuit en même temps et il doit inclure les courants combinés de toutes les unités du groupe qui peuvent être alimentées simultanément par l'intermédiaire de cette unité et qui peuvent être mises en fonctionnement simultanément.

NOTE 3 Des exemples de marquages de COURANT ASSIGNE sont:

– pour les matériels avec des TENSIONS ASSIGNEES multiples:

  120/240 V; 2,4/1,2 A ;

  100-120/200-240 V; 2,4/1,2 A ;

– pour les matériels avec une PLAGE ASSIGNEE DE TENSIONS:

  100-240 V; 2,8 A;

  100-240 V; 2,8 A-1,4 A ;

  100-120 V; 2,8 A ;

  200-240 V; 1,4 A.

Il est reconnu que dans certaines régions, il est habituel d'utiliser un point (·) comme marqueur décimal à la place d'une virgule.

Des marquages supplémentaires sont permis, pourvu qu'ils ne soient pas source de confusion.

Lorsqu'il est fait usage de symboles, ceux-ci doivent être conformes à l'ISO 7000 ou à la CEI 60417, lorsque les symboles appropriés existent.

1.7.1.2 Marquages d'identification

Le matériel doit être pourvu des marquages d'identification suivants:

– le nom du fabricant ou la marque de fabrique ou la marque d'identification;
– le numéro de modèle ou la référence du type;
– le symbole ⧈, IEC 60417-5172 (DB:2003-02), pour l'identification du MATERIEL DE CLASSE II uniquement, à l'exception des cas interdits par 2.6.2.

Des marquages d'identification supplémentaires sont permis, à condition qu'ils ne soient pas source de confusion.

Ces marquages d'identification doivent être facilement visibles dans toute ZONE D'ACCES D'OPERATEUR, mais ils ne doivent pas être placés sur le fond d'un matériel de masse supérieure à 18 kg. Pour le MATERIEL FIXE, le marquage d'identification doit être visible après l'installation du matériel pour un usage normal.

1.7.1.3 Utilisation des symboles graphiques

Les symboles graphiques placés sur le matériel, qu'ils soient ou non exigés par la présente norme, doivent être conformes à la CEI 60417 ou à l'ISO 3864-2 ou à l'ISO 7000, si disponibles. En l'absence de symboles appropriés, le fabricant peut concevoir des symboles graphiques spécifiques.

Les symboles placés sur le matériel doivent être expliqués dans le manuel d'utilisation.

1.7.2 Instructions concernant la sécurité et marquage

1.7.2.1 Généralités

Des instructions suffisantes doivent être fournies à l'UTILISATEUR concernant toutes les conditions nécessaires pour assurer que, lorsqu'il est utilisé conformément aux instructions du fabricant, le matériel n'est pas susceptible de présenter un danger au sens de cette norme.

S'il est nécessaire de prendre des précautions spéciales pour éviter l'apparition de dangers pendant le fonctionnement, l'installation, la maintenance, le transport et le stockage du matériel, les instructions nécessaires doivent être disponibles.

NOTE 1 Des précautions spéciales peuvent être nécessaires, par exemple pour la liaison du matériel à l'alimentation et l'interconnexion d'unités séparées, le cas échéant.

NOTE 2 Lorsque cela s'applique, il convient que les instructions d'installation fassent référence aux normes nationales d'installation.

NOTE 3 Dans de nombreux pays, les instructions et les marquages des matériels qui concernent la sécurité doivent être rédigées dans une langue acceptable dans le pays où le matériel est installé. Les instructions relatives à la maintenance ne sont normalement disponibles que pour le PERSONNEL DE MAINTENANCE et sont généralement acceptables si elles sont en anglais seulement.

NOTE 4 En Allemagne, les informations relatives à la sécurité, y compris pour le PERSONNEL DE MAINTENANCE, doivent être rédigées en langue allemande.

NOTE 5 Au Canada, il est recommandé que les instructions et les marquages soient en anglais et en français.

NOTE 6 En Finlande, en Norvège et en Suède, il faut que le MATERIEL DE LA CLASSE I DE TYPE A RACCORDE PAR PRISE DE COURANT, destiné à être raccordé à un autre matériel ou un réseau, porte, si la sécurité repose sur une connexion à la terre de protection ou si des parasurtenseurs sont connectés entre les bornes du réseau et des parties accessibles, un marquage indiquant qu'il faut le connecter à un socle mis à la terre du réseau d'alimentation.

Les instructions pour le fonctionnement et, pour les MATÉRIELS RACCORDÉS PAR PRISE DE COURANT destinés à être installés par l'UTILISATEUR, les instructions d'installation doivent être à la disposition de l'UTILISATEUR.

1.7.2.2 Dispositifs de sectionnement

Lorsque le dispositif de sectionnement n'est pas incorporé dans le matériel (voir 3.4.3) ou lorsque la fiche de prise de courant du câble d'alimentation est destinée à servir de dispositif de sectionnement, les instructions d'installation doivent indiquer que:

– pour le MATÉRIEL RELIÉ À DEMEURE AU RESEAU, un dispositif de sectionnement facilement accessible doit être incorporé à l'extérieur du matériel;

– pour le MATÉRIEL RACCORDÉ PAR PRISE DE COURANT, le socle de prise de courant doit être installé à proximité du matériel et doit être aisément accessible.

1.7.2.3 Dispositifs de protection contre les surintensités

Pour les MATERIELS DU TYPE B RACCORDES PAR PRISE DE COURANT OU POUR LES MATERIELS RELIES A DEMEURE, les instructions d'installation doivent spécifier les caractéristiques assignées maximales d'un dispositif de protection contre les surintensités à prévoir à l'extérieur du matériel sauf lorsqu'il existe des dispositifs de protection contre les surintensités appropriés à l'intérieur du matériel [voir aussi 2.6.3.3 b)].

NOTE Les caractéristiques assignées maximales spécifiées peuvent ne pas être celles du dispositif de protection disponible dans le pays d'installation. Il est recommandé d'autoriser l'utilisation d'un dispositif dont les caractéristiques assignées sont inférieures qui sera toujours approprié pour le COURANT ASSIGNE du matériel plus toute marge nécessaire pour le courant d'appel.

1.7.2.4 Schéma d'alimentation IT

Si le matériel a été conçu ou, si nécessaire, modifié pour le raccordement à un schéma d'alimentation IT, les instructions d'installation du matériel doivent l'indiquer.

1.7.2.5 Accès de l'opérateur avec un outil

S'il est nécessaire d'utiliser un OUTIL pour avoir accès à une ZONE D'ACCES DE L'OPERATEUR, tous les autres compartiments de cette zone qui présentent un danger doivent, soit être inaccessibles à l'OPERATEUR par l'utilisation du même OUTIL, soit porter un marquage pour décourager l'accès de l'OPERATEUR.

Un marquage acceptable pour les dangers de chocs électriques est (ISO 3864, n° 5036).

1.7.2.6 Ozone

Pour les matériels qui peuvent produire de l'ozone, les instructions d'installation et de fonctionnement doivent mentionner la nécessité de prendre des précautions pour s'assurer que la concentration d'ozone est limitée à une valeur sûre.

NOTE La limite d'exposition à long terme actuellement recommandée pour l'ozone est de $0{,}1 \times 10^{-6}$ (0,2 mg/m^3) calculée comme une concentration moyenne pondérée dans le temps sur 8 h. Il y a lieu de noter que l'ozone est plus lourd que l'air.

1.7.3 Cycles de fonctionnement courts

Les matériels qui ne sont pas prévus pour le SERVICE CONTINU doivent porter l'indication de la DUREE ASSIGNEE DE FONCTIONNEMENT et de la DUREE ASSIGNEE DE REPOS, à moins que la durée de fonctionnement ne soit limitée par construction.

Le marquage de la DUREE ASSIGNEE DE FONCTIONNEMENT correspond à l'utilisation normale.

Les indications relatives à la DUREE ASSIGNEE DE FONCTIONNEMENT doivent précéder la DUREE ASSIGNEE DE REPOS, les deux indications étant séparées par une barre oblique (/).

1.7.4 Réglage de la tension d'alimentation

Pour le matériel destiné à être raccordé à des TENSIONS ou FRÉQUENCES ASSIGNÉES multiples, la méthode de réglage doit être entièrement traitée dans les instructions de maintenance ou dans la notice d'installation.

A moins que le dispositif de réglage ne soit une simple commande placée près du marquage de puissance et que le réglage de cette commande ne soit évident par simple examen, l'instruction suivante ou une instruction similaire doit figurer sur le marquage ou à proximité de celui-ci:

VOIR LA NOTICE D'INSTALLATION
AVANT DE RACCORDER AU RÉSEAU

1.7.5 Socles de prise de courant sur le matériel

Si, dans le matériel, un socle de prise de courant normalisé est accessible à l'OPERATEUR, l'indication de la charge maximale admissible à raccorder à ce socle de prise de courant doit être marquée à proximité de celui-ci.

Des socles de prises de courant conformes à la CEI 60083 sont des exemples de socles de prises de courant normalisés.

1.7.6 Identification des fusibles

Un marquage doit être placé à proximité de chaque fusible ou porte-fusible ou sur le porte-fusible ou à un autre endroit pourvu qu'il soit facile de voir à quel porte-fusible s'applique le marquage, donnant le courant assigné du fusible et, lorsque des fusibles de tensions assignées différentes peuvent être utilisés, la tension assignée du fusible.

Lorsque des éléments fusibles à caractéristiques de fusion spéciales telles qu'une temporisation ou une capacité de coupure sont nécessaires, le type doit également être indiqué.

Pour les fusibles qui ne sont pas dans une ZONE D'ACCÈS DE L'OPÉRATEUR et pour les fusibles soudés situés dans les ZONES D'ACCÈS DE L'OPÉRATEUR, il est permis de fournir une référence croisée sans ambiguïté (par exemple F1, F2, etc.) dans les instructions de maintenance qui doivent contenir les informations correspondantes.

NOTE Voir 2.7.6 pour les avertissements au PERSONNEL DE MAINTENANCE.

1.7.7 Bornes de raccordement

1.7.7.1 Bornes de mise à la terre et de liaison à la terre de protection

Une borne prévue pour le raccordement d'un CONDUCTEUR DE MISE A LA TERRE DE PROTECTION doit être ~~marquée~~ indiquée par le symbole ⏚ IEC 60417-5019 (DB:2002-10). Ce symbole ne doit pas être utilisé pour d'autres bornes de mise à la terre, mais il est permis d'utiliser le symbole pour identifier une borne de mise à la terre de protection distincte spécifiée en 5.1.7.1.

Il n'est pas prescrit de marquer les autres bornes pour le CONDUCTEUR DE LIAISON A LA TERRE DE PROTECTION mais lorsque de telles bornes sont marquées, le symbole ⏚ (IEC 60417-5017 (DB: 2002-10) doit être utilisé.

Les situations suivantes sont exemptées des exigences ci-dessus:

- lorsque les bornes pour le raccordement d'une alimentation sont prévues sur un composant (par exemple un bornier) ou sur un sous-ensemble (par exemple une unité d'alimentation), le symbole ⏚ est permis pour la borne de mise à la terre de protection au lieu du symbole ⏚;
- sur les sous-ensembles ou les composants, le symbole ⏚ est permis à la place du symbole ⏚ pourvu que cela ne donne pas lieu à confusion.

Ces symboles ne doivent être situés ni sur les vis ni sur les autres parties susceptibles d'être enlevées lors du raccordement des conducteurs.

Ces exigences s'appliquent aux bornes pour le raccordement d'un CONDUCTEUR DE MISE A LA TERRE DE PROTECTION qui peut faire partie intégrante d'un câble d'alimentation ou être acheminé avec les conducteurs d'alimentation.

1.7.7.2 Bornes pour les conducteurs du réseau d'alimentation en courant alternatif

Pour les MATÉRIELS RELIÉS À DEMEURE et les matériels avec des CÂBLES D'ALIMENTATION FIXÉS À DEMEURE:

- les bornes prévues uniquement pour le raccordement du conducteur neutre du RESEAU L'ALIMENTATION EN COURANT ALTERNATIF, si elles existent, doivent porter l'indication de la lettre majuscule N; et
- pour les matériels triphasés, si une rotation de phase incorrecte risque d'entraîner une augmentation excessive de température ou un autre danger, les bornes destinées à la connexion des conducteurs de ligne du RESEAU D'ALIMENTATION EN COURANT ALTERNATIF doivent être marquées de façon qu'avec les instructions d'installation, il n'y ait pas d'ambiguïté pour la séquence de rotation de phase.

Ces indications ne doivent être situées ni sur les vis, ni sur les autres parties susceptibles d'être enlevées lors du raccordement des conducteurs.

1.7.7.3 Bornes pour les conducteurs du réseau d'alimentation en courant continu

Pour les MATERIELS RELIES A DEMEURE et les matériels avec des CABLES D'ALIMENTATION FIXES A DEMEURE, les bornes prévues uniquement pour le raccordement d'un RESEAU D'ALIMENTATION EN COURANT CONTINU doivent être marquées pour indiquer la polarité.

S'il existe une borne unique prévue à la fois comme borne principale de mise à la terre de protection dans le matériel et pour la connexion à un pôle du RESEAU D'ALIMENTATION EN COURANT CONTINU, elle doit être marquée comme spécifié en 1.7.7.1 en plus de la polarité.

Ces indications ne doivent être situées ni sur les vis, ni sur les autres parties susceptibles d'être enlevées lors du raccordement des conducteurs.

1.7.8 Dispositifs de commande et indicateurs

1.7.8.1 Identification, emplacement et marquage

A moins que cela ne soit manifestement superflu, les voyants, interrupteurs et autres dispositifs de commande liés à la sécurité doivent être identifiés ou situés de manière à indiquer clairement quelle fonction ils commandent.

Les marques et indications des interrupteurs et autres dispositifs de commande doivent être situées soit:

- sur l'interrupteur ou le dispositif de commande ou à proximité, soit
- ailleurs, de telle manière que la relation entre le marquage et l'interrupteur ou le dispositif de commande auquel il s'applique soit évidente.

Les indications utilisées à cet effet doivent être, autant que possible, compréhensibles sans connaissance de la langue, des normes nationales, etc.

1.7.8.2 Couleurs

Lorsque la sécurité est impliquée, les couleurs des organes de commande et des voyants doivent être conformes à la CEI 60073. Lorsque des couleurs sont utilisées pour des organes de commande et des voyants fonctionnels, toute couleur, y compris le rouge, est permise pourvu qu'il soit clair que la sécurité n'est pas impliquée.

1.7.8.3 Symboles

Lorsque des symboles sont utilisés sur ou à proximité des dispositifs de commande, (par exemple interrupteurs et boutons-poussoirs) pour indiquer les positions «MARCHE» et «ARRÊT», ce doit être un trait | pour «MARCHE» ou un cercle O pour «ARRÊT» (IEC 60417-5007(DB:2002-10) et IEC 60417-5008 (DB:2002-10)). Pour les interrupteurs du type «poussez-poussez», le symbole ⦶ doit être utilisé (IEC 60417-5010 (DB:2002-10)).

Il est permis d'utiliser les symboles O et | pour indiquer les positions «ARRÊT» et «MARCHE» sur tout interrupteur de l'alimentation primaire ou secondaire, y compris les interrupteurs sectionneurs.

Une «POSITION DE VEILLE» doit être indiquée par le symbole approprié ⏻ (IEC 60417-5009 (DB:2002-10).

1.7.8.4 Marquage utilisant des chiffres

Si des chiffres sont utilisés pour indiquer les différentes positions d'un dispositif de commande quelconque, la position «ARRÊT» doit être indiquée par le chiffre 0 (zéro) et les chiffres plus élevés doivent être utilisés pour indiquer une charge, une puissance, etc., plus élevées.

1.7.9 Isolation des sources d'alimentation multiples

Lorsqu'il y a plusieurs connexions alimentant un matériel sous une TENSION DANGEREUSE ou à des NIVEAUX D'ÉNERGIE DANGEREUX, un marquage placé en évidence à proximité de l'accès aux parties dangereuses prévu pour le PERSONNEL DE MAINTENANCE doit indiquer quel est ou quels sont le ou les dispositifs de sectionnement isolant complètement le matériel et quels dispositifs de sectionnement peuvent être utilisés pour isoler chaque section du matériel.

1.7.10 Thermostats et autres dispositifs de réglage

Les THERMOSTATS et autres dispositifs de réglage analogues destinés à être réglés au cours de l'installation ou en usage normal doivent être pourvus d'une indication donnant le sens de l'augmentation ou de la diminution de la valeur de la grandeur réglée. Une indication par les symboles + et – est permise.

1.7.11 Durabilité

Toutes les marques et indications prescrites dans la présente norme doivent être durables et lisibles. Dans l'appréciation de la durabilité du marquage, il doit être tenu compte de l'effet d'une utilisation normale.

La vérification de la conformité consiste à effectuer un examen et à frotter les marques et indications à la main pendant 15 s avec un chiffon imbibé d'eau et de nouveau pendant 15 s avec un chiffon imbibé d'essence. Après cet essai, les marques et indications doivent être lisibles; il ne doit pas être possible d'enlever facilement les plaques signalétiques et celles-ci ne doivent pas se recroqueviller.

L'essence qui doit être utilisée pour l'essai est de l'hexane, un solvant aliphatique avec une teneur maximale en carbures aromatiques de 0,1 % en volume, une teneur en kauributanol de

29, une température initiale d'ébullition d'environ 65 °C, un point sec d'environ 69 °C et une masse volumique d'environ 0,7 kg/l.

Sinon, il est autorisé d'utiliser un hexane approprié comme réactif avec un minimum de 85 % comme n-hexane.

NOTE La désignation “n-hexane” correspond à la nomenclature chimique pour un hydrocarbure "normal" ou à chaîne droite. Cette essence peut aussi être identifiée comme hexane approprié comme réactif (CAS# 110-54-3) certifié par l'ACS (American Chemical Society).

1.7.12 Parties amovibles

Les marquages exigés par la présente norme ne doivent pas être placés sur des parties amovibles qui peuvent être remises en place de telle sorte que le marquage devienne trompeur.

1.7.13 Batteries remplaçables

Si un matériel est pourvu d'une batterie remplaçable, et si son remplacement par une batterie de type incorrect peut provoquer une explosion (par exemple dans le cas de certains types de batteries au lithium), ce qui suit est applicable:

– si la batterie est placée dans une ZONE D'ACCES DE L'OPERATEUR, il doit y avoir un marquage à côté de la batterie ou un avis à la fois dans les instructions pour l'utilisation et dans les instructions pour la maintenance;
– si la batterie est placée ailleurs dans le matériel, il doit y avoir un marquage à côté de la batterie ou un avis dans les instructions pour la maintenance.

Ce marquage ou cet avis doit inclure le texte suivant ou un texte similaire:

ATTENTION
IL Y A RISQUE D'EXPLOSION SI LA BATTERIE EST REMPLACÉE
PAR UNE BATTERIE DE TYPE INCORRECT.
METTRE AU REBUT LES BATTERIES USAGÉES
CONFORMÉMENT AUX INSTRUCTIONS

1.7.14 Matériel pour emplacements à accès restreint

Pour le matériel destiné à être installé uniquement dans un EMPLACEMENT A ACCES RESTREINT, les instructions d'installation doivent contenir une indication à cet effet.

2 Protection contre les dangers

2.1 Protection contre les chocs électriques et les dangers de transfert d'énergie

2.1.1 Protection dans la zone d'accès de l'opérateur

Le présent paragraphe spécifie des exigences pour la protection contre les chocs électriques provenant des parties sous tension, fondées sur le principe que l'OPERATEUR est autorisé à avoir accès à:

– des parties nues de CIRCUITS TBTS; et
– des parties nues de circuits à limitation de courant; et
– des CIRCUITS TRT dans les conditions spécifiées en 2.1.1.1.

L'accès à d'autres parties et câblages sous tension, et à leur isolation, est restreint comme spécifié en 2.1.1.1.

Des exigences supplémentaires sont spécifiées en 2.1.1.5 et en 2.1.1.8 pour la protection contre les dangers de transfert d'énergie.

2.1.1.1 Accès aux parties sous tension

Le matériel doit être construit de façon qu'il existe, dans les ZONES D'ACCES DE L'OPERATEUR, une protection suffisante contre un contact avec:

– des parties nues de CIRCUITS TBT; et

– des parties nues sous TENSIONS DANGEREUSES; et

– l'ISOLATION SOLIDE assurant l'ISOLATION FONCTIONNELLE OU PRINCIPALE de parties ou de câblages dans les CIRCUITS TBT à l'exception de ce qui est permis en 2.1.1.3; et

– l'isolation solide assurant l'isolation fonctionnelle ou l'isolation principale de parties ou de câblages sous tension dangereuse; et

NOTE 1 L'ISOLATION FONCTIONNELLE comprend mais n'est pas limitée à une isolation telle que du vernis, de l'émail à base de solvant, du papier ordinaire, du coton et une pellicule d'oxyde ou une isolation déplaçable telle que des perles isolantes et de la matière de remplissage autre que de la résine autodurcissante.

– des parties conductrices non mises à la terre séparées des CIRCUITS TBT ou des parties sous TENSION DANGEREUSE par une ISOLATION FONCTIONNELLE ou PRINCIPALE seulement; et

– les parties nues des CIRCUITS TRT avec l'exception que l'accès est permis avec:

- les contacts de connecteurs qui ne peuvent pas être touchés par le calibre d'essai (Figure 2C);
- les parties conductrices nues à l'intérieur d'un compartiment pour piles ou batteries conforme à 2.1.1.2;
- les parties nues conductrices des CIRCUITS TRT-1 qui ont un point quelconque connecté, conformément à 2.6.1 d), à une borne de mise à la terre de protection;
- les parties nues conductrices des connecteurs dans les CIRCUITS TRT-1 qui sont séparées des parties conductrices accessibles non mises à la terre du matériel conformément à 6.2.1.

NOTE 2 Un exemple typique est l'enveloppe d'un connecteur coaxial.

NOTE 3 L'accès aux CIRCUITS TRT-1 et aux CIRCUITS TRT-3 à travers d'autres circuits est également restreint par 6.2.1, dans certains cas.

Il n'y a pas de restriction pour l'accès aux CIRCUITS A LIMITATION DE COURANT.

Ces exigences sont applicables à toutes les positions du matériel, lorsqu'il est équipé de conducteurs et mis en fonctionnement en usage normal.

La protection doit être réalisée par isolation ou par mise en place de dispositifs de garde ou par utilisation de verrouillages.

La vérification est effectuée par tout ce qui suit:

a) Par un examen.

b) Par un essai avec le doigt d'épreuve, Figure 2A, qui ne doit pas se trouver en contact avec les parties décrites ci-dessus, lorsqu'il est appliqué aux ouvertures dans les ENVELOPPES après enlèvement des parties détachables par l'OPERATEUR, y compris les portes fusibles, et avec les portes et couvercles accessibles à l'OPERATEUR ouverts. Il est permis de laisser les lampes en place pour cet essai. Les connecteurs détachables par l'OPERATEUR, autres que ceux conformes à la CEI 60083, la CEI 60309, la CEI 60320, la CEI 60906-1 ou la CEI 60906-2 doivent également être essayés pendant la déconnexion.

c) Par un essai avec la broche d'essai, Figure 2B, qui ne doit pas se trouver en contact avec des parties nues sous TENSION DANGEREUSE lorsqu'elle est appliquée à travers les ouvertures dans les ENVELOPPES ELECTRIQUES externes. Les parties détachables par l'OPERATEUR, y compris les portes fusibles et les lampes, sont laissées en place, et les portes et couvercles accessibles à l'OPERATEUR sont fermés pendant cet essai.

d) Par un essai avec le calibre d'essai Figure 2C, lorsque cela est approprié.

Le doigt d'épreuve, la broche d'essai et le calibre d'essai sont appliqués comme ci-dessus, sans force appréciable, dans toutes les positions possibles, avec l'exception suivante: les matériels à poser sur le sol et de masse supérieure à 40 kg ne sont pas inclinés.

Le matériel destiné à être encastré, monté sur des racks ou incorporé dans des matériels plus importants est essayé avec l'accès au matériel limité suivant la méthode de fixation indiquée en détail dans les instructions d'installation.

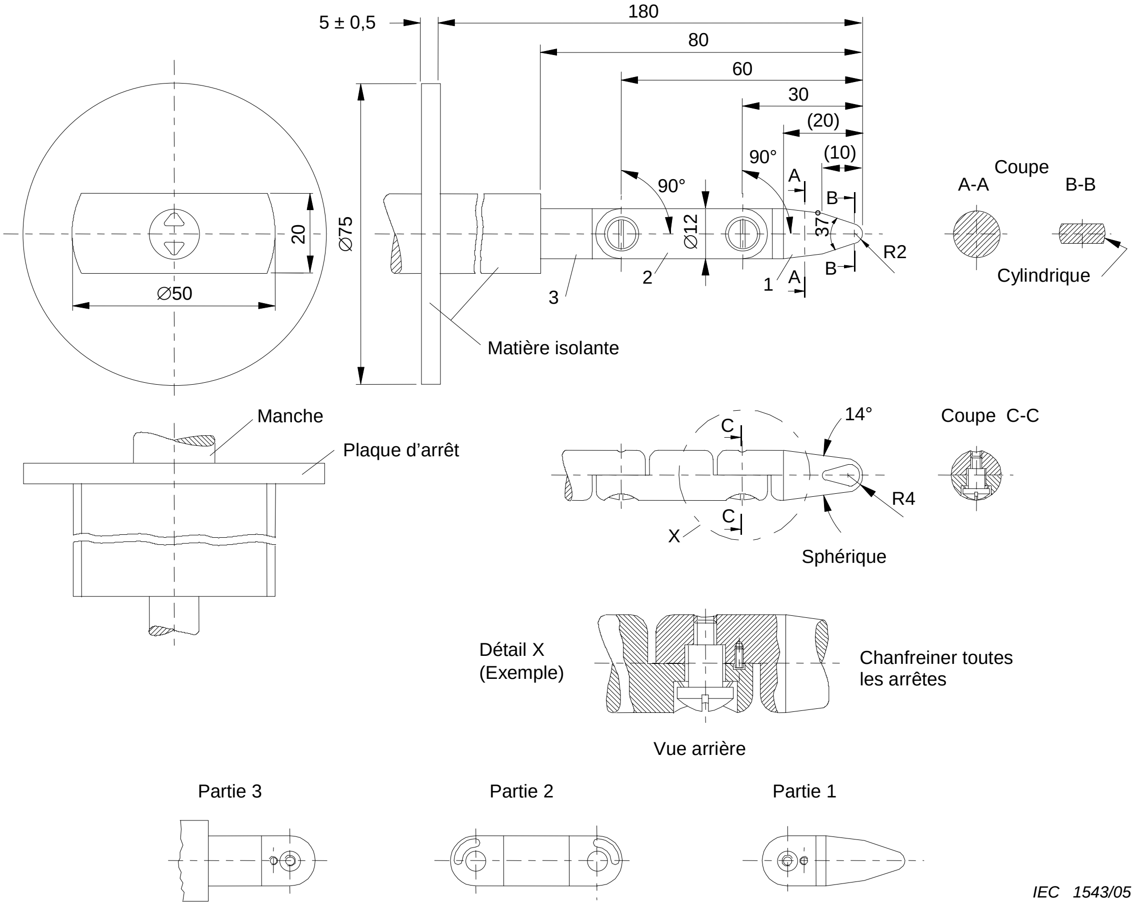
Les ouvertures ne permettant pas l'entrée du doigt d'épreuve, essai b) ci-dessus sont, de plus, essayées au moyen d'un doigt d'épreuve de mêmes dimensions mais droit et sans jointures, qui est appliqué avec une force de 30 N. Si ce dernier doigt d'épreuve pénètre, l'essai b) est répété avec l'exception que le doigt est poussé dans l'ouverture avec toute force nécessaire jusqu'à une valeur de 30 N.

NOTE 4 Si un indicateur de contact électrique est utilisé pour montrer un contact, il y a lieu de prendre des précautions afin que l'application de l'essai ne détériore pas les composants des circuits électroniques.

Lorsque le contact entre l'outil d'essai et la partie n'est pas autorisé dans les essais ci-dessus, il n'y a pas d'exigence d'espace minimal pour les tensions inférieures à 1 000 V en courant alternatif et à 1 500 V en courant continu. Pour des tensions supérieures, il doit y avoir un espace entre la partie sous TENSION DANGEREUSE et le doigt d'épreuve, Figure 2A, ou la broche d'essai, Figure 2B, placé dans la position la plus défavorable. Cet espace, voir la Figure 2D, doit soit

- *avoir une longueur minimale égale à la DISTANCE DANS L'AIR minimale pour l'ISOLATION PRINCIPALE spécifiée en 2.10.3 (ou à l'Annexe G), soit*
- *satisfaire à l'essai de rigidité diélectrique de 5.2.2.*

Si des composants sont réglables, par exemple pour assurer la tension d'une courroie, l'essai au doigt d'épreuve est effectué avec chaque composant réglé dans la position la plus défavorable de la plage de réglage, la courroie étant enlevée, si nécessaire, à cet effet.



Dimensions linéaires en millimètres

Tolérances des dimensions sans indication de tolérances:

– sur les angles de 14° et 37°: ±15′

– sur les rayons: ±0,1 mm

– sur les dimensions linéaires:

≤15 mm:	$^{0}_{-0,1}$ mm
>15 mm ≤ 25 mm:	±0,1 mm
>25 mm:	±0,3 mm

Matériau du doigt: par exemple acier trempé.

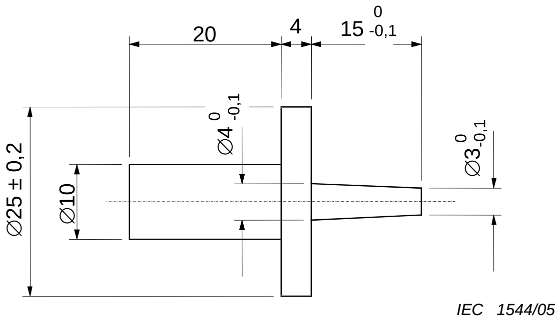
Les deux articulations de ce doigt doivent permettre le mouvement dans le même plan et dans la même direction avec un angle de 90° $^{+10°}_{0}$.

NOTE 1 L'emploi de la solution pointe-rainure n'est qu'une des solutions possibles pour limiter l'angle de pliage à 90°. Pour cette raison, les dimensions et les tolérances de ces détails ne sont pas indiquées dans le dessin. La conception réelle doit assurer un angle de pliage de 90° avec une tolérance de 0° à +10°.

NOTE 2 Les dimensions entre parenthèses sont données uniquement pour information.

NOTE 3 Les dimensions du doigt d'épreuve sont celles données dans la CEI 61032, Figure 2, calibre d'essai B. Dans certains cas, les tolérances sont différentes.

Figure 2A – Doigt d'épreuve

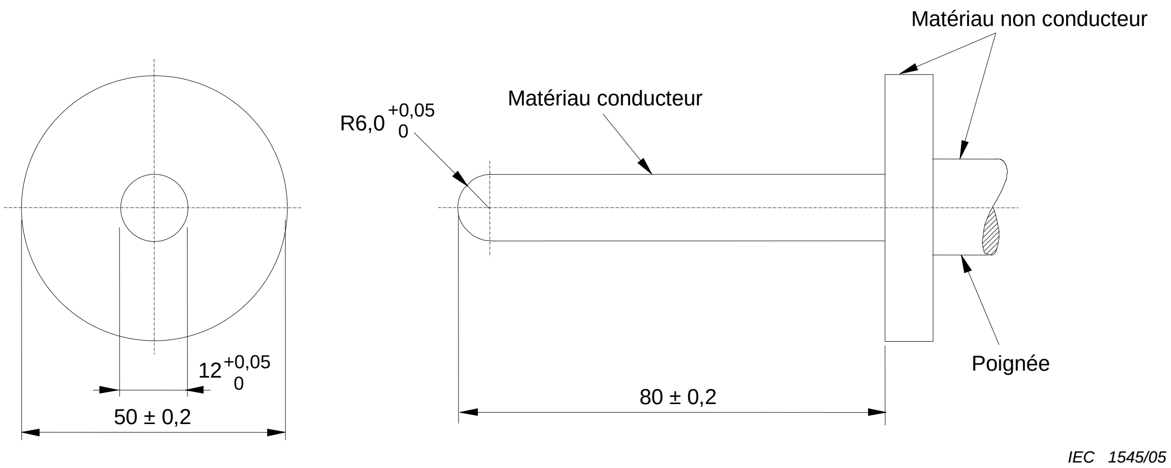


Dimensions en millimètres

Les dimensions de la poignée (Ø 10 et 20) ne sont pas critiques.

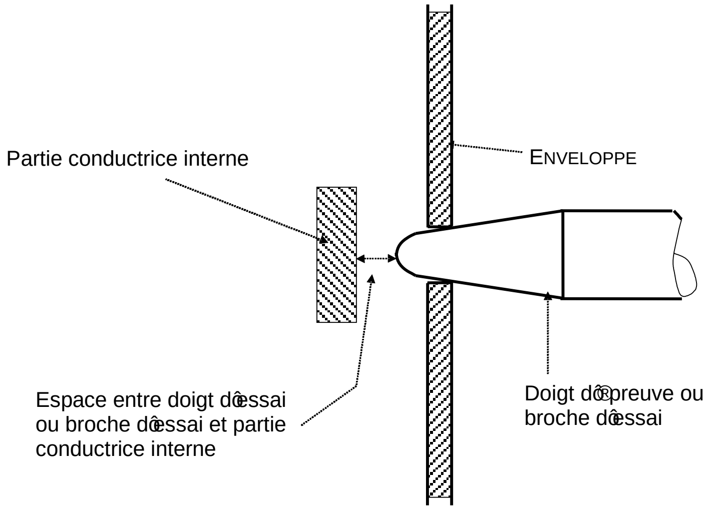
NOTE Les dimensions de la broche d'essai sont celles données dans la CEI 61032, Figure 9, calibre d'essai 13. Dans certains cas, les tolérances sont différentes.

Figure 2B – Broche d'essai



Dimensions en millimètres

Figure 2C – Calibre d'essai



Il nôexiste pas dôexigence dôespace minimal entre le doigt dôessai ou la broche dôessai et la partie conductrice interne pour les tensions jusqu'¨ 1 000 V en courant alternatif et 1 500 V en courant continu.

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Figure 2D – Accessibilité des parties conductrices internes

2.1.1.2 Compartiments pour piles ou batteries

L'acc¯s par un OPERATEUR aux parties conductrices nues des CIRCUITS TRT ¨ l'int®rieur d'un compartiment de batteries dans le mat®riel est permis si toutes les conditions suivantes sont remplies:

- *le compartiment a une porte qui nécessite une action délibérée pour son ouverture, comme l'emploi d'un outil ou d'un dispositif à verrouillage; et*
- *le circuit trt n'est pas accessible lorsque la porte est fermée; et*
- *il y a près de la porte ou sur la porte, si celle-ci est fixée au matériel, un marquage donnant les instructions pour la protection de l'utilisateur lorsque la porte est ouverte.*

Une information indiquant que le c©ble t®l®phonique doit °tre d®connect® du mat®riel avant l'ouverture de la porte est un exemple d'instruction acceptable.

La conformité est vérifiée par examen.

2.1.1.3 Accès au câblage TBT

L'accessibilit® ¨ l'isolation du c©blage interne dans un CIRCUIT TBT par l'OPERATEUR est autoris®e, pourvu que:

a) lôisolation soit conforme aux exigences d'une ISOLATION SUPPLEMENTAIRE d®taill®es en 3.1.4; ou

b) que toutes les conditions suivantes soient remplies:
   - *le câblage ne nécessite pas de manipulation par l'opérateur et il est placé de façon que l'opérateur n'ait pas la possibilité de tirer dessus ou il est fixé de façon que les points de connexion soient soulagés de toute contrainte; et*
   - *le câblage est placé et fixé de façon à ne pas toucher des parties conductrices accessibles non mises à la terre; et*
   - *l'isolation satisfait aux essais de rigidité diélectrique de 5.2.2 pour l'isolation supplémentaire; et*
   - *la distance à travers l'isolation est supérieure ou égale aux valeurs données dans le Tableau 2A.*

Tableau 2A – Distance à travers l'isolation du câblage interne

TENSION DE SERVICE (en cas de défaillance de l'ISOLATION PRINCIPALE)		Distance minimale à travers l'isolation
V crête ou continue	V efficace (sinusoïdale)	mm
De 71 à 350 inclus	De 50 à 250 inclus	0,17
Supérieure à 350	Supérieure à 250	0,31

La vérification est effectuée par examen, par des mesures et par les essais de 5.2.2.

2.1.1.4 Accès à des circuits sous tension dangereuse

L'isolation du câblage interne sous TENSION DANGEREUSE qui est accessible à l'OPERATEUR ou qui n'est pas placé ou fixé pour l'empêcher de toucher des parties conductrices accessibles non mises à la terre doit satisfaire aux exigences de 3.1.4 pour l'ISOLATION DOUBLE ou l'ISOLATION RENFORCEE.

La vérification est effectuée par examen, par des mesures et, si nécessaire, par un essai.

2.1.1.5 Dangers de transfert d'énergie

Il ne doit pas y avoir de risque de blessure dû à un transfert d'énergie dans une ZONE D'ACCES DE L'OPERATEUR.

La vérification est effectuée par examen, par des mesures et, si nécessaire, par essais.

a) Il existe un risque de blessure dû à un transfert d'énergie s'il est probable qu'au moins deux ou plusieurs parties nues (dont l'une peut être mise à la terre), entre lesquelles existe un NIVEAU D'ENERGIE DANGEREUX, seront court-circuitées par un objet métallique.

b) La probabilité de court-circuiter les parties considérées est déterminée au moyen du doigt d'épreuve, Figure 2A (voir 2.1.1.1), en position droite. Il ne doit pas être possible de court-circuiter ces parties avec ce doigt d'épreuve, appliqué sans force appréciable.

c) L'existence d'un NIVEAU D'ENERGIE DANGEREUX est déterminée comme suit:

1) le matériel étant dans les conditions normales de fonctionnement, une charge résistive variable est connectée entre les parties considérées et réglées pour obtenir un niveau de 240 VA. Si nécessaire, on effectue un réglage supplémentaire pour maintenir les 240 VA pendant 60 s. Si la tension est supérieure à 2 V, la puissance de sortie est à un NIVEAU D'ENERGIE DANGEREUX, sauf si un dispositif de protection contre les surintensités s'ouvre pendant cet essai ou si, pour toute autre raison, la puissance ne peut être maintenue à 240 VA pendant 60 s;

2) l'énergie emmagasinée dans un condensateur est à un NIVEAU D'ENERGIE DANGEREUX si la tension U est de 2 V ou plus et si l'énergie emmagasinée E, calculée par l'équation suivante, ~~dépasse~~ est supérieure ou égale à 20 J:

$$E = 0,5\ CU^2 \times 10^{-6}$$

où

E est l'énergie, en joules (J);

C est la capacité, en microfarads (µF);

U est la tension mesurée aux bornes du condensateur, en volts (V).

2.1.1.6 Organes de commande

Les axes conducteurs des boutons de commande, des poignées, des leviers et des organes de manœuvre analogues situés dans des ZONES D'ACCES DE L'OPERATEUR ne doivent pas être connectés à des parties sous TENSION DANGEREUSE, des CIRCUITS TBT ou des CIRCUITS TRT.

De plus, les poignées, leviers, boutons de commande et les organes de manœuvres analogues conducteurs qui sont manœuvrés en usage normal et qui sont mis à la terre uniquement par un pivot ou par un roulement doivent être soit:

– séparés des tensions dangereuses par une isolation double ou renforcée; soit
– avoir leurs parties accessibles couvertes par une isolation supplémentaire pour une tension dangereuse et par une isolation principale pour un circuit trt.

La vérification est effectuée par examen, par des mesures et par les essais de rigidité diélectrique applicables de 5.2.2.

2.1.1.7 Décharge des condensateurs dans le matériel

Le matériel doit être conçu de façon qu'en un point externe de déconnexion d'un RESEAU D'ALIMENTATION accessible à l'OPERATEUR, le risque de choc électrique dû à la charge stockée des condensateurs connectés dans le matériel soit réduit. Aucun essai de choc électrique n'est requis à moins que la tension nominale du RESEAU D'ALIMENTATION ne dépasse 42,4 V en valeur de crête ou 60 V en courant continu.

La vérification est effectuée par examen du matériel et des schémas des circuits correspondants en tenant compte de la possibilité de déconnexion de l'alimentation avec l'interrupteur «MARCHE»/«ARRÊT» dans chacune des positions.

Le matériel est considéré comme conforme si tout condensateur ayant une valeur de capacité marquée ou nominale supérieure à 0,1 µF et dans un circuit relié au RESEAU D'ALIMENTATION a un moyen de décharge entraînant une constante de temps inférieure ou égale à:

– *1 s pour les matériels du type a raccordés par prise de courant; et*
– *10 s pour les matériels du type b raccordés par prise de courant.*

La constante de temps correspondante est le produit de la capacité effective en microfarads par la résistance effective de décharge en mégohms. S'il est difficile de déterminer les valeurs de la capacité effective et de la résistance effective, une mesure de la décroissance de la tension au point externe de déconnexion peut être utilisée. Lorsqu'on réalise la mesure de la décroissance de la tension, ~~le résultat est rapporté à~~ la mesure est soit faite avec, ou soit rapportée à, un appareil, ayant une impédance d'entrée comprenant une résistance de 100 M$\Omega \pm$ 5 MΩ en parallèle avec une capacité d'entrée ~~de 20 pF ± 5 pF~~ inférieure ou égale à 25 pF.

NOTE Pendant un intervalle égal à une constante de temps, la tension se sera réduite à 37 % de sa valeur initiale.

2.1.1.8 Dangers liés à l'énergie – réseaux d'alimentation en courant continu

Le matériel doit être conçu de manière à ce qu'un point extérieur de déconnexion accessible à l'OPERATEUR d'un RESEAU D'ALIMENTATION EN COURANT CONTINU soit dans une des situations suivantes:

– *il n'existe pas de niveau d'énergie dangereux (par exemple dû à la charge stockée sur un condensateur ou une batterie dans le matériel ou à un réseau redondant d'alimentation en courant continu en alimentation de secours), ou*
– *le niveau d'énergie dangereux est éliminé dans les 2 s qui suivent la déconnexion.*

Les points extérieurs de déconnexion comprennent les fiches des MATERIELS RACCORDES PAR PRISE DE COURANT et les interrupteurs sectionneurs extérieurs au matériel.

La vérification est effectuée par l'examen du matériel et des schémas des circuits correspondants en tenant compte de la possibilité de déconnexion de l'alimentation avec l'interrupteur «MARCHE»/«ARRÊT» dans chacune des positions.

Si nécessaire, l'existence d'un NIVEAU D'ENERGIE DANGEREUX est déterminée comme suit:

a) Condensateur connecté à un RESEAU D'ALIMENTATION EN COURANT CONTINU

Un essai est réalisé, le matériel fonctionnant normalement. Le RESEAU D'ALIMENTATION EN COURANT CONTINU est ensuite déconnecté et la tension à travers le condensateur (U) est mesurée 2 s après la déconnexion.

L'énergie stockée est calculée à partir de la formule suivante:

$$E = 0,5\ CU^2 \times 10^{-6}$$

où

E est l'énergie, en joules (J);

C est la capacité, en microfarads (µF);

U est la tension mesurée aux bornes du condensateur, en volts (V).

Un NIVEAU D'ENERGIE DANGEREUX existe si la tension, U, est égale à 2 V ou plus et si l'énergie ~~stockée~~ emmagasinée, E, est supérieure ou égale à 20 J.

b) Batterie interne connectée à un RESEAU D'ALIMENTATION EN COURANT CONTINU

Un essai est réalisé, le RESEAU D'ALIMENTATION EN COURANT CONTINU étant déconnecté et une charge résistive étant connectée aux bornes d'entrée là où le RESEAU D'ALIMENATION EN COURANT CONTINU est normalement connecté. L'appareil en essai est mis en fonctionnement avec alimentation par sa batterie interne. La charge variable est réglée de manière à tirer 240 VA. Si nécessaire, un réglage supplémentaire est réalisé pour maintenir la valeur de 240 VA pendant 60 s.

Si U est supérieure à 2 V, la puissance de sortie est à un NIVEAU D'ENERGIE DANGEREUX, sauf si un dispositif de protection contre les surintensités s'ouvre au cours de l'essai ci-dessus ou si, pour toute autre raison, la puissance ne peut pas être maintenue à 240 VA pendant 60 s.

Si la puissance de sortie présente un NIVEAU D'ENERGIE DANGEREUX, un essai supplémentaire est réalisé avec la charge variable déconnectée et l'APPAREIL EN ESSAI mis en fonctionnement à partir du RESEAU D'ALIMENTATION EN COURANT CONTINU.

L'alimentation est déconnectée et le niveau d'énergie aux bornes d'entrée, 2 s après la déconnexion, ne doit pas être à un NIVEAU D'ENERGIE DANGEREUX.

NOTE On estime qu'il sera possible de court-circuiter les parties accidentellement à l'extérieur du matériel. Il n'existe pas d'essai pour déterminer la probabilité de court-circuiter des parties.

2.1.1.9 Amplificateurs audio dans les matériels de traitement de l'information

Les circuits accessibles, les bornes et les parties des amplificateurs audio et des circuits associés doivent être conformes soit

– *à 2.1.1.1 de la présente norme, soit*

– *à 9.1.1 de la CEI 60065.*

La vérification est effectuée par examen et, si nécessaire, par les essais de 9.1.1 de la CEI 60065, au cours desquels les amplificateurs audio sont mis en fonctionnement conformément à 4.2.4 de la CEI 60065.

2.1.2 Protection dans une zone d'accès pour la maintenance

Dans une ZONE D'ACCES POUR LA MAINTENANCE, les exigences suivantes s'appliquent.

Les exigences de 2.1.1.7 s'appliquent à tous les types de matériels et, pour les MATERIELS RELIES A DEMEURE AU RESEAU, la limite de constante de temps est de 10 s. En outre, les exigences de 2.1.1.8 s'appliquent.

Les parties nues sous des TENSIONS DANGEREUSES doivent être situées ou protégées de sorte que des contacts involontaires avec de telles parties ne soient pas susceptibles de se produire au cours d'opérations de maintenance concernant d'autres parties du matériel.

Les parties nues fonctionnant sous des TENSIONS DANGEREUSES doivent être situées ou protégées de sorte qu'un court-circuit involontaire avec des CIRCUITS TBTS ou des CIRCUITS TRT (par exemple par des OUTILS ou des calibres d'essai utilisés par le PERSONNEL DE MAINTENANCE) soit improbable.

Aucune exigence n'est spécifiée concernant l'accessibilité aux CIRCUITS TBT ou aux CIRCUITS TRT. Toutefois, les parties nues qui présentent un NIVEAU D'ENERGIE DANGEREUX doivent être situées ou protégées de telle façon qu'un court-circuit involontaire, par des matériaux conducteurs qui peuvent être présents, ne soit pas susceptible de se produire pendant les opérations de maintenance concernant d'autres parties du matériel.

Toutes les protections prescrites pour la conformité à 2.1.2 doivent être aisément amovibles et remplaçables si leur retrait est nécessaire pour la maintenance.

La vérification est effectuée par examen et par des mesures. Pour décider si un contact avec des parties nues est ou n'est pas susceptible de se produire, il est tenu compte de la façon dont le PERSONNEL DE MAINTENANCE a besoin d'accéder au-delà, ou à proximité, des parties nues pour intervenir sur d'autres parties. Pour la détermination d'un NIVEAU D'ENERGIE DANGEREUX, voir 2.1.1.5 c).

2.1.3 Protection dans un emplacement à accès restreint

Pour les matériels à installer dans les EMPLACEMENTS A ACCES RESTREINT, les exigences pour les ZONES D'ACCES DE L'OPERATEUR s'appliquent à l'exception de ce qui est permis dans les quatre alinéas suivants.

En général, les exigences de 2.1.1.7 et 2.1.1.8 s'appliquent à tous les types de matériels sauf aux MATERIELS RELIES A DEMEURE. Toutefois, des marquages et des instructions appropriés doivent être fournis pour protéger contre les dangers de transfert d'énergie en présence d'un NIVEAU D'ENERGIE DANGEREUX.

Si un CIRCUIT SECONDAIRE sous TENSION DANGEREUSE est utilisé pour alimenter un générateur de signal de sonnerie qui satisfait à 2.3.1 b), le contact avec les parties nues du circuit est permis avec le doigt d'épreuve, Figure 2A (voir 2.1.1.1). Toutefois, de telles parties doivent être situées ou protégées de telle sorte qu'un contact involontaire ne soit pas susceptible de se produire.

Les parties nues qui présentent un NIVEAU D'ENERGIE DANGEREUX doivent être situées ou protégées de telle façon qu'un court-circuit involontaire par des matériaux conducteurs qui peuvent être présents ne soit pas susceptible de se produire.

Aucune exigence n'est spécifiée concernant le contact avec les parties nues des CIRCUITS TRT-1, TRT-2 et TRT-3.

La vérification est effectuée par examen et par des mesures. Pour décider si un contact avec des parties nues est ou n'est pas susceptible de se produire, il faut tenir compte de la façon dont le PERSONNEL DE MAINTENANCE *a besoin d'accéder au-delà, ou à proximité, des parties nues pour intervenir sur d'autres parties. Pour la détermination d'un* NIVEAU D'ENERGIE DANGEREUX*, voir 2.1.1.5 c).*

2.2 Circuits TBTS

2.2.1 Exigences générales

Les CIRCUITS TBTS doivent présenter des tensions de contact sûres, à la fois dans les conditions normales de fonctionnement et après un premier défaut (voir 1.4.14). Lorsque aucune charge extérieure n'est appliquée à un CIRCUIT TBTS (circuit ouvert), les limites de tension de 2.2.2 et 2.2.3 ne doivent pas être dépassées.

La conformité avec 2.2.1 à 2.2.4 est vérifiée par examen et par les essais appropriés.

2.2.2 Tensions dans les conditions normales

Dans un CIRCUIT TBTS unique ou dans des CIRCUITS TBTS interconnectés, la tension entre deux conducteurs quelconques du CIRCUIT ou des CIRCUITS TBTS et entre un de ces conducteurs quelconques et la terre (voir 1.4.9), ne doit pas dépasser 42,4 V valeur de crête, ou 60 V tension continue, dans les conditions normales de fonctionnement.

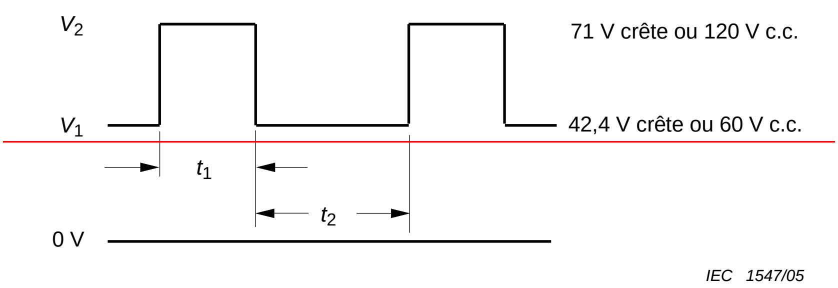
NOTE 1 Un circuit qui est conforme aux exigences ci-dessus mais qui est soumis à des surtensions provenant d'un RESEAU DE TELECOMMUNICATIONS ou d'un SYSTEME DE DISTRIBUTION PAR CABLES est un CIRCUIT TRT-1.

NOTE 2 Pour les conditions normales, la limite de tension des CIRCUITS TBTS est la même que pour un CIRCUIT TBT; un CIRCUIT TBTS peut être considéré comme un CIRCUIT TBT avec une protection supplémentaire dans les conditions de défaut.

2.2.3 Tensions dans les conditions de défaut

A l'exception de ce qui est permis en 2.3.2.1 b), dans l'éventualité d'un premier défaut (voir 1.4.14), les tensions entre deux conducteurs quelconques du CIRCUIT ou de CIRCUITS TBTS et entre un de ces conducteurs quelconques et la terre (voir 1.4.9), ne doivent pas être supérieures à 42,4 V valeur de crête, ou 60 V tension continue (V_1 à la Figure 2E.1 et Figure 2E.2) pendant plus de 200 ms. De plus, une limite de 71 V valeur de crête ou 120 V ~~tension continue~~ crête (V_2 à la Figure 2E.1 et Figure 2E.2) ne doit pas être dépassée.

NOTE Au Canada et aux Etats-Unis, l'exception prévue en 2.3.2.1 b) n'est pas permise.



~~**Figure 2E – Tensions dans les circuits TBTS dans les conditions de premier défaut**~~

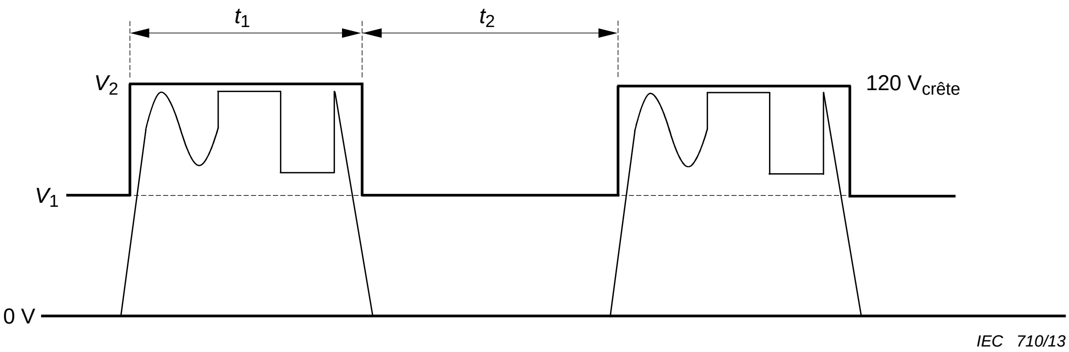


Figure 2E.1 – Tensions dans les circuits TBTS dans des conditions de premier défaut pour une seule impulsion au-dessus de *V*1

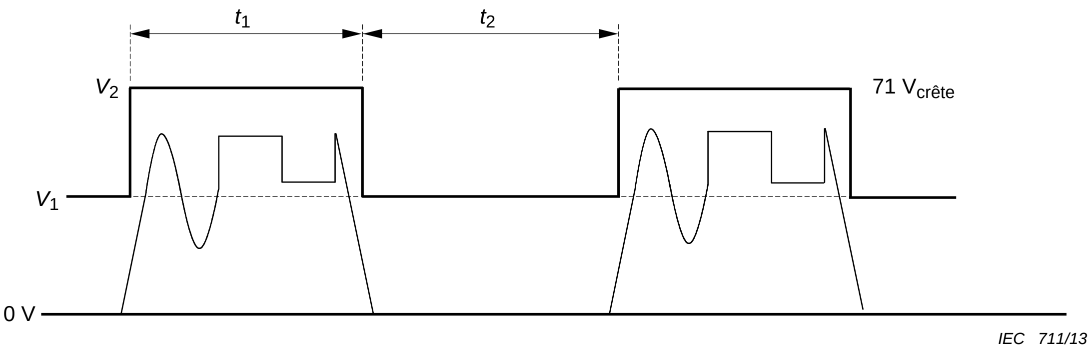


Figure 2E.2 – Tensions dans les circuits TBTS dans des conditions de premier défaut pour impulsions multiples au-dessus de *V*1

Figure 2E – Tensions dans les circuits TBTS dans les conditions de premier défaut

Pour les tensions de nature répétitive après un défaut (par exemple provenant d'alimentation en mode de protection en courant avec réarmement continu), des impulsions supplémentaires supérieures à V_1 (mais inférieures à V_2) sont autorisées dans les conditions suivantes:

– si $t_1 \leq 20$ ms, t_2 doit être supérieur à 1 s;

– si $t_1 > 20$ ms, t_2 doit être supérieur à 3 s; et

– t_1 ne doit pas dépasser 200 ms.

~~Une seule impulsion supérieure à V_1 est autorisée pendant la période t_1, mais elle peut avoir n'importe quelle forme d'onde.~~

Une limite de 120 $V_{crête}$ s'applique si l'impulsion passe au-dessus de V_1 une seule fois pendant le temps t_1 (voir Figure 2E.1 par exemple).

Une limite de 71 $V_{crête}$ s'applique si l'impulsion passe au-dessus de V_1 plus d'une fois pendant le temps t_1 (voir Figure 2E.2 par exemple).

A l'exception de ce qui est permis en 2.2.4, un circuit TBTS doit être séparé d'une partie soumise à une TENSION DANGEREUSE par une ou plusieurs des constructions spécifiées en 2.9.4.

Il est permis que certaines parties d'un circuit (par exemple un circuit transformateur-redresseur) satisfassent aux exigences pour les CIRCUITS TBTS et soient accessibles à l'OPERATEUR, alors que d'autres parties du même circuit ne satisfont pas à toutes les exigences pour le CIRCUIT TBTS et ne sont donc pas autorisées à être accessibles à l'OPERATEUR.

2.2.4 Connexion des circuits TBTS à d'autres circuits

Il est permis qu'un CIRCUIT TBTS soit connecté à d'autres circuits pourvu que, lorsque le CIRCUIT TBTS est ainsi connecté, toutes les conditions suivantes soient remplies:

– à l'exception de ce qui est permis en 1.5.7 et 2.4.3, le CIRCUIT TBTS doit être séparé de tout CIRCUIT PRIMAIRE (y compris le neutre) à l'intérieur du matériel par une ISOLATION PRINCIPALE; et
– le CIRCUIT TBTS satisfait aux limites de 2.2.2 dans les conditions normales de fonctionnement; et
– à l'exception de ce qui est spécifié en 2.3.2.1 b), le CIRCUIT TBTS satisfait aux limites de 2.2.3 dans le cas de premier défaut (voir 1.4.14) dans le CIRCUIT TBTS, ou dans le CIRCUIT SECONDAIRE auquel le CIRCUIT TBTS est connecté.

Si un CIRCUIT TBTS est connecté à un ou plusieurs autres circuits, le CIRCUIT TBTS est la partie qui satisfait aux exigences de 2.2.2 et 2.2.3.

Si un CIRCUIT TBTS est alimenté électriquement par un CIRCUIT SECONDAIRE qui est séparé d'un circuit sous TENSION DANGEREUSE par:

– une double isolation ou une isolation renforcée; ou
– un écran conducteur mis à la terre qui est séparé du circuit SOUS TENSION DANGEREUSE par une ISOLATION PRINCIPALE,

le CIRCUIT TBTS doit être considéré comme étant séparé du circuit sous TENSION DANGEREUSE par la même méthode.

NOTE Pour les exigences applicables en Norvège, voir 1.7.2.1 Note 6, 6.1.2.1 Note 2 et 6.1.2.2 Note.

Si un CIRCUIT TBTS est créé à partir d'un CIRCUIT SECONDAIRE sous TENSION DANGEREUSE, et que le CIRCUIT SECONDAIRE sous TENSION DANGEREUSE est séparé du CIRCUIT PRIMAIRE par UNE DOUBLE ISOLATION ou par une ISOLATION RENFORCEE, le CIRCUIT TBTS doit rester dans les limites données en 2.2.3 dans les conditions du premier défaut (voir 1.4.14). Dans ce cas, dans le but d'appliquer les conditions de premier défaut, le fait de court-circuiter l'isolation dans un transformateur qui assure la séparation entre le CIRCUIT SECONDAIRE sous TENSION DANGEREUSE et le CIRCUIT TBTS est considéré comme un premier défaut, pourvu que l'isolation dans le transformateur satisfasse à un essai de rigidité diélectrique pour l'ISOLATION PRINCIPALE conformément à 5.2.2.

2.3 Circuits TRT

2.3.1 Limites

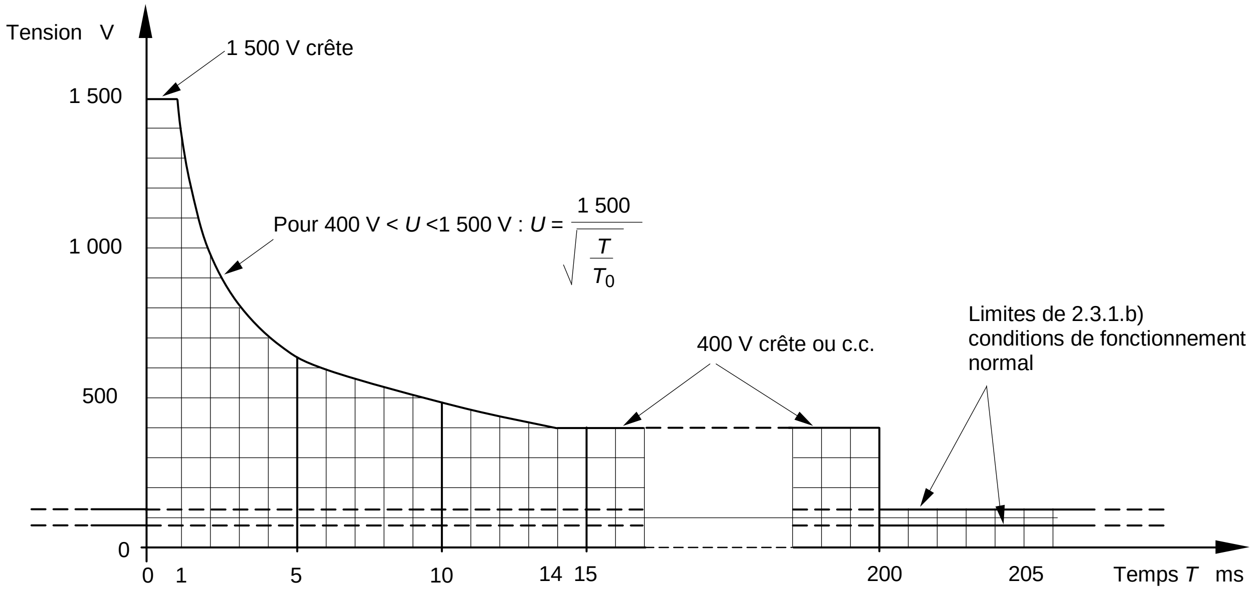
Dans un CIRCUIT TRT unique ou dans des CIRCUITS TRT interconnectés, la tension entre deux conducteurs quelconques du ou des CIRCUITS TRT et entre un de ces conducteurs quelconques et la terre (voir 1.4.9) doit satisfaire à ce qui suit.

a) CIRCUITS TRT-1

Les tensions ne dépassent pas ce qui suit:

– les limites de tension de 2.2.2 pour un CIRCUIT TBTS dans les conditions normales de fonctionnement;
– les limites de tensions de la Figure 2F mesurées à travers une résistance de 5 000 Ω ± 2 % dans l'éventualité d'un premier défaut (voir 1.4.14) dans le matériel.

NOTE 1 Dans l'éventualité d'un premier défaut de l'isolation ou de la défaillance d'un composant, la limite après 200 ms est la limite de 2.3.1 b) pour un CIRCUIT TRT-2 ou TRT-3 pour les conditions normales de fonctionnement.



U V

T ms

T_0 1 ms

Figure 2F – Tensions maximales admises après un premier défaut

b) CIRCUITS TRT-2 et TRT-3

Les tensions dépassent les limites de 2.2.2 pour un CIRCUIT TBTS mais ne dépassent pas ce qui suit:

– lorsque les signaux de sonnerie de téléphone sont présents, des tensions telles que le signal satisfait aux critères des Articles M.2 ou M.3;

– en l'absence de signaux de sonnerie de téléphone:

- une combinaison des TENSIONS CONTINUE et alternative dans les conditions normales de fonctionnement, telle que:

$$\frac{U_{ca}}{71} + \frac{U_{cc}}{120} \leq 1$$

où

U_{ca} est la valeur crête de la tension alternative (V) à n'importe quelle fréquence;

U_{cc} est la valeur de la TENSION CONTINUE (V).

NOTE 2 Si U_{cc} a la valeur zéro, U_{ca} peut atteindre 71 V valeur de crête.

NOTE 3 Si U_{ca} a la valeur zéro, U_{cc} peut atteindre 120 V.

et

- les limites de tensions de la Figure 2F mesurées à travers une résistance de 5 000 Ω ± 2 % dans l'éventualité d'un premier défaut (voir 1.4.14) dans le matériel.

La vérification est effectuée par examen et par des mesures.

NOTE 4 Les signaux télégraphiques et les signaux de télétype peuvent être présents sur les RESEAUX DE TELECOMMUNICATIONS existants. Toutefois, l'utilisation de ces signaux est considérée comme obsolète et leurs caractéristiques ne sont pas prises en considération dans la présente norme.

2.3.2 Séparation des circuits TRT des autres circuits et des parties accessibles

NOTE En Finlande, en Norvège et en Suède, il existe des exigences complémentaires d'isolation, voir 6.1.2.1 Note 2 et 6.1.2.2 Note.

2.3.2.1 Exigences générales

NOTE 1 Voir également 6.1.2, 6.2 et 7.3.

Les CIRCUITS TBTS, les CIRCUITS TRT-1 et les parties conductrices accessibles doivent être séparées des CIRCUITS TRT-2 et TRT-3 de telle manière qu'en cas de premier défaut (voir 1.4.14) les deux conditions suivantes soient satisfaites:

a) les tensions des CIRCUITS TRT-1 ne dépassent pas les limites de la Figure 2F; et

b) les tensions des CIRCUITS TBTS et des parties conductrices accessibles ne dépassent pas les limites spécifiées en 2.3.1 b) pour les CIRCUITS TRT-2 ET TRT-3 dans les conditions de fonctionnement normal.

NOTE 2 Au Canada et aux Etats Unis, en cas de premier défaut comme décrit ci-dessus, les limites de 2.2.3 s'appliquent aux CIRCUITS TBTS et aux parties conductrices accessibles.

NOTE 3 Dans les conditions normales de fonctionnement, les limites de 2.2.2 s'appliquent toujours à chaque CIRCUIT TBTS et partie conductrice accessible.

NOTE 4 Les limites de 2.3.1 s'appliquent toujours à chaque CIRCUIT TRT.

Au choix du fabricant, il est permis de traiter un CIRCUIT TRT-1 ou TRT-2 comme un circuit TRT-3. Dans ce cas, le CIRCUIT TRT-1 OU TRT-2 doit satisfaire toutes les exigences de séparation pour un CIRCUIT TRT-3.

Une des méthodes spécifiées en 2.3.2.2, 2.3.2.3, 2.3.2.4 et 2.10.5.13 doit être utilisée**.**

La vérification est effectuée comme spécifié en 2.3.2.2, 2.3.2.3, 2.3.2.4 ou 2.10.5.13.

2.3.2.2 Protection par l'isolation principale

Les exigences de 2.3.2.1 sont satisfaites si les parties sont séparées par l'ISOLATION PRINCIPALE.

La vérification est effectuée par un examen, une mesure et l'essai de rigidité diélectrique de l'ISOLATION PRINCIPALE et, si nécessaire, par la simulation des défaillances des composants et de l'ISOLATION PRINCIPALE (voir 1.4.14). Toutefois, si une étude des schémas des circuits montre clairement que les limites spécifiées en 2.3.1 b) ne seront pas dépassées, il n'est pas nécessaire de simuler la défaillance des composants ni de l'ISOLATION PRINCIPALE.

NOTE 1 L'essai de 2.3.5 n'est pas requis.

NOTE 2 Lorsque l'ISOLATION PRINCIPALE est fournie et lorsque 6.2.1 s'applique aussi à cette isolation, la tension d'essai prescrite en 6.2.2 est, dans la plupart des cas, supérieure à celle pour l'ISOLATION PRINCIPALE.

2.3.2.3 Protection par mise à la terre

Les exigences de 2.3.2.1 sont considérées comme satisfaites si le CIRCUIT TBTS, le CIRCUIT TRT-1 ou la partie conductrice accessible est connecté à la borne principale de mise à la terre de protection conformément à 2.6.1 c) ou d); et un des points suivants , a), b), c) ou d) s'applique.

a) pour les MATERIELS RACCORDES PAR PRISE DE COURANT, une borne de mise à la terre séparée doit être fournie en plus de la borne principale de mise à la terre de protection, si elle existe (voir 2.6.4.1). Les instructions d'installation doivent spécifier que cette borne séparée de mise à la terre de protection est reliée à la terre de façon permanente.

b) Pour les MATERIELS DE TYPE B RACCORDES PAR PRISE DE COURANT ayant des connexions avec les RESEAUX DE TELECOMMUNICATIONS ou les SYSTEMES DE DISTRIBUTION PAR CABLES qui sont tous raccordés par prise de courant, un marquage doit être fourni sur le matériel et une indication doit être fournie dans les instructions d'installation. Ils doivent spécifier que l'UTILISATEUR doit déconnecter tous les connecteurs du RESEAU DE TELECOMMUNICATION et du SYSTEME DE DISTRIBUTION PAR CABLES avant de déconnecter le CABLE D'ALIMENTATION.

c) Pour les MATERIELS DE TYPE A RACCORDES PAR PRISE DE COURANT, les exigences de b) ci-dessus s'appliquent et, de plus, les instructions d'installation doivent spécifier qu'ils doivent être installés par le PERSONNEL DE MAINTENANCE et connectés à un socle équipé d'un contact de mise à la terre de protection.

d) Pour les MATERIELS RELIES A DEMEURE, il n'y a pas d'exigence supplémentaire.

NOTE Si une mise à la terre est prévue et qu'elle n'est pas conforme à a), b), c) ou d), voir 2.3.2.4.

La vérification est effectuée par examen et, si nécessaire, par simulation des défaillances de composants ou de l'isolation telles qu'elles sont susceptibles de survenir dans le matériel (voir 1.4.14). Les limites de tension spécifiées en 2.3.2.1 doivent être satisfaites.

De plus, l'essai de 2.3.5 doit être effectué si le CIRCUIT TRT-2 ou le CIRCUIT TRT-3 est destiné à recevoir des signaux ou de la puissance qui sont générés à l'extérieur pendant le fonctionnement normal (par exemple dans un RESEAU DE TELECOMMUNICATIONS). Des premiers défauts ne sont pas simulés au cours de l'essai de 2.3.5.

Avant les essais ci-dessus, une isolation qui ne satisfait pas aux exigences pour l'ISOLATION PRINCIPALE est court-circuitée. Toutefois, si la simulation des défaillances est plus sévère si elle est conduite sans court-circuit de l'isolation, l'essai est réalisé sans le court-circuit.

2.3.2.4 Protection avec d'autres constructions

D'autres constructions sont autorisées si elles assurent que les limites de tension spécifiées en 2.3.2.1 sont satisfaites mais ne sont pas fondées sur l'ISOLATION PRINCIAPLE ou la mise à la terre ou sur la séparation comme spécifié en 2.10.5.13.

La vérification est effectuée par simulation des défaillances des composants ou de l'isolation telles qu'elles sont susceptibles de survenir dans le matériel (voir 1.4.14).

Si une mise à la terre est prévue et qu'elle n'est pas conforme à 2.3.2.3 a), b), c) ou d), les essais sont réalisés, l'appareil en essai n'étant pas relié à la terre. Les limites de tension spécifiées en 2.3.2.1 doivent être satisfaites.

De plus, l'essai de 2.3.5 doit être effectué si le CIRCUIT TRT-2 ou le CIRCUIT TRT-3 est destiné à recevoir des signaux ou de la puissance qui sont générés à l'extérieur pendant le fonctionnement normal (par exemple dans un RESEAU DE TELECOMMUNICATIONS). Des premiers défauts ne sont pas simulés au cours de l'essai de 2.3.5.

Avant les essais ci-dessus, une isolation qui ne satisfait pas aux exigences pour l'ISOLATION PRINCIPALE est court-circuitée. Toutefois, si la simulation des défaillances est plus sévère si elle est conduite sans court-circuit de l'isolation, l'essai est réalisé sans le court-circuit.

2.3.3 Séparation des tensions dangereuses

A l'exception de ce qui est permis en 2.3.4, un CIRCUIT TRT doit être séparé des circuits soumis à une TENSION DANGEREUSE par une ou plusieurs des constructions spécifiées en 2.9.4.

La vérification est effectuée par examen et par des mesures.

2.3.4 Connexion des circuits TRT à d'autres circuits

Avec les exceptions indiquées en 1.5.7, il est permis de connecter un CIRCUIT TRT à d'autres circuits à condition qu'il soit séparé par une ISOLATION PRINCIPALE de tout CIRCUIT PRIMAIRE (y compris le neutre) à l'intérieur du matériel.

NOTE 1 Les limites de 2.3.1 s'appliquent toujours aux CIRCUITS TRT.

Si un CIRCUIT TRT est connecté à un ou plusieurs autres circuits, le CIRCUIT TRT est la partie qui satisfait aux limites de 2.3.1.

Si l'alimentation d'un CIRCUIT TRT provient d'un CIRCUIT SECONDAIRE qui lui est relié électriquement, et qui est séparé d'un circuit sous TENSION DANGEREUSE par:

– une double isolation ou une isolation renforcée; ou
– la mise en place d'un écran conducteur relié à la terre, séparé d'un circuit sous TENSION DANGEREUSE par une ISOLATION PRINCIPALE;

le CIRCUIT TRT doit être considéré comme étant séparé du circuit sous TENSION DANGEREUSE par la même méthode.

Si un CIRCUIT TRT est créé à partir d'un CIRCUIT SECONDAIRE sous TENSION DANGEREUSE, et que le CIRCUIT SECONDAIRE sous TENSION DANGEREUSE est séparé du CIRCUIT PRIMAIRE par UNE DOUBLE ISOLATION ou par une ISOLATION RENFORCEE, le CIRCUIT TRT doit rester dans les limites données en 2.3.1 dans les conditions du premier défaut (voir 1.4.14). Dans ce cas, dans le but d'appliquer les conditions de premier défaut, le fait de court-circuiter l'isolation dans un transformateur qui assure la séparation entre le CIRCUIT SECONDAIRE sous TENSION DANGEREUSE et le CIRCUIT TRT est considéré comme un premier défaut, pourvu que l'isolation dans le transformateur satisfasse à un essai de rigidité diélectrique pour l'ISOLATION PRINCIPALE conformément à 5.2.2.

La vérification est effectuée par examen et par simulation de premiers défauts (voir 1.4.14) tels qu'ils sont susceptibles de se produire dans le matériel. De telles simulations de défauts ne doivent pas avoir pour effet que les tensions relevées aux bornes d'une résistance de 5 000 Ω ± 2 % connectée entre deux conducteurs quelconques d'un CIRCUIT TRT, ou entre un quelconque de ces conducteurs et la terre, soient situées en dehors de la surface hachurée de la Figure 2F (voir 2.3.1). L'observation est prolongée jusqu'à ce que les conditions stables aient duré au moins 5 s.

NOTE 2 Pour les exigences applicables en Norvège, voir 1.7.2.1 Note 6, 6.1.2.1 Note 2 et 6.1.2.2 Note.

2.3.5 Essai des tensions de fonctionnement produites extérieurement

Cet essai n'est réalisé que s'il est spécifié en 2.3.2.3 ou en 2.3.2.4.

On utilise un générateur d'essai spécifié par le fabricant, représentant la tension normale de fonctionnement maximale attendue provenant de la source externe. En l'absence d'une telle spécification, on utilise un générateur d'essai qui fournit 120 V ± 2 V en courant alternatif à 50 Hz ou 60 Hz et qui a une impédance interne de 1 200 ± 2 %.

NOTE Le générateur d'essai mentionné ci-dessus n'est pas destiné à représenter les tensions réelles sur le RESEAU DE TELECOMMUNICATIONS mais à apporter des contraintes sur le circuit du matériel à l'essai d'une façon répétitive.

Le générateur d'essai est connecté aux bornes du RÉSEAU DE TÉLÉCOMMUNICATIONS du matériel. Un pôle du générateur d'essai est aussi connecté à la borne de mise à la terre du matériel (voir Figure 2G). La tension d'essai est appliquée pendant une durée maximale de 30 min. S'il est clair qu'il n'y aura pas d'autre détérioration, l'essai est terminé plus tôt.

Pendant l'essai, le CIRCUIT TBTS, le CIRCUIT TRT-1 ou la partie conductrice accessible doit continuer de satisfaire à 2.2.2.

L'essai est répété après inversion des connexions aux bornes du RÉSEAU DE TÉLÉCOMMUNICATIONS du matériel.

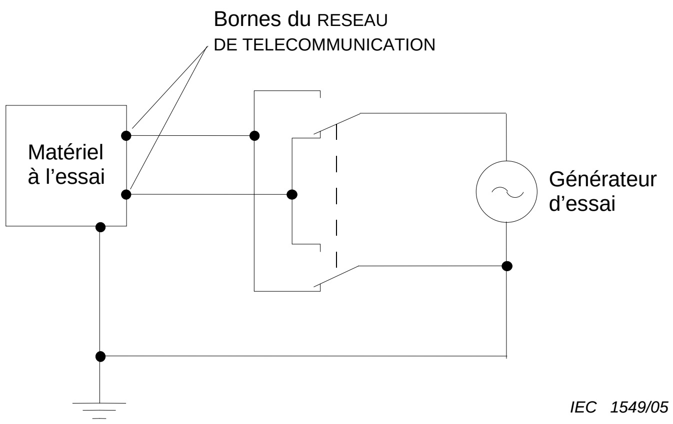


Figure 2G – Générateur d'essai

2.4 Circuits à limitation de courant

2.4.1 Exigences générales

Les CIRCUITS A LIMITATION DE COURANT doivent être conçus de façon que les limites spécifiées en 2.4.2 ne soient pas dépassées dans les conditions normales de fonctionnement et dans le cas d'un premier défaut dans le matériel (voir 1.4.14 et 1.5.7).

A l'exception de ce qui est permis en 2.4.3, la séparation entre les parties accessibles des CIRCUITS A LIMITATION DE COURANT et les autres circuits doit être conforme à ce qui est décrit en 2.2 pour les CIRCUITS TBTS.

La vérification de la conformité aux Paragraphes 2.4.1 à 2.4.3 est effectuée par examen, par une mesure et, si nécessaire, par un essai.

NOTE 1 Une partie conductrice accessible ou un circuit, séparé d'une autre partie par une DOUBLE ISOLATION ou une ISOLATION RENFORCEE, sur laquelle est câblée une résistance ou un groupe de résistances, est traitée comme un CIRCUIT A LIMITATION DE COURANT (voir 1.5.7).

NOTE 2 Un CIRCUIT A LIMITATION DE COURANT peut être dérivé d'un CIRCUIT PRIMAIRE ou d'un CIRCUIT SECONDAIRE.

2.4.2 Valeurs limites

Pour les fréquences ne dépassant pas 1 kHz, le courant permanent mesuré à travers une résistance non inductive de 2 000 Ω ± 10 % connectée entre deux parties quelconques d'un CIRCUIT A LIMITATION DE COURANT, ou entre une telle partie quelconque et la terre (voir 1.4.9), ne doit pas dépasser 0,7 mA, valeur de crête, en courant alternatif, ou 2 mA en courant continu.

Pour les fréquences supérieures à 1 kHz, la limite de 0,7 mA est multipliée par la valeur de la fréquence en kilohertz mais ne doit pas dépasser 70 mA valeur de crête.

En variante, il est permis d'utiliser les appareils de mesure de l'Annexe D à la place de la résistance non inductive de 2 000 Ω ± 10 % mentionnée ci-dessus.

Lorsque l'on utilise l'appareil de mesure de la Figure D.1, la tension, U_2, est mesurée et le courant est calculé en divisant la tension mesurée, U_2, par 500. La valeur calculée ne doit pas dépasser 0,7 mA valeur de crête.

NOTE 1 Si l'un des côtés du CIRCUIT A LIMITATION DE COURANT a une connexion conductrice à la terre, il convient que le point B de l'appareil de mesure de la Figure D.1 soit connecté à ce point.

Lorsqu'on utilise l'appareil de mesure de la Figure D.2, la valeur mesurée du courant ne doit pas dépasser 0,7 mA valeur de crête.

Pour les parties dont la tension ne dépasse pas 450 V valeur de crête ou tension continue, la capacité du circuit ne doit pas dépasser 0,1 µF.

Pour les parties dont la tension *U* dépasse 0,45 kV valeur de crête ou tension continue, mais ne dépasse pas 15 kV valeur de crête ou tension continue, la capacité du circuit ne doit pas dépasser 45/*U* nF, où *U* est exprimé en kilovolts.

NOTE 2 La limite 45/*U* correspond à une charge stockée de 45 µC.

Pour les parties dont la tension *U* dépasse 15 kV valeur de crête ou tension continue, la capacité du circuit ne doit pas dépasser 700 / U^2 nF, où *U* est exprimé en kilovolts.

NOTE 3 La limite de 700/U^2 correspond à une énergie disponible de 350 mJ.

2.4.3 Connexion des circuits à limitation de courant à d'autres circuits

Il est permis que les CIRCUITS A LIMITATION DE COURANT soient alimentés par d'autres circuits, ou connectés à d'autres circuits pourvu que les conditions suivantes soient remplies:

– le CIRCUIT A LIMITATION DE COURANT satisfait aux limites de 2.4.2 dans les conditions normales de fonctionnement;
– le CIRCUIT A LIMITATION DE COURANT continue de satisfaire aux limites de 2.4.2, en cas de premier défaut d'un composant quelconque ou de l'isolation dans le CIRCUIT A LIMITATION DE COURANT, ou d'un composant quelconque ou de l'isolation du circuit auquel il est connecté.

Si un CIRCUIT A LIMITATION DE COURANT est connecté à un ou plusieurs autres circuits, le CIRCUIT A LIMITATION DE COURANT est la partie qui satisfait aux exigences de 2.4.1.

2.5 Sources à puissance limitée

Une source à puissance limitée doit être conforme à l'un des points suivants , a), b), c) ou d):

a) la puissance de sortie est limitée par construction conformément au Tableau 2B; ou

b) une impédance linéaire ou non linéaire limite la puissance de sortie conformément au Tableau 2B. Si un dispositif à coefficient de température positif est utilisé, il doit:
  - satisfaire aux essais spécifiés dans les Articles 15, 17, J.15 et J.17 de la CEI 60730-1; ou
  - satisfaire aux exigences de la CEI 60730-1 pour un dispositif pour une action de type 2.AL.

c) un circuit de régulation, ou un limiteur de courant à circuit intégré (CI), limite la puissance de sortie conformément au Tableau 2B à la fois avec et sans premier défaut simulé (voir 1.4.14) dans le circuit de régulation ou le limiteur de courant à circuit intégré (circuit ouvert ou court-circuit) . Un essai de premier défaut entre l'entrée et la sortie n'est pas réalisé si le limiteur de courant à circuit intégré satisfait à un programme d'essai adapté tel que donné dans l'Annexe CC; ou

d) un dispositif de protection contre les surintensités limite la puissance de sortie conformément au Tableau 2C.

Lorsqu'un dispositif de protection contre les surintensités est utilisé, ce doit être un élément fusible ou un dispositif électromécanique non réglable et non réarmable.

Une source à puissance limitée fonctionnant sur un RESEAU D'ALIMENTATION EN COURANT ALTERNATIF ou une source à puissance limitée fonctionnant sur une batterie qui est rechargée sur un RESEAU D'ALIMENTATION EN COURANT ALTERNATIF pendant qu'elle fournit l'alimentation doit comporter un transformateur d'isolement.

La vérification est effectuée par examen et par des mesures, et, lorsque c'est approprié, par examen des données du fabricant pour les batteries. Les batteries doivent être totalement chargées lors des mesures de U_{oc} et I_{sc} conformément aux Tableaux 2B et 2C.

La charge non capacitive indiquée dans les Tableaux 2B et 2C est réglée pour donner la valeur maximale mesurée de I_{sc} ou S.

Des défauts simulés dans un circuit de régulation, exigé selon le point c) ci-dessus, sont appliqués sous les valeurs maximales mesurées ci-dessus pour I_{sc} ou S.

Tableau 2B – Limites des sources de puissance sans dispositif de protection contre les surintensités

Tension de sortie [a] **(U_{oc})**		**Courant de sortie** [b d] **(I_{sc})**	**Puissance apparente** [c d] **(S)**
V courant alternatif	**V courant continu**	**A**	**VA**
≤ 30	≤ 30	≤ 8,0	≤ 100
–	30 < U_{oc} ≤ 60	≤ 150/U_{oc}	≤ 100

[a] U_{oc}: Tension de sortie mesurée conformément à 1.4.5 avec tous les circuits de charge déconnectés. Les tensions sont pour du courant alternatif pratiquement sinusoïdal et du courant continu sans ondulation. Pour les courants alternatifs non sinusoïdaux et pour les courants continus avec une ondulation supérieure à 10 % crête, la tension crête ne doit pas dépasser 42,4 V.

[b] I_{sc}: Courant maximal de sortie avec une charge non capacitive quelconque, y compris un court-circuit.

[c] S (VA): Puissance de sortie maximale VA avec une charge non capacitive quelconque.

[d] La mesure de I_{sc} et de S est réalisée 5 s après l'application de la charge si la protection est assurée par un circuit électronique ~~ou un dispositif à coefficient de température positif~~, et 60 s pour un dispositif à coefficient de température positif ou dans les autres cas.

Tableau 2C – Limites des sources de puissance avec dispositif de protection contre les surintensités

Tension de sortie [a] **(U_{oc})**		**Courant de sortie** [b] [d] **(I_{sc})**	**Puissance apparente** [c] [d] **(S)**	**Valeur du courant assigné du dispositif de protection contre les surintensités** [e]
V courant alternatif	**V courant continu**	**A**	**VA**	**A**
≤ 20	≤ 20	$\leq 1\ 000/U_{oc}$	≤ 250	$\leq 5{,}0$
$20 < U_{oc} \leq 30$	$20 < U_{oc} \leq 30$			$\leq 100/U_{oc}$
–	$30 < U_{oc} \leq 60$			$\leq 100/U_{oc}$

[a] U_{oc}: Tension de sortie mesurée conformément à 1.4.5 avec tous les circuits de charge déconnectés. Les tensions sont pour du courant alternatif pratiquement sinusoïdal et du courant continu sans ondulation. Pour les courants alternatifs non sinusoïdaux et pour les courants continus avec une ondulation supérieure à 10 % crête, la tension crête ne doit pas dépasser 42,4 V.

[b] I_{sc}: Courant de sortie maximal avec toute charge non capacitive, y compris un court-circuit, mesuré 60 s après avoir appliqué la charge.

[c] S (VA): Puissance de sortie maximale en VA, quelle que soit la charge non capacitive, mesurée 60 s après l'application de la charge.

[d] Les impédances de limitation de courant sont maintenues pendant la mesure mais tout dispositif de protection contre les surintensités est contourné.

NOTE La raison pour laquelle les mesures sont effectuées avec les dispositifs de protection contre les surintensités contournés est de déterminer la quantité d'énergie disponible qui pourrait provoquer un échauffement pendant le délai de fonctionnement des dispositifs de protection contre les surintensités.

[e] Les valeurs du courant assigné du dispositif de protection contre les surintensités sont basées sur des éléments fusibles et des disjoncteurs qui coupent le circuit en moins de 120 s avec un courant égal à 210 % de la valeur du courant spécifiée dans le tableau.

2.6 Dispositions pour la mise à la terre

NOTE Pour les exigences complémentaires concernant la mise à la terre des matériels destinés à être connectés sur les RESEAUX DE TELECOMMUNICATIONS, voir 2.3.2.3, 2.3.2.4, 2.3.3, 2.3.4, 6.1.1 et 6.1.2 et, pour les SYSTEMES DE DISTRIBUTION PAR CABLES, voir 7.2 et 7.4.1.

2.6.1 Terre de protection

Les parties suivantes des matériels doivent être reliées de façon sûre à la borne de terre de protection principale du matériel.

a) Parties conductrices accessibles qui peuvent être supposées à une TENSION DANGEREUSE dans le cas d'un premier défaut (voir 1.4.14).

b) Parties à reliées à la terre comme exigé en 2.9.4 d) ou e).

c) CIRCUITS TBTS, CIRCUITS TRT et parties conductrices accessibles dont la mise à la terre est prescrite par 2.3.2.3 ou 2.3.2.4, si la source de puissance n'est pas un RESEAU DE TELECOMMUNICATIONS ou un SYSTEME DE DISTRIBUTION PAR CABLES.

d) CIRCUITS TBTS, CIRCUITS TRT et parties conductrices accessibles dont la mise à la terre est prescrite par 2.3.2.3, si la source de puissance est un RESEAU DE TELECOMMUNICATIONS ou un SYSTEME DE DISTRIBUTION PAR CABLES.

e) Circuits, écrans de transformateurs et composants (tels que les parasurtenseurs) qui ne sont pas supposés être sous une TENSION DANGEREUSE dans le cas d'un premier défaut (voir 1.4.14) mais que l'on demande de mettre à la terre pour réduire les parasites qui pourraient affecter l'isolation (par exemple voir 6.2.1 et 7.4.1);

f) CIRCUITS TBTS et CIRCUITS TRT dont la mise à la terre est prescrite pour réduire ou éliminer les COURANTS DE CONTACT d'un RESEAU DE TELECOMMUNICATIONS ou un SYSTEME DE DISTRIBUTION PAR CABLES (voir 5.1.8.1).

NOTE Les parties a), b) et c) sont susceptibles de transporter des courants de défaut destinés à faire fonctionner les dispositifs de protection contre les surintensités. Le parties d), e) et f) transportent d'autres courants.

Dans les ZONES D'ACCES POUR LA MAINTENANCE, lorsque les parties conductrices telles que les bâtis moteurs, les châssis électroniques, etc. doivent supporter une TENSION DANGEREUSE dans le cas d'un premier défaut (voir 1.4.14), ces parties conductrices doivent être connectées à la borne de mise à la terre de protection principale. Si cela est impossible ou irréalisable, un marquage adapté doit indiquer au PERSONNEL DE MAINTENANCE que de telles parties ne sont pas mises à la terre et qu'il convient de vérifier qu'elles ne sont pas sous TENSION DANGEREUSE avant de les toucher.

La vérification est effectuée par examen et, lorsque c'est approprié, par les essais spécifiés en 2.6.3.

2.6.2 Mise à la terre fonctionnelle

Dans le cas où la MISE A LA TERRE FONCTIONNELLE des parties conductrices accessibles ~~ou non accessibles~~ est nécessaire, tout ce qui suit s'applique au circuit de MISE A LA TERRE FONCTIONNELLE:

– le CIRCUIT DE TERRE FONCTIONNELLE doit être séparé des parties sous TENSION DANGEREUSE dans les matériels par:

  - une DOUBLE ISOLATION ou une ISOLATION RENFORCEE; ou
  - un écran mis à la terre de protection ou d'autres parties conductrices mises à la terre de protection séparées des parties sous TENSION DANGEREUSE par au moins une ISOLATION PRINCIPALE; et

– il est permis de connecter la MISE A LA TERRE FONCTIONNELLE à la borne de terre de protection, ou à un CONDUCTEUR DE LIAISON A LA TERRE DE PROTECTION; et

– les bornes de raccordement à utiliser uniquement pour la MISE A LA TERRE FONCTIONNELLE ne doivent pas être marquées par le symbole (IEC 60417-5017(DB:2002-10)) ou par le symbole (IEC 60417-5019 (DB:2002-10)), avec l'exception que, lorsqu'une borne de raccordement est fournie sur un composant (par exemple un bornier) ou sur un sous-ensemble, le symbole est permis; et

NOTE Les autres marquages tels que l'un des symboles (IEC 60417-5018 (DB:2002-10)) ou (IEC 60417-5020 (DB:2002-10)), s'ils sont appropriés, sont permis.

– pour les conducteurs de MISE A LA TERRE FONCTIONNELLE internes, la combinaison des couleurs vert et jaune ne doit pas être utilisée excepté dans le cas des composants pré assemblés à usage multiple (par exemple câbles à conducteurs multiples les filtres CEM); et

~~– dans un câble d'alimentation dans lequel un conducteur vert et jaune est utilisé uniquement pour fournir une mise à la terre fonctionnelle:~~

  - ~~le matériel ne doit pas être marqué avec le symbole (IEC 60417-5172 (2003-02)); et~~
  - ~~il n'y a pas d'exigences autres que celles de 3.1.9 concernant la terminaison de ce conducteur côté matériel.~~

Pour les matériels ayant un câble d'alimentation dans lequel un conducteur vert et jaune est utilisé uniquement pour fournir une MISE A LA TERRE FONCTIONNELLE:

- le matériel ne doit pas être marqué avec le symbole , CEI 60417-5172 (2003-02); et
- le matériel peut être marqué avec:

  - le symbole , CEI 60417-5018 (2011-07); ou

- le symbole , CEI 60417-6092 (2011-10).

Ces symboles ne doivent pas être utilisés pour un MATERIEL DE CLASSE I.

Il n'y a pas d'exigences autres que celles de 3.1.9 concernant la terminaison de ce conducteur de MISE A LA TERRE FONCTIONNELLE côté matériel.

La conformité est vérifiée par examen.

2.6.3 Conducteurs de mise à la terre de protection et conducteurs de liaison à la terre

2.6.3.1 Généralités

Les CONDUCTEURS DE MISE A LA TERRE DE PROTECTION et les CONDUCTEURS DE LIAISON A LA TERRE DE PROTECTION doivent avoir une capacité suffisante de transport de courant.

Les exigences de 2.6.3.2, 2.6.3.3 et 2.6.3.4 s'appliquent seulement aux CONDUCTEURS DE MISE A LA TERRE DE PROTECTION et aux CONDUCTEURS DE LIAISON A LA TERRE DE PROTECTION fournis pour être conformes à 2.6.1 a), b) et c).

Pour les CONDUCTEURS DE MISE A LA DE TERRE DE PROTECTION et les CONDUCTEURS DE LIAISON A LA TERRE DE PROTECTION fournis pour être conformes à 2.6.1 d), les exigences de 2.6.3.4 e) s'appliquent.

Pour les CONDUCTEURS DE MISE A LA TERRE DE PROTECTION et les CONDUCTEURS DE LIAISON A LA TERRE DE PROTECTION fournis pour être conformes à 2.6.1 e) et 2.6.1 f) et pour les conducteurs de MISE A LA TERRE FONCTIONNELLE, la capacité de passage du courant doit être adaptée au courant réel dans les conditions normales de fonctionnement, conformément à 3.1.1, c'est-à-dire qu'il ne leur est pas demandé de supporter les courants de défaut à la terre.

2.6.3.2 Taille des conducteurs de mise à la terre de protection

Les CONDUCTEURS DE MISE A LA TERRE DE PROTECTION dans les câbles d'alimentation fournis avec le matériel doivent être conformes aux tailles minimales de conducteurs données dans le Tableau 3B (voir 3.2.5).

La vérification est effectuée par examen et par des mesures.

2.6.3.3 Taille des conducteurs de liaison de protection

Les CONDUCTEURS DE LIAISON A LA TERRE DE PROTECTION doivent être conformes à un des points suivants:

– aux tailles minimales de conducteur du Tableau 3B (voir 3.2.5); ou
– aux exigences du 2.6.3.4 et aussi, si le courant nominal du circuit est supérieur à 16 A, aux tailles minimales de conducteur du Tableau 2D; ou
– pour les composants seulement, ne pas être plus petits que les conducteurs alimentant en puissance le composant.

Les CARACTERISTIQUES ASSIGNEES DU COURANT DE PROTECTION du circuit (utilisé dans le Tableau 2D et dans l'essai de 2.6.3.4) dépendent de la fourniture et de l'emplacement du dispositif de protection contre les surintensités. Elles doivent être prises comme les valeurs les plus faibles de a) b) ou c), selon ce qui est applicable.

a) Pour les MATERIELS DE TYPE A RACCORDES PAR PRISE DE COURANT, les CARACTERISTIQUES ASSIGNEES DU COURANT DE PROTECTION sont celles d'un dispositif de protection contre les surintensités à l'extérieur du matériel (par exemple dans le câblage du bâtiment, dans la fiche réseau ou dans un rack du matériel) pour protéger le matériel, avec une valeur nominale de 16 A.

NOTE 1 Dans la plupart des pays, 16 A est considéré comme une valeur adaptée comme CARACTERISTIQUE ASSIGNEE DU COURANT DE PROTECTION du circuit.

NOTE 2 Au Canada et aux USA, la CARACTERISTIQUE ASSIGNEE DU COURANT DE PROTECTION du circuit retenue est de 20 A.

NOTE 3 Au Royaume-Uni, la caractéristique assignée du circuit à retenir est de 13 A, et non 16 A.

b) Pour les MATERIELS DE TYPE B RACCORDES PAR PRISE DE COURANT et les MATERIELS RELIES A DEMEURE (voir 2.7.1), LA VALEUR ASSIGNEE DU COURANT DE PROTECTION est la valeur assignée maximale du dispositif de protection contre les surintensités spécifiée dans les instructions d'installation du matériel à prévoir à l'extérieur du matériel (voir 1.7.2.3).

c) Pour tous les matériels indiqués ci-dessus, la VALEUR ASSIGNEE DU COURANT DE PROTECTION est celle d'un dispositif de protection contre les surintensités, s'il est fourni dans le matériel ou comme partie de celui-ci et qui protège le circuit ou la partie devant être mis à la terre.

La vérification est effectuée par examen et par des mesures.

Tableau 2D – Taille minimale des conducteurs de liaison de protection

CARACTERISTIQUE ASSIGNEE DU COURANT DE PROTECTION du circuit à considérer	**Tailles minimales des conducteurs**	
Jusqu'à et y compris **A**	**Section** **mm²**	**AWG ou kcmil (section en mm²)**
~~16~~ 20	Taille non spécifiée	Taille non spécifiée
25	1,5	14 (2)
32	2,5	12 (3)
40	4,0	10 (5)
63	6,0	8 (8)
80	10	6 (13)
100	16	4 (21)
125	25	2 (33)
160	35	1 (42)
190	50	0 (53)
230	70	000 (85)
260	95	0000 (107)
300	120	250 kcmil (126)
340	150	300 kcmil (152)
400	185	400 kcmil (202)
460	240	500 kcmil (253)

NOTE Les dimensions AWG et kcmil sont données pour information uniquement. Les sections associées ont été arrondies pour ne montrer que des chiffres significatifs. Les AWG se réfèrent à l'American Wire Gauge et le terme «cmil» se réfère aux *mils circulaires* dans lesquels 1 cmil est égal à la surface d'un cercle ayant un diamètre de 1 mil (un millième de pouce). Ces termes sont communément employés en Amérique du Nord pour désigner des tailles de conducteurs.

2.6.3.4 Résistance des conducteurs de mise à la terre et leurs terminaisons

Les conducteurs de mise à la terre et leurs terminaisons ne doivent pas avoir une résistance trop grande.

Les CONDUCTEURS DE MISE A LA TERRE DE PROTECTION sont considérés conformes sans essai.

Les CONDUCTEURS DE LIAISON A LA TERRE DE PROTECTION qui satisfont aux tailles minimales de conducteurs du Tableau 3B (voir 3.2.5) sur toute leur longueur et dont toutes les bornes satisfont au Tableau 3E (voir 3.3.5), sont considérés conformes sans essai.

La vérification est effectuée par examen et par des mesures et, pour les CONDUCTEURS DE LIAISON A LA TERRE DE PROTECTION *qui ne sont pas conformes aux tailles minimales du Tableau 3B (voir 3.2.5) sur toute leur longueur ou dont les bornes ne satisfont pas toutes au Tableau 3E (voir 3.3.5), par l'essai suivant.*

La chute de tension dans un CONDUCTEUR DE LIAISON A LA TERRE DE PROTECTION *est mesurée après avoir effectué l'essai de courant pendant la période de temps spécifiée ci-dessous. L'essai de courant peut être effectué soit en alternatif soit en continu et la tension d'essai ne doit pas dépasser 12 V. Les mesures sont effectuées entre la borne de terre de protection principale et le point du matériel que 2.6.1 prescrit de mettre à la terre. La résistance du* CONDUCTEUR DE MISE A LA TERRE DE PROTECTION *n'est pas incluse dans la mesure. Cependant, si le* CONDUCTEUR DE MISE A LA TERRE DE PROTECTION *est fourni avec le matériel, il est permis de l'inclure dans le circuit d'essai, mais la mesure de la chute de tension est effectuée uniquement entre la borne principale de mise à la terre de protection et la partie qu'il est prescrit de mettre à la terre.*

Dans un matériel où la liaison à la terre de protection à un sous-ensemble ou à une unité séparée est réalisée au moyen d'un conducteur d'un câble multiconducteurs assurant également l'alimentation de ce sous-ensemble ou de cette unité à partir du réseau, la résistance du CONDUCTEUR DE LIAISON A LA TERRE DE PROTECTION *dans ce câble n'est pas comprise dans la mesure. Cependant, cette option est seulement permise si le câble est protégé par un dispositif de protection aux caractéristiques assignées appropriées qui tient compte de la taille du conducteur.*

Si la protection d'un CIRCUIT TBTS *ou d'un* CIRCUIT TRT *est assurée par la mise à la terre du circuit protégé lui-même conformément à 2.9.4 e), les limites de chute de résistance et de tension s'appliquent entre le côté mis à la terre du circuit protégé et la borne principale de mise à la terre de protection.*

*Si le circuit est protégé par une mise à la terre de l'enroulement d'un transformateur alimentant le circuit protégé, les limites de chute de la résistance et de la tension s'appliquent entre le côté qui n'est pas relié à la terre de l'enroulement et la borne principale de mise à la terre de protection. l'*ISOLATION PRINCIPALE *entre les enroulements primaire et secondaire n'est pas soumise aux essais de premier défaut exigés en 5.3.7 et en 1.4.14.*

On prend soin que la résistance de contact entre l'extrémité de la sonde de mesure et la partie conductrice en essai n'influence pas les résultats de l'essai.

Le courant d'essai, la durée de l'essai et les résultats d'essais sont les suivants:

a) *Pour les matériels alimentés par le* RESEAU, *si la* CARACTERISTIQUE ASSIGNEE DU COURANT DE PROTECTION *du circuit en essai (voir 2.6.3.3) est inférieure ou égale à 16 A, le courant d'essai est égal à 200 % la valeur de la* CARACTERISTIQUE ASSIGNEE DU COURANT DE PROTECTION *appliquée pendant 120 s.*

   La résistance du CONDUCTEUR DE LIAISON A LA TERRE DE PROTECTION, *calculée à partir de la chute de tension, ne doit pas dépasser 0,1 Ω. A l'issue de l'essai, le* CONDUCTEUR DE LIAISON A LA TERRE DE PROTECTION *ne doit pas être endommagé.*

b) *Pour les matériels alimentés par un* RESEAU D'ALIMENTATION EN COURANT ALTERNATIF, *si la* CARACTERISTIQUE ASSIGNEE DU COURANT DE PROTECTION *du circuit en essai dépasse 16 A, le courant d'essai est égal à 200 %, la valeur de la* CARACTERISTIQUE NOMINALE DU COURANT DE PROTECTION *et la durée de l'essai est telle qu'indiqué au Tableau 2E.*

Tableau 2E – Durée de l'essai, réseaux d'alimentation en courant alternatif

CARACTERISTIQUE ASSIGNEE DU COURANT DE PROTECTION du circuit (I_{pc}) A	Durée de l'essai min
≤ 30	2
$30 < I_{pc} \leq 60$	4
$60 < I_{pc} \leq 100$	6
$100 < I_{pc} \leq 200$	8
> 200	10

La chute de tension dans le CONDUCTEUR DE LIAISON A LA TERRE DE PROTECTION *ne doit pas dépasser 2,5 V. A l'issue de l'essai, le* CONDUCTEUR DE LIAISON A LA TERRE DE PROTECTION *ne doit pas être endommagé.*

c) *Comme alternative à b) ci-dessus, les essais sont fondés sur les caractéristiques de temps/courant du dispositif de protection contre les surintensités qui limite le courant de défaut dans le conducteur de liaison à la terre de protection Ce dispositif est soit prévu à l'intérieur du matériel en essai soit spécifié dans les instructions d'installation fournies à l'extérieur du matériel. Les essais sont réalisés à 200 % de la* CARACTERISTIQUE ASSIGNEE DU COURANT DE PROTECTION, *pour la durée correspondant à 200 % de la caractéristique temps/courant. Si la durée pour 200 % n'est pas donnée, il est permis d'utiliser le point le plus proche sur la caractéristique temps/courant.*

La chute de tension dans le CONDUCTEUR DE LIAISON A LA TERRE DE PROTECTION *ne doit pas dépasser 2,5 V. A l'issue de l'essai, le* CONDUCTEUR DE LIAISON A LA TERRE DE PROTECTION *ne doit pas être endommagé.*

d) *Pour les matériels alimentés par un réseau en courant continu, si la* CARACTERISTIQUE ASSIGNEE DU COURANT DE PROTECTION *du circuit en essai dépasse 16 A, le courant d'essai et la durée sont tels que spécifiés par le fabricant.*

La chute de tension dans le CONDUCTEUR DE LIAISON A LA TERRE DE PROTECTION *ne doit pas dépasser 2,5 V. A l'issue de l'essai, le* CONDUCTEUR DE LIAISON A LA TERRE DE PROTECTION *ne doit pas être endommagé.*

e) *Pour les* CONDUCTEURS DE LIAISON A LA TERRE DE PROTECTION *fournis pour satisfaire à 2.6.1 d), le courant d'essai est égal à 150 % du courant maximal disponible provenant du* RESEAU DE TELECOMMUNICATIONS *ou du* SYSTEME DE DISTRIBUTION PAR CABLES *(si connu) avec une valeur minimale de 2 A, appliquée pendant 120 s. La chute de tension dans le* CONDUCTEUR DE LIAISON A LA TERRE DE PROTECTION *ne doit pas dépasser 2,5 V.*

2.6.3.5 Couleur de l'isolation

L'isolation du CONDUCTEUR DE MISE A LA TERRE DE PROTECTION dans le câble d'alimentation fourni avec le matériel doit être vert et jaune.

Si un CONDUCTEUR DE LIAISON A LA TERRE DE PROTECTION est isolé, l'isolation doit être vert et jaune sauf dans les deux cas suivants:

– pour une tresse de mise à la terre, l'isolation doit être soit vert et jaune soit transparente;
– pour un CONDUCTEUR DE LIAISON A LA TERRE DE PROTECTION dans des assemblages tels que câble en ruban, barres omnibus, câblage imprimé souple, etc., toute couleur est acceptable, pourvu qu'il ne risque pas d'y avoir une mauvaise interprétation quant à l'emploi du conducteur.

A l'exception de ce qui est permis en 2.6.2, la combinaison de couleurs vert et jaune doit être utilisée seulement pour identifier les CONDUCTEURS DE MISE A LA TERRE DE PROTECTION et les CONDUCTEURS DE LIAISON DE PROTECTION.

La conformité est vérifiée par examen.

2.6.4 Bornes

2.6.4.1 Généralités

Les exigences de 2.6.4.2 et de 2.6.4.3 s'appliquent uniquement aux bornes mises à la terre de protection fournies pour la conformité à 2.6.1 a), b) et c).

NOTE Pour les exigences complémentaires concernant les bornes, voir 3.3.

Pour la mise à la terre de protection fournie pour la conformité à 2.6.1 d), e) et f), il suffit que les bornes soient conformes à 3.3.

2.6.4.2 Bornes de mise à la terre et de liaison à la terre de protection

Le matériel devant avoir une mise à la terre de protection doit avoir une borne principale de mise à la terre de protection. Pour le matériel avec un CABLE D'ALIMENTATION NON FIXE A DEMEURE, la borne de mise à la terre dans le dispositif d'entrée est considérée comme la borne principale de mise à la terre de protection.

Si un matériel est pourvu de plus d'une connexion d'alimentation (par exemple différentes tensions, ou fréquences, ou alimentation de secours), il est permis d'avoir une borne principale de mise à la terre de protection associée à chaque connexion d'alimentation. Dans de tels cas, les bornes doivent être dimensionnées suivant la valeur du courant d'alimentation associé.

Les bornes doivent être conçues pour résister à un desserrage accidentel du conducteur. En général, les conceptions communément utilisées pour les bornes de courant, autres que certaines bornes de type pilier, fournissent une résilience suffisante pour être conformes à cette exigence; pour les autres conceptions, des précautions spéciales doivent être prises, telles que l'usage d'une partie à résilience adaptée et qui ne peut pas être démontée par inadvertance.

A l'exception de ce qui est noté ci-dessous, toutes les bornes de mise à la terre ou de liaison à la terre de protection, de type pilier, à plot de contact ou à vis doivent être conformes aux exigences de taille minimale données au Tableau 3E (voir 3.3.5).

Lorsqu'une borne pour un CONDUCTEUR DE LIAISON A LA TERRE DE PROTECTION n'est pas conforme au Tableau 3E (voir 3.3.5), l'essai de 2.6.3.4 doit être appliqué au trajet du CONDUCTEUR DE LIAISON A LA TERRE DE PROTECTION dans lequel la borne est utilisée.

La borne principale de mise à la terre de protection pour le MATERIEL RELIE A DEMEURE doit être

– située de telle sorte qu'elle soit facilement accessible quand la connexion de l'alimentation est faite; et
– munie de piliers plots, vis ou bornes analogues montés en usine, et avec les moyens de fixation nécessaires s'il est exigé d'avoir un CONDUCTEUR DE MISE A LA TERRE DE PROTECTION de plus de 7 mm^2 (3 mm de diamètre).

La vérification est effectuée par examen et par des mesures.

2.6.4.3 Séparation entre le conducteur de mise à la terre de protection et les conducteurs de liaison à la terre de protection

Des bornes séparées, qui peuvent être sur la même barre omnibus, doivent être fournies, une pour le CONDUCTEUR DE MISE A LA TERRE DE PROTECTION, ou une pour chaque CONDUCTEUR DE

MISE A LA TERRE DE PROTECTION si plus d'un est prévu, et un ou plusieurs pour les CONDUCTEURS DE LIAISON A LA TERRE DE PROTECTION.

Toutefois, il est permis de fournir une seule borne du type vis ou à plot, dans les MATERIELS RELIES A DEMEURE ayant un CABLE D'ALIMENTATION FIXE A DEMEURE, et dans les MATERIELS DE TYPE A OU B RACCORDES PAR PRISE DE COURANT ayant un CABLE D'ALIMENTATION FIXE A DEMEURE spécial, pourvu que la terminaison de câblage du CONDUCTEUR DE MISE A LA TERRE DE PROTECTION soit séparée par un écrou de celles des CONDUCTEURS DE LIAISON A LA TERRE DE PROTECTION. L'ordre d'empilage des terminaisons du CONDUCTEUR DE MISE A LA TERRE DE PROTECTION et des CONDUCTEURS DE LIAISON A LA TERRE DE PROTECTION n'est pas spécifié.

Il est aussi permis de fournir une seule borne dans les matériels avec un socle de connecteur.

La conformité est vérifiée par examen.

2.6.5 Intégrité de la mise à la terre de protection

2.6.5.1 Interconnexion des matériels

Dans un système de matériels interconnectés, la connexion de la mise à la terre de protection doit être assurée pour tout matériel nécessitant une connexion de mise à la terre de protection, sans tenir compte de la disposition du matériel dans le système.

Le matériel qui a un CONDUCTEUR DE LIAISON A LA TERRE DE PROTECTION pour maintenir la continuité des circuits de mise à la terre de protection avec d'autres matériels dans le système ne doit pas être marqué du symbole ▣ (IEC 60417-5172 (DB:2003-02).

Un tel matériel doit aussi fournir l'alimentation aux autres matériels dans le système (voir 2.6.5.3).

La conformité est vérifiée par examen.

2.6.5.2 Composants dans le conducteur de mise à la terre de protection et dans les conducteurs de liaison à la terre de protection

LES CONDUCTEURS DE MISE A LA TERRE DE PROTECTION et les CONDUCTEURS DE LIAISON A LA TERRE DE PROTECTION ne doivent pas contenir d'interrupteurs ou de dispositifs contre les surintensités.

La conformité est vérifiée par examen.

2.6.5.3 Déconnexion de la terre de protection

Les connexions de mise à la terre de protection doivent être telles que la déconnexion de la mise à la terre de protection en un point d'une unité ou d'un système ne rompt pas la connexion de la mise à la terre de protection aux autres parties ou unités dans un système, à moins que le danger identifié ne soit en même temps retiré.

La conformité est vérifiée par examen.

2.6.5.4 Parties pouvant être démontées par un opérateur

Les connexions de la mise à la terre de protection doivent être faites plus tôt et défaites plus tard que les connexions de l'alimentation dans les cas suivants:

– le connecteur d'une partie qui peut être enlevée par un OPERATEUR;
– une prise sur un câble d'alimentation;
– un socle de connecteur.

La conformité est vérifiée par examen.

2.6.5.5 Pièces démontées pendant la maintenance

Les connexions de mise à la terre de protection doivent être conçues de telle sorte qu'elles n'auront pas à être démontées pour la maintenance, mis à part celles qui sont liées au démontage de la partie qu'elles protègent, à moins que le danger identifié ne soit en même temps retiré.

La conformité est vérifiée par examen.

2.6.5.6 Résistance à la corrosion

Les parties conductrices en contact avec les bornes et les connexions de mise à la terre de protection et de liaison à la terre de protection ne doivent pas être sujettes à une corrosion significative causée par une réaction électrochimique, dans toutes les conditions d'environnement concernant le fonctionnement, le stockage et le transport, comme spécifié dans les instructions fournies avec le matériel. Les combinaisons placées au-dessus de la ligne dans l'Annexe J doivent être évitées. La résistance à la corrosion peut être obtenue par un procédé approprié de placage ou de recouvrement.

La vérification est effectuée par examen et par référence au tableau des potentiels électrochimiques (Annexe J).

2.6.5.7 Vis pour la liaison à la terre de protection

NOTE Les exigences suivantes complètent celle de 3.1.6.

Les vis autotaraudeuses (par enlèvement ou par repoussage de matière) et les vis à grand pas sont autorisées pour assurer la liaison à la terre de protection mais il ne doit pas être nécessaire d'interrompre la connexion pendant la maintenance.

Dans tous les cas, l'épaisseur de la partie métallique au point où une vis est taraudée ne doit pas être de moins de deux fois le pas de la vis taraud. Il est permis d'utiliser une extrusion locale d'une partie métallique pour augmenter l'épaisseur utile.

Au moins deux vis doivent être utilisées pour chaque connexion. Toutefois, il est permis d'utiliser une seule vis autotaraudeuse pourvu que l'épaisseur de la partie métallique au point où la vis est taraudée soit d'au moins 0,9 mm pour les vis de type filetage par forme et 1,6 mm pour les vis de type filetage par découpe.

La conformité est vérifiée par examen.

2.6.5.8 Confiance dans le réseau de télécommunications ou les systèmes de distribution par câbles

La mise à la terre de protection ne doit pas dépendre du RESEAU DE TELECOMMUNICATIONS ou D'UN SYSTEME DE DISTRIBUTION PAR CABLES.

La conformité est vérifiée par examen.

2.7 Protection contre les surintensités et les défauts à la terre dans les circuits primaires

2.7.1 Exigences générales

La protection contre les surintensités, les courts-circuits et les défauts à la terre dans les CIRCUITS PRIMAIRES doit être fournie soit comme partie intégrante du matériel soit comme partie de l'installation du bâtiment.

Si la protection d'un MATÉRIEL DU TYPE B RACCORDÉ PAR UNE PRISE DE COURANT ou d'un MATÉRIEL RELIÉ À DEMEURE dépend de dispositifs de protection extérieurs, les instructions d'installation du matériel doivent l'indiquer et doivent également spécifier les exigences pour la protection contre les courts-circuits ou contre les surintensités, ou les deux, lorsque c'est nécessaire.

NOTE Dans les pays membres du CENELEC et de la Chine, il faut que les dispositifs de protection nécessaires pour la conformité aux exigences de 5.3, avec certaines exceptions, soient inclus comme partie du matériel.

La conformité est vérifiée par examen.

2.7.2 Défauts non simulés en 5.3.7

La protection contre les défauts non simulés en 5.3.7 (par exemple les courts-circuits à la terre de protection d'un enroulement dans un CIRCUIT PRIMAIRE) n'a pas besoin d'être installée comme partie intégrante du matériel.

La conformité est vérifiée par examen.

2.7.3 Protection en amont contre les courts-circuits

A moins qu'une protection en amont appropriée ne soit fournie, les dispositifs de protection doivent avoir un pouvoir de coupure (rupture) adéquat pour interrompre le courant maximal de défaut susceptible de se présenter (y compris le courant de court-circuit).

Pour les MATERIELS RELIES A DEMEURE ou les MATERIELS DU TYPE B RACCORDES PAR PRISE DE COURANT, il est permis que la protection en amont contre les courts-circuits soit dans l'installation du bâtiment.

Pour les MATERIELS DU TYPE A RACCORDES PAR PRISE DE COURANT, il est considéré que l'installation du bâtiment assure la protection en amont contre les courts-circuits.

NOTE Si des fusibles conformes à la CEI 60127 sont utilisés dans les CIRCUITS PRIMAIRES, il convient qu'ils aient un pouvoir de coupure élevé (1 500 A) si le courant de court-circuit présumé dépasse 35 A ou dix fois le courant nominal du fusible, suivant la valeur la plus élevée.

La vérification est effectuée par examen et par les essais de 5.3.

2.7.4 Nombre et emplacement des dispositifs de protection

Le nombre et l'emplacement des systèmes ou dispositifs de protection dans les CIRCUITS PRIMAIRES doivent être tels que soient détectés et interrompus les courants excessifs circulant dans tout chemin de courant correspondant à un défaut (par exemple entre lignes, entre ligne et neutre, entre ligne et CONDUCTEUR DE MISE A LA TERRE DE PROTECTION ou entre ligne et CONDUCTEUR DE LIAISON A LA TERRE DE PROTECTION).

Il n'y a pas de protection exigée contre les défauts à la terre, dans les matériels qui:

– n'ont pas de connexion à la terre; ou
– ont une DOUBLE ISOLATION ou une ISOLATION RENFORCEE entre le CIRCUIT PRIMAIRE et toutes les parties connectées à la terre.

NOTE 1 Lorsqu'une DOUBLE ISOLATION ou une ISOLATION RENFORCEE est fournie, un court-circuit à la terre serait considéré comme un double défaut.

Dans une alimentation d'une charge utilisant plus d'un conducteur de ligne, si un dispositif de protection interrompt le conducteur de neutre, il doit également interrompre tous les autres conducteurs d'alimentation. Les dispositifs de protection unipolaires ne doivent donc pas être utilisés dans de tels cas.

La vérification est effectuée par examen et, lorsque c'est nécessaire, par une simulation de premier défaut (voir 1.4.14).

NOTE 2 Pour les dispositifs de protection qui font partie intégrante du matériel, des exemples de nombre et d'emplacement des fusibles ou des pôles de disjoncteurs nécessaires pour fournir une interruption du courant de défaut dans les systèmes d'alimentation communément rencontrés sont donnés dans l'exemple informatif figurant au Tableau 2F pour les matériels et sous-ensembles monophasés, et dans l'exemple informatif figurant au Tableau 2G pour les matériels triphasés. Les exemples ne sont pas nécessairement valables pour les dispositifs de protection extérieurs au matériel.

Tableau 2F – Exemples informatifs de dispositifs de protection dans les matériels et sous-ensembles monophasés

Connexion du matériel à l'alimentation	Protection contre	Nombre minimal de coupe-circuits à fusibles ou de pôles de disjoncteurs	Emplacement
Cas A: Matériel destiné à être relié à des schémas d'alimentations avec neutre à la terre identifiés de façon sûre excepté pour le cas C ci-dessous	Défauts à la terre	1	Conducteur de ligne
	Surintensité	1	L'un ou l'autre des conducteurs
Cas B: Matériel destiné à être relié à toute alimentation y compris les schémas d'alimentation IT et les alimentations avec fiches réversibles excepté pour le cas C ci-dessous	Défauts à la terre	2	Les deux conducteurs
	Surintensité	1	L'un ou l'autre des conducteurs
Cas C: Matériel destiné à être relié à des schémas d'alimentation à 3 conducteurs avec neutre à la terre identifié	Défauts à la terre	2	Tous les conducteurs de ligne
	Surintensité	2	Tous les conducteurs de ligne

Tableau 2G – Exemples informatifs de dispositifs de protection dans les matériels triphasés

Système d'alimentation	Nombre de conducteurs d'alimentation	Protection contre	Nombre minimal de coupe-circuits à fusibles ou de pôles de disjoncteur	Emplacement
Triphasé sans neutre	3	Défauts à la terre	3	Les trois conducteurs
		Surintensité	2	Deux des conducteurs
Avec neutre à la terre (TN ou TT)	4	Défauts à la terre	3	Tous les conducteurs de ligne
		Surintensité	3	Tous les conducteurs de ligne
Avec neutre non mis à la terre	4	Défauts à la terre	4	Les quatre conducteurs
		Surintensité	3	Tous les conducteurs de ligne

2.7.5 Protection par plusieurs dispositifs

Lorsque des dispositifs de protection sont utilisés dans plus d'un pôle d'une alimentation à une charge donnée, ces dispositifs doivent être placés côte à côte. Il est permis de combiner plusieurs dispositifs de protection dans un seul composant.

La conformité est vérifiée par examen.

2.7.6 Avertissement au personnel de maintenance

Un marquage convenable doit être fourni sur le matériel ou une indication doit figurer dans les instructions pour la maintenance, pour alerter le PERSONNEL DE MAINTENANCE d'un danger possible, lorsque les deux conditions suivantes existent:

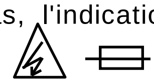
– lorsqu'un fusible est utilisé dans le neutre d'un matériel monophasé relié à demeure ou équipé d'une prise non réversible; et

– lorsque, après le fonctionnement du fusible, les parties du matériel qui restent alimentées risquent de représenter un danger pendant la maintenance.

Le marquage suivant ou un marquage similaire est considéré comme convenable:

ATTENTION
DOUBLE POLE/FUSIBLE SUR LE NEUTRE

Comme variante au texte ci-dessus, il est permis d'utiliser la combinaison des symboles représentatifs suivante, qui comprend le symbole danger de choc électrique ISO 3864 N° 5036, celui du fusible IEC-60417-5016 (DB:2002-10) et une indication que le fusible est dans le neutre N. Toutefois l'indication doit figurer également dans les instructions pour la maintenance. Toutefois dans ce cas, l'indication doit également être contenue dans les instructions de maintenance.


N

La conformité est vérifiée par examen.

2.8 Verrouillages de sécurité

2.8.1 Exigences générales

Des VERROUILLAGES DE SECURITE doivent être prévus lorsque l'OPERATEUR a accès à des zones présentant normalement des risques de danger au sens de la présente norme.

La conformité est vérifiée par examen.

2.8.2 Exigences de protection

Les VERROUILLAGES DE SECURITE doivent être conçus de façon que le risque ait disparu avant que le couvercle, la porte, etc., ne se trouvent dans une position quelconque permettant le contact avec des parties dangereuses par le doigt d'épreuve de la Figure 2A (voir 2.1.1.1).

Pour la protection contre les chocs électriques, les rayonnements et les dangers de transfert d'énergie, l'enlèvement, l'ouverture ou le retrait du couvercle, de la porte, etc. doivent:

– nécessiter la mise hors tension préalable de telles parties; ou

– amorcer automatiquement la déconnexion de l'alimentation de telles parties, et abaisser en 2 s la tension à une valeur inférieure ou égale à 42,4 V valeur de crête, ou 60 V tension continue, et le niveau d'énergie à une valeur inférieure à 20 J.

Pour une partie mobile qui continue son mouvement pendant un moment et qui continue à présenter un danger mécanique (par exemple un tambour de rotative), l'enlèvement, l'ouverture ou le retrait du couvercle, de la porte, etc., doivent:

– nécessiter la réduction préalable du mouvement à un niveau de sécurité acceptable; ou

– amorcer automatiquement la réduction du mouvement à un niveau de sécurité acceptable.

La vérification est effectuée par examen, par des mesures et par l'utilisation du doigt d'épreuve de la Figure 2A (voir 2.1.1.1).

2.8.3 Retour imprévu du danger

Les VERROUILLAGES DE SECURITE doivent être conçus de telle façon qu'un retour imprévu du danger ne puisse se produire lorsque les couvercles, dispositifs de protection, portes, etc., ne sont pas en position fermée.

Tout VERROUILLAGE DE SECURITE accessible à l'OPERATEUR qui peut être mis en fonctionnement au moyen du doigt d'épreuve, Figure 2A (voir 2.1.1.1), est considéré comme étant susceptible de provoquer un retour par inadvertance du danger.

Les interrupteurs de VERROUILLAGE DE SECURITE doivent être choisis en tenant compte des chocs mécaniques et des vibrations en fonctionnement normal, de façon que ceux-ci ne provoquent pas un enclenchement malencontreux dans une position dangereuse.

La vérification est effectuée par examen et, lorsque c'est nécessaire, par un essai avec le doigt d'épreuve de la Figure 2A (voir 2.1.1.1).

2.8.4 Fonctionnement sans défaillance

Un système de VERROUILLAGE DE SECURITE doit être conçu et construit de façon que:

– si une défaillance du VERROUILLAGE DE SECURITE pendant la vie normale du matériel n'est pas susceptible de se produire et, même si une défaillance survient, elle ne crée pas un danger grave; ou

– si une défaillance du VERROUILLAGE DE SECURITE pendant la vie normale du matériel est possible, la panne ne créera pas un danger contre lequel une protection est prescrite.

Pour la protection contre les dangers extrêmes, soit un système redondant constitué de deux systèmes de VERROUILLAGE DE SECURITE doit être utilisé, soit les distances de séparation fixes dans un simple circuit de système de VERROUILLAGE DE SÉCURITÉ (par exemple, l'un de ceux associés à des cartes imprimées) doivent satisfaire aux exigences concernant l'ISOLATION RENFORCEE.

NOTE Un système de VERROUILLAGE DE SECURITE est considéré comprendre des composants/éléments qui sont directement capables de déconnecter la partie dangereuse (par exemple, les contacts de relais ou un interrupteur), y compris les composants (par exemple, une bobine de relais) et autres pièces constituant partie intégrante du circuit de déclenchement (par exemple, celles montées sur des cartes imprimées).

La ~~vérification est effectuée~~ conformité est vérifiée par examen du système de VERROUILLAGE DE SECURITE, des schémas du circuit et des données disponibles et, si nécessaire, par simulation de premiers défauts (voir 1.4.14) (par exemple, la défaillance d'un dispositif à semi-conducteur ou d'un composant électromécanique). Les parties mécaniques mobiles dans les systèmes mécaniques et électromécaniques ne sont pas soumises aux essais simulés de premier défaut si elles satisfont à 2.8.5 et 2.8.7. Les distances de séparation fixes dans des circuits du système de VERROUILLAGE DE SÉCURITÉ (par exemple, ceux associés aux cartes imprimées) qui assurent une protection autre que celle contre les dangers extrêmes ne sont pas soumises aux essais simulés de premier défaut si les distances de séparation satisfont à 2.8.7.1.

Il est permis d'utiliser des VERROUILLAGES DE SECURITE simulés pour les essais.

2.8.5 Parties mobiles

Les parties mobiles dans les VERROUILLAGES DE SECURITE mécaniques et électromécaniques doivent avoir une endurance adéquate.

La vérification est effectuée par examen du VERROUILLAGE DE SECURITE, des données disponibles et, si nécessaire, en soumettant le VERROUILLAGE DE SECURITE à un fonctionnement de 10 000 cycles, sans défaillance autre que dans le cas de fonctionnement sûr.

NOTE L'essai ci-dessus est effectué pour vérifier l'endurance des parties mobiles autres que celles qui existent dans les interrupteurs de VERROUILLAGE DE SECURITE et les relais. Les interrupteurs VERROUILLAGE DE SECURITE et les relais, s'ils existent, sont soumis à 2.8.7. Si l'essai de 2.8.7.3 est prescrit en plus de l'essai ci-dessus, il convient de combiner les essais.

2.8.6 Ré enclenchement forcé

Lorsqu'il peut être nécessaire au PERSONNEL DE MAINTENANCE d'effectuer un ré enclenchement forcé d'un VERROUILLAGE DE SECURITE, le système de ré enclenchement forcé doit:

- nécessiter un effort volontaire pour fonctionner; et
- réenclencher automatiquement le fonctionnement normal lorsque la maintenance est terminée ou empêcher le fonctionnement normal tant que le PERSONNEL DE MAINTENANCE ne l'a pas réenclenché; et
- nécessiter un OUTIL pour fonctionner lorsqu'il est situé dans la ZONE D'ACCES DE L'OPERATEUR, et ne pas pouvoir fonctionner avec le doigt d'épreuve de la Figure 2A (voir 2.1.1.1); et
- ne pas contourner un VERROUILLAGE DE SECURITE contre un danger important à moins qu'un autre moyen sûr de protection de sécurité ne devienne efficace lorsque le verrouillage est ainsi contourné. Le matériel doit être conçu de façon que le VERROUILLAGE DE SECURITE ne puisse être contourné tant que l'autre moyen de protection n'est pas entièrement en place et en état de fonctionner.

La conformité est vérifiée par examen.

2.8.7 Interrupteurs, relais et leurs circuits connexes

Un interrupteur dans un système de VERROUILLAGE DE SECURITE doit:

- être conforme à la CEI 61058-1, avec évaluation pour 10 000 cycles de fonctionnement conformément à 7.1.4.4 de la CEI 61058-1; ou
- être conforme à 2.8.7.1 et satisfaire aux essais de 2.8.7.3 et 2.8.7.4; ou
- satisfaire aux essais de 2.8.7.2, 2.8.7.3 et 2.8.7.4.

Un relais dans un système de VERROUILLAGE DE SECURITE doit:

- être conforme à 2.8.7.1 et satisfaire aux essais de 2.8.7.3 et 2.8.7.4; ou
- satisfaire aux essais de 2.8.7.2, 2.8.7.3 et 2.8.7.4.

La vérification est effectuée par examen et par les essais appropriés de 2.8.7.1 à 2.8.7.4.

2.8.7.1 ~~Distances d'ouverture des contacts~~ Distances de séparation pour les intervalles de contact et leurs circuits connexes

~~Si la distance d'ouverture des contacts est située dans le CIRCUIT PRIMAIRE, cette distance d'ouverture des contacts ne doit pas être inférieure à celle du dispositif de sectionnement (voir 3.4.2). Si la distance d'ouverture des contacts est située dans un circuit autre que le CIRCUIT PRIMAIRE, la distance d'ouverture des contacts de l'interrupteur ne doit pas être inférieure à la valeur applicable de la DISTANCE DANS L'AIR pour une ISOLATION PRINCIPALE dans un CIRCUIT SECONDAIRE, spécifiée en 2.10.3 (ou dans l'Annexe G).~~

Si les distances de séparation pour les intervalles de contact et leurs circuits respectifs sont situées dans le CIRCUIT PRIMAIRE, les distances de séparation ne doivent pas être inférieures à celles correspondant à un dispositif de sectionnement (voir 3.4.2). Si la distance de séparation se situe dans un circuit autre qu'un CIRCUIT PRIMAIRE, elle ne doit pas être inférieure à la valeur minimale correspondante de la DISTANCE DANS L'AIR pour l'ISOLATION PRINCIPALE dans un CIRCUIT SECONDAIRE spécifiée en 2.10.3 (ou dans l'Annexe G).

La ~~vérification est effectuée~~ conformité est vérifiée par examen des données disponibles et, si nécessaire, par des mesures.

2.8.7.2 Essai de surcharge

Le contact d'un interrupteur ou d'un relais dans le système de VERROUILLAGE DE SECURITE ~~ou le relais~~ est soumis à une surcharge constituée de 50 cycles de fonctionnement à une *cadence de six à dix cycles par minute, ouvrant et fermant 150 % du courant imposé dans l'application, excepté que lorsqu'un contact d'interrupteur ou de relais commute la charge d'un moteur, l'essai est effectué avec le rotor du moteur en position bloquée. Après l'essai, le système de VERROUILLAGE DE SECURITE avec l'interrupteur ou le relais doit être encore en état de fonctionner.*

2.8.7.3 Essai d'endurance

Le contact d'un interrupteur ou d'un relais dans le système de VERROUILLAGE DE SECURITE ~~ou le relais~~ est soumis à un essai d'endurance, ouvrant et fermant 100 % du courant imposé dans l'application, à une cadence de six à dix cycles de fonctionnement par minute. Une cadence plus élevée est permise si elle est ~~requise~~ demandée par le fabricant. Pour les interrupteurs à lame souple utilisés dans les systèmes de VERROUILLAGE DE SECURITE situés dans des CIRCUITS TBT, des CIRCUITS TBTS et des CIRCUITS TRT-1, l'essai est de 100 000 cycles de fonctionnement. Pour les autres interrupteurs et relais dans les systèmes de VERROUILLAGE DE SECURITE, l'essai est de 10 000 cycles de fonctionnement. Après l'essai, le système de VERROUILLAGE DE SECURITE avec un interrupteur ou relais doit être encore en état de fonctionner.

2.8.7.4 Essai de rigidité diélectrique

Excepté pour les interrupteurs à lame souple dans des CIRCUITS TBT, des CIRCUITS TBTS et des CIRCUITS TRT-1, un essai de rigidité diélectrique, tel que spécifié en 5.2.2, est effectué entre les contacts des relais et des interrupteurs après les essais de 2.8.7.2 et 2.8.7.3. Si le contact est dans un CIRCUIT PRIMAIRE, la tension d'essai est celle spécifiée pour une ISOLATION RENFORCÉE. Si le contact est dans un circuit autre qu'un CIRCUIT PRIMAIRE, la tension d'essai est celle spécifiée pour une ISOLATION PRINCIPALE dans un CIRCUIT PRIMAIRE.

2.8.8 Actionneurs mécaniques

Dans le cas où la sécurité repose sur la partie mobile d'un VERROUILLAGE DE SECURITE mécanique, des précautions doivent être prises pour s'assurer qu'elle n'est pas surchargée. Dans le cas où cette exigence n'est pas couverte par la conception du composant, le déplacement excessif au-delà de la position de fonctionnement de la partie mobile doit être limité à 50 % du maximum, par exemple par son montage ou son emplacement, ou par le réglage.

La vérification est effectuée par examen et par des mesures.

2.9 Isolation électrique

2.9.1 Propriétés des matériaux isolants

Le choix et l'application des matériaux isolants doivent prendre en compte les contraintes électriques, thermiques et mécaniques, la fréquence de la TENSION DE SERVICE et l'environnement de travail (température, pression, humidité et pollution).

Ni le caoutchouc naturel ni les matériaux hygroscopiques ni les matériaux contenant de l'amiante ne doivent être utilisés comme isolation.

On ne doit pas compter sur des courroies d'entraînement et des dispositifs de couplage pour assurer l'isolation électrique, à moins que la courroie ou le dispositif de couplage ne soit d'une construction spéciale évitant le risque d'un remplacement inapproprié.

La vérification est effectuée par examen et, si nécessaire, par l'évaluation des données pour le matériau.

Lorsque nécessaire, si les données ne confirment pas que le matériau est non hygroscopique, la nature hygroscopique d'un matériau isolant est déterminée en soumettant le composant, ou *le sous-ensemble employant l'isolation en question, à l'épreuve hygroscopique de 2.9.2. L'isolation est ensuite soumise à l'essai de rigidité diélectrique approprié de 5.2.2, alors qu'elle est encore dans l'enceinte humide ou dans la pièce dans laquelle les échantillons ont été portés à la température prescrite.*

2.9.2 Conditionnement hygroscopique

Lorsqu'il est ~~prescrit~~ exigé en 2.9.1, 2.10.8.3, 2.10.10 ou 2.10.11, le conditionnement hygroscopique est effectué pendant 48 h dans une enceinte ou dans une salle contenant de l'air avec une humidité relative ~~comprise entre 91 % et 95 %~~ de (93 ± 3) %. La température de l'air, en tout endroit où les échantillons peuvent être placés, est maintenue, à ~~1 ° C~~ ±2°C près, à une valeur quelconque appropriée t comprise entre 20 °C et 30 °C telle qu'il n'y ait pas production de condensation. Au cours de ce conditionnement, le composant ou le sous-ensemble n'est pas mis sous tension.

Pour le matériel destiné à être utilisé dans des conditions tropicales, la durée doit être de 120 h à une température de (40 ± 2) °C et une humidité relative de (93 ± 3) %.

Avec l'accord du fabricant, la durée ~~de 48 h~~ peut être augmentée.

Avant le conditionnement hygroscopique, l'échantillon est porté à une température comprise entre t et t + 4 °C.

2.9.3 Nature de l'isolation

L'isolation doit être considérée comme étant une ISOLATION FONCTIONNELLE, une ISOLATION PRINCIPALE, une ISOLATION SUPPLEMENTAIRE, une ISOLATION RENFORCEE ou une DOUBLE ISOLATION.

L'application de l'isolation dans un grand nombre de situations courantes est décrite dans le Tableau 2H et illustrée dans la Figure 2H, mais d'autres solutions et d'autres situations existent. Ces exemples sont informatifs. Dans certains cas, le degré d'isolation nécessaire peut être supérieur ou inférieur. Lorsqu'un degré d'isolation différent peut être nécessaire, ou si une configuration particulière des parties sous tension n'est pas représentée dans les exemples, il convient que le degré nécessaire d'isolation soit déterminé en considérant les effets d'un premier défaut (voir 1.4.14). Il convient que cela laisse intactes les exigences pour la protection contre les chocs électriques.

Dans certains cas, l'isolation peut être pontée par un chemin conducteur (par exemple lorsque 1.5.6, 1.5.7, 2.2.4, 2.3.4 ou 2.4.3 s'appliquent), pourvu que le niveau de sécurité soit maintenu.

Pour la DOUBLE ISOLATION, il est permis d'intervertir les éléments constituant l'ISOLATION PRINCIPALE et l'ISOLATION SUPPLEMENTAIRE. Si la DOUBLE ISOLATION est utilisée, les CIRCUITS TBT ou les parties conductrices non mises à la terre sont permises entre l'ISOLATION PRINCIPALE et l'ISOLATION SUPPLEMENTAIRE pourvu que le niveau total d'isolation soit maintenu.

Une SURFACE FRONTIERE est traitée comme un CIRCUIT TBTS non relié à la terre si elle fait partie soit:

– d'une ENVELOPPE conductrice non reliée à la terre; soit
– d'une ENVELOPPE non conductrice.

La conformité est vérifiée par examen.

Tableau 2H – Exemples d'application de l'isolation

Nature de l'isolation	Emplacement de l'isolation entre	Emplacement de l'isolation et	Légende pour la Figure 2H
FONCTIONNELLE [a]	CIRCUIT TBTS non mis à la terre ou une partie conductrice à double isolation non mise à la terre	– une partie conductrice mise à la terre – une partie conductrice à double isolation – un CIRCUIT TBTS non mis à la terre – un CIRCUIT TBTS mis à la terre – un CIRCUIT TRT-1 mis à la terre	F1 F2 F2 F1 F10 [f]
	un CIRCUIT TBTS mis à la terre	– un CIRCUIT TBTS mis à la terre – une partie conductrice mise à la terre – un CIRCUIT TRT-1 non mis à la terre – un CIRCUIT TRT-1 mis à la terre	F11 F11 F12 [f] F13 [f]
	un CIRCUIT TBT ou une partie conductrice à isolation principale	– une partie conductrice mise à la terre – un CIRCUIT TBTS mis à la terre – une partie conductrice à isolation principale – CIRCUIT TBT	F3 F3 F4 F4
	un CIRCUIT SECONDAIRE sous TENSION DANGEREUSE mis à la terre	un CIRCUIT SECONDAIRE sous TENSION DANGEREUSE mis à la terre	F5
	CIRCUIT TRT-1	CIRCUIT TRT-1	F7
	CIRCUIT TRT-2	CIRCUIT TRT-2	F8
	CIRCUIT TRT-3	CIRCUIT TRT-3	F9
	entre parties série/parallèle d'un enroulement d'un transformateur		F6
PRINCIPALE	CIRCUIT PRIMAIRE	– un CIRCUIT SECONDAIRE sous TENSION DANGEREUSE mis à la terre ou non – une partie conductrice mise à la terre – un CIRCUIT TBTS mis à la terre – une partie conductrice à isolation principale – CIRCUIT TBT	B1 B2 B2 B3 B3
	un CIRCUIT SECONDAIRE sous TENSION DANGEREUSE mis à la terre ou non	– un CIRCUIT SECONDAIRE sous TENSION DANGEREUSE non mis à la terre – une partie conductrice mise à la terre – un CIRCUIT TBTS mis à la terre – une partie conductrice à isolation principale – CIRCUIT TBT	B4 B5 B5 B6 B6
	CIRCUIT TBTS non mis à la terre ou une partie conductrice à double isolation non mise à la terre	– un CIRCUIT TRT-1 non mis à la terre – un CIRCUIT TRT-2 – un CIRCUIT TRT-3	B7 [f] B8 [d] B9 [d] [e]
	un CIRCUIT TBTS mis à la terre	– un CIRCUIT TNV-2 – un CIRCUIT TRT-3	B10 [d] B11 [d] [e]
	CIRCUIT TRT-2	– un CIRCUIT TRT-1 non mis à la terre – un CIRCUIT TRT-1 mis à la terre – un CIRCUIT TRT-3	B12 [d] [e] B13 [d] ~~[e]~~ [f] B14 [f]
	CIRCUIT TRT-3	– un CIRCUIT TRT-1 non mis à la terre – un CIRCUIT TRT-1 mis à la terre	B12 B13 [d]
SUPPLEMENTAIRE	une partie conductrice à isolation principale ou un CIRCUIT TBT	– une partie conductrice à double isolation – un CIRCUIT TBTS non mis à la terre	S1 [b] S1 [b]
	CIRCUIT TRT	– une partie conductrice à isolation principale – un CIRCUIT TBT	S2 ~~[d]~~ S2

Tableau 2H *(fin)*

Nature de l'isolation	Emplacement de l'isolation		Légende pour la Figure 2H
	entre	et	
SUPPLEMENTAIRE ou RENFORCEE	un CIRCUIT SECONDAIRE sous TENSION DANGEREUSE non mis à la terre	– une partie conductrice à double isolation – un CIRCUIT TBTS non mis à la terre – un CIRCUIT TRT	S/R1 [c] S/R1 [c] S/R2 [c]
RENFORCEE	CIRCUIT PRIMAIRE	– une partie conductrice à double isolation – un CIRCUIT TBTS non mis à la terre – un CIRCUIT TRT	R1 R1 R2
	un CIRCUIT SECONDAIRE sous TENSION DANGEREUSE mis à la terre	– une partie conductrice à double isolation – un CIRCUIT TBTS non mis à la terre – un CIRCUIT TRT	R3 R3 R4

L'expression «partie conductrice» se réfère à une partie conductrice électriquement qui:

– n'est pas normalement sous tension, et

– n'est reliée à aucun des circuits suivants:

- un circuit sous TENSION DANGEREUSE, ou
- un CIRCUIT TBT, ou
- un CIRCUIT TRT, ou
- un CIRCUIT TBTS, ou
- un CIRCUIT A LIMITATION DE COURANT.

Des exemples d'une telle partie conductrice sont la MASSE du matériel, le noyau d'un transformateur et, dans certains cas, un écran conducteur d'un transformateur.

Si une telle partie conductrice est protégée d'une partie sous TENSION DANGEREUSE par:

– une DOUBLE ISOLATION ou une ISOLATION RENFORCEE, elle est appelée «partie conductrice à double isolation»;

– une ISOLATION PRINCIPALE et une mise à la terre de protection, elle est appelée «partie conductrice mise à la terre»;

– une ISOLATION PRINCIPALE mais sans mise à la terre, c'est-à-dire sans deuxième niveau de protection, elle est appelée «partie conductrice à isolation principale».

Un circuit ou une partie conductrice est dit «mis à la terre» s'il est relié à une borne ou à un contact de mise à la terre de protection de façon à satisfaire aux exigences de 2.6 (bien qu'il ne soit pas nécessairement au potentiel de terre). Dans le cas contraire, le circuit ou la partie conductrice sont dits «non mis à la terre».

[a] Pour les exigences applicables à l'ISOLATION FONCTIONNELLE, voir 5.3.4.

[b] La TENSION DE SERVICE de l'ISOLATION SUPPLEMENTAIRE entre un CIRCUIT TBT ou une partie conductrice à isolation principale et une partie conductrice accessible non mise à la terre est égale à la TENSION DE SERVICE la plus sévère pour l'ISOLATION PRINCIPALE. La TENSION DE SERVICE la plus sévère peut être due à un CIRCUIT PRIMAIRE ou à un CIRCUIT SECONDAIRE et l'isolation est spécifiée en conséquence.

[c] L'isolation entre un CIRCUIT SECONDAIRE sous TENSION DANGEREUSE non mis à la terre et une partie ou un circuit accessible non mis à la terre (S/R, S/R1 ou S/R2 à la Figure 2H) doit satisfaire à la plus sévère des exigences suivantes:

– ISOLATION RENFORCEE dont la TENSION DE SERVICE est égale à la TENSION DANGEREUSE; ou

– ISOLATION SUPPLEMENTAIRE dont la TENSION DE SERVICE est égale à la tension entre le CIRCUIT SECONDAIRE sous TENSION DANGEREUSE et:

- un autre CIRCUIT SECONDAIRE sous TENSION DANGEREUSE, OU
- un CIRCUIT PRIMAIRE.

Ces exemples s'appliquent si:

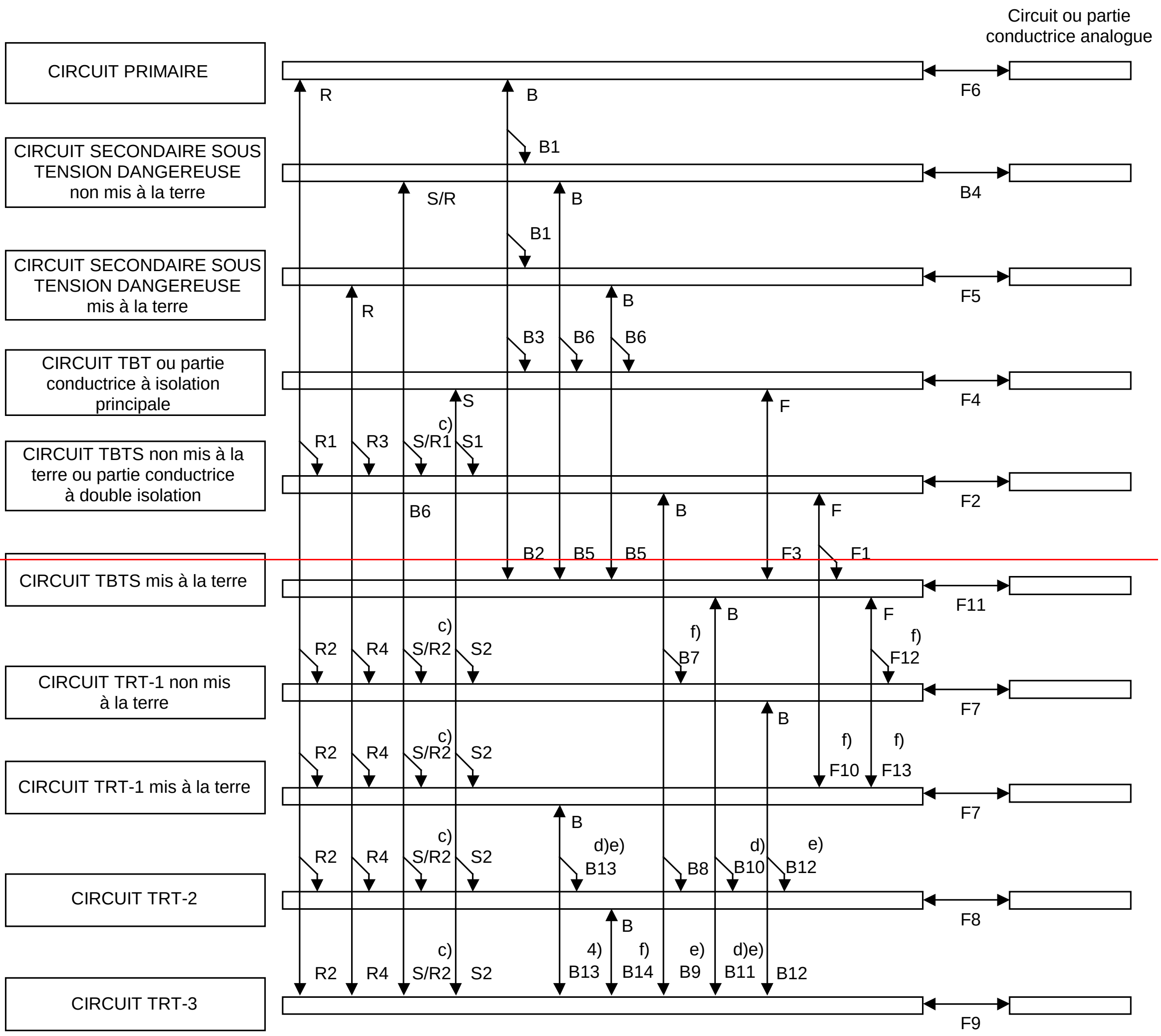
– il y a uniquement une ISOLATION PRINCIPALE entre le CIRCUIT SECONDAIRE et le CIRCUIT PRIMAIRE; et

– il y a uniquement une ISOLATION PRINCIPALE entre le CIRCUIT SECONDAIRE et la terre.

[d] L'ISOLATION principale n'est pas toujours prescrite (voir 2.3.2.1 et 2.10.5.13).

[e] Les exigences de 2.10 s'appliquent, voir aussi 6.2.1.

[f] Les exigences de 2.10 ne s'appliquent pas, mais voir 6.2.1.



F: ISOLATION FONCTIONNELLE
S: ISOLATION SUPPLÉMENTAIRE
R: ISOLATION RENFORCÉE

B : ISOLATION PRINCIPALE
S/R: voir c du Tableau 2G

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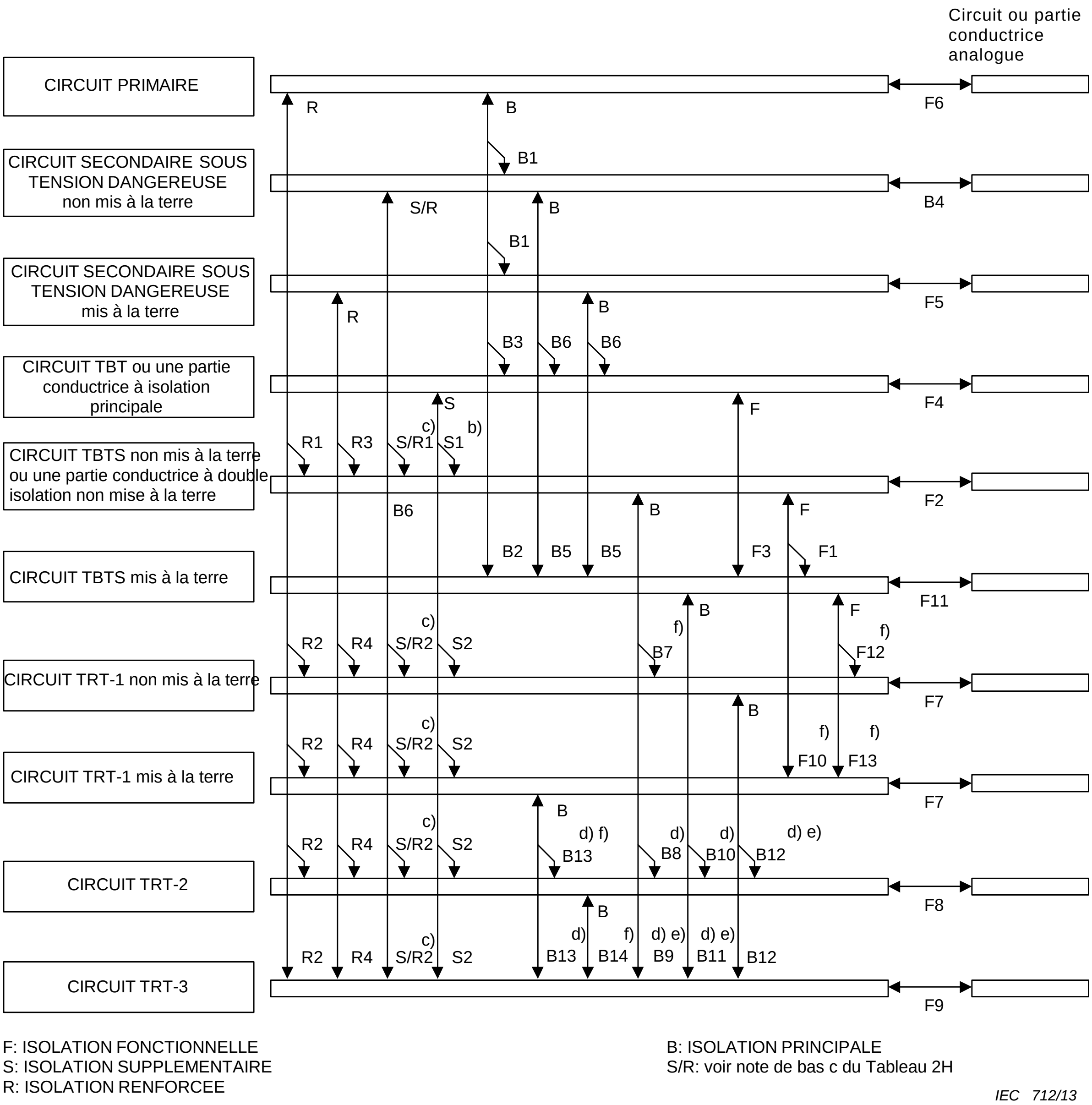


NOTE Les références b), c), d), e) et f) se rapportent aux notes de bas de tableau correspondantes du Tableau 2H.

Figure 2H – Exemples d'application de l'isolation

2.9.4 Séparation des tensions dangereuses

Lorsque des parties conductrices accessibles, y compris des CIRCUITS TBTS, des CIRCUITS TRT et leurs enroulements respectifs, sont séparées des parties sous TENSION DANGEREUSE, les constructions suivantes sont permises. L'isolation, y compris chaque élément de DOUBLE ISOLATION, doit être adaptée pour la TENSION DE SERVICE ou, si cela est applicable, pour la TENSION DE TENUE PRESCRITE entre les parties. Les différentes méthodes de séparation se répartissent en trois groupes, méthodes 1, 2 et 3.

a) (Méthode 1) DOUBLE ISOLATION ou ISOLATION RENFORCEE assurant une séparation permanente, assurée par des barrières, par guidage ou fixation; ou

b) (Méthode 1) DOUBLE ISOLATION ou ISOLATION RENFORCEE sur ou entre les parties à séparer; ou

c) (Méthode 1) DOUBLE ISOLATION, comprenant une ISOLATION PRINCIPALE sur une des parties à séparer et ISOLATION SUPPLEMENTAIRE sur l'autre partie; ou

d) (Méthode 2) ISOLATION PRINCIPALE sur la partie sous TENSION DANGEREUSE, avec écrans de protection connectés à la principale borne de mise à la terre conformément à 2.6.1 b); ou

e) (Méthode 3) ISOLATION PRINCIPALE sur la partie sous TENSION DANGEREUSE, avec connexion de l'autre partie à la principale borne de mise à la terre de protection conformément à 2.6.1 b), de telle manière que les limites de tension pour la partie accessible soient maintenues par des impédances de circuit relatives ou par le fonctionnement d'un dispositif de protection; ou

f) toute autre construction assurant une séparation équivalente.

NOTE 1 Pour connaître les exemples d'autres constructions assurant une séparation équivalente, se reporter au Tableau 2H et à la Figure 2H.

Pour e), il est permis de protéger un circuit en reliant à la terre une autre partie que le circuit protégé lui-même, par exemple l'enroulement secondaire d'un transformateur qui alimente le circuit protégé.

NOTE 2 Il convient de prendre en compte les conséquences d'une possible mise à la terre du circuit en un second point, par exemple par connexion avec un autre matériel.

La conformité est vérifiée par examen.

2.10 Distances dans l'air, lignes de fuite et distances à travers l'isolation

2.10.1 Généralités

En général, la vérification de la conformité à 2.10.1 est effectuée par examen et, si nécessaire, par des mesures.

2.10.1.1 Fréquence

Les exigences en matière d'isolation données en 2.10 sont pour des fréquences inférieures ou égales à 30 kHz. Il est permis d'utiliser les mêmes exigences pour une isolation fonctionnant à des fréquences supérieures à 30 kHz jusqu'à ce que des données supplémentaires soient disponibles.

NOTE Pour des informations sur le comportement de l'isolation en fonction de la fréquence, voir la CEI 60664-1 et la CEI 60664-4.

2.10.1.2 Degrés de pollution

Les degrés de pollution sont classés comme suit:

– Le degré de pollution 1 s'applique en l'absence de pollution ou en présence d'une pollution sèche et non conductrice uniquement. La pollution n'a pas d'influence. Normalement, cela est obtenu en enfermant les composants et les sous-ensembles de façon adéquate par enveloppement ou scellement hermétique de manière à empêcher toute pénétration de poussière ou d'humidité (voir 2.10.12).

– Le degré de pollution 2 s'applique en présence d'une pollution non conductrice qui pourrait devenir temporairement conductrice à la suite d'une condensation occasionnelle. Ce degré est généralement approprié aux matériels couverts par le domaine d'application de la présente norme;

– le degré de pollution 3 s'applique lorsqu'un environnement local à l'intérieur du matériel est soumis à une pollution conductrice ou à une pollution sèche non conductrice qui pourrait devenir conductrice à la suite d'une condensation attendue.

2.10.1.3 Valeurs réduites pour l'isolation fonctionnelle

Il n'existe pas de DISTANCE DANS L'AIR ou de LIGNE DE FUITE minimale pour l'ISOLATION FONCTIONNELLE, sauf si cela est prescrit en 5.3.4 a).

NOTE Si les DISTANCES DANS L'AIR et les LIGNES DE FUITE pour l'ISOLATION FONCTIONNELLE sont plus petites que celles spécifiées en 2.10.3, 2.10.4 et dans l'Annexe G, elles sont soumises aux exigences de 5.3.4 b) ou de 5.3.4 c).

2.10.1.4 Parties conductrices non connectées intercalées

Il est permis que les DISTANCES DANS L'AIR et les LIGNES DE FUITE soient divisées par interposition de parties conductrices non connectées (flottantes), telles que les contacts non utilisés d'un connecteur, pourvu que la somme des distances individuelles satisfasse aux exigences minimales spécifiées, voir le Tableau F.1 et la Figure F.13.

2.10.1.5 Isolation à dimensions variables

Si l'isolation d'un transformateur a différentes TENSIONS DE SERVICE sur la longueur de l'enroulement, il est permis de faire varier les DISTANCES DANS L'AIR, LIGNES DE FUITE et DISTANCES A TRAVERS L'ISOLATION en conséquence.

NOTE Un exemple d'une telle construction est un enroulement de 30 kV constitué de bobines multiples connectées en série et mis à la terre à une seule extrémité.

2.10.1.6 Exigences spéciales de séparation

Les exigences de 2.10 et de l'Annexe G ne s'appliquent pas à la séparation prévue pour satisfaire à 2.3.2 à moins d'utiliser une ISOLATION PRINCIPALE, ni à la séparation prévue pour satisfaire à 6.1.2 ou à 6.2.1.

NOTE Voir aussi la Note f du Tableau 2H.

2.10.1.7 Isolation dans les circuits générant des impulsions de démarrage

Pour un circuit qui génère des impulsions de démarrage pour allumer une lampe à décharge et si le circuit est un CIRCUIT A LIMITATION DE COURANT conforme à 2.4, les exigences pour l'ISOLATION FONCTIONNELLE s'appliquent entre le circuit et d'autres parties conductrices (voir 5.3.4).

Si le circuit n'est pas un CIRCUIT A LIMITATION DE COURANT, les exigences pour l'ISOLATION PRINCIPALE, l'ISOLATION SUPPLEMENTAIRE et l'ISOLATION RENFORCEE s'appliquent aux LIGNES DE FUITE et aux distances à travers l'isolation. Pour les DISTANCES DANS L'AIR, voir 2.10.3.5.

NOTE Pour les TENSIONS DE SERVICE des cas ci-dessus, voir 2.10.2.1 i).

2.10.2 Détermination de la tension de service

En général, la vérification de la conformité selon 2.10.2 est effectuée par examen et, si nécessaire, par des mesures.

2.10.2.1 Généralités

Pour la détermination des TENSIONS DE SERVICE, toutes les exigences suivantes s’appliquent (voir aussi 1.4.8).

a) Les parties conductrices accessibles non mises à la terre doivent être supposées l'être.

b) Si un enroulement d'un transformateur ou une autre partie est flottant (n'est pas relié à un circuit qui fixe son potentiel par rapport à la terre), il doit être supposé relié à la terre au point par lequel la plus haute TENSION DE SERVICE est obtenue.

c) A l’exception de ce qui est permis en 2.10.1.5, pour l'isolation entre deux enroulements de transformateur, la plus haute tension entre deux points quelconques dans les deux enroulements doit être utilisée en tenant compte des tensions externes auxquelles les enroulements seront reliés.

d) A l'exception de ce qui est permis en 2.10.1.5, pour l'isolation entre un enroulement de transformateur et une autre partie, la tension la plus haute entre un point quelconque de l'enroulement et l'autre partie doit être utilisée.

e) Lorsque la DOUBLE ISOLATION est utilisée, la TENSION DE SERVICE à travers l'ISOLATION PRINCIPALE doit être déterminée en imaginant un court-circuit à travers l'ISOLATION SUPPLEMENTAIRE et vice versa. Pour la DOUBLE ISOLATION entre les enroulements d'un transformateur, le court-circuit doit être supposé comme ayant lieu au point par lequel la plus haute TENSION DE SERVICE est produite dans l'autre isolation.

f) Lors que la TENSION DE SERVICE est déterminée par des mesures, la puissance d'entrée fournie à l'APPAREIL EN ESSAI doit être la valeur de la TENSION ASSIGNEE ou la tension dans la PLAGE ASSIGNEE DE TENSIONS qui donne lieu à la valeur mesurée la plus élevée.

NOTE Les tolérances concernant la TENSION ASSIGNEE ou la PLAGE ASSIGNEE DE TENSIONS ne sont pas prises en compte.

g) On doit considérer que la TENSION DE SERVICE entre tout point du CIRCUIT PRIMAIRE et la terre et entre tout point du CIRCUIT PRIMAIRE et un CIRCUIT SECONDAIRE est supérieure à ce qui suit:
   - la TENSION ASSIGNEE ou la tension la plus élevée de la PLAGE ASSIGNEE DE TENSIONS; et
   - la tension mesurée.

h) Lorsqu'on détermine la TENSION DE SERVICE pour un CIRCUIT TRT connecté à un RESEAU DE TELECOMMUNICATIONS, les tensions normales de fonctionnement doivent être prises en compte. Si elles ne sont pas connues, on doit prendre les valeurs suivantes comme hypothèses:
   - 60 V en courant continu pour les CIRCUITS TRT-1;
   - 120 V en courant continu pour les CIRCUITS TRT-2 et les circUITS TRT-3.

   Les signaux de sonnerie de téléphone ne doivent pas être pris en compte à cet effet.

i) Si les impulsions de démarrage sont utilisées pour allumer des lampes à décharge, la valeur de crête de la tension de service est la valeur de crête des impulsions avec la lampe connectée mais avant l'allumage de celle-ci. La VALEUR EFFICACE DE LA TENSION DE SERVICE pour déterminer les LIGNES DE FUITE minimales est la tension mesurée après l'allumage de la lampe.

2.10.2.2 Valeur efficace de la tension de service

Les LIGNES DE FUITE minimales dépendent des VALEURS EFFICACES DES TENSIONS DE SERVICE.

Lorsqu'on détermine une valeur efficace de tension de service, les règles suivantes doivent être utilisées:

- la valeur efficace mesurée doit être utilisée pour toutes les formes d'ondes;
- les conditions de courte durée (par exemple les signaux cadencés de sonnerie de téléphone dans les CIRCUITS TRT) ne doivent pas être prises en compte;
- les transitoires non répétitifs (par exemple dus aux perturbations atmosphériques) ne doivent pas être pris en compte.

NOTE La valeur efficace obtenue d'une forme d'onde ayant une tension efficace en courant alternatif "*A*" et un décalage de tension "*B*" est donnée par la formule suivante:

$$\text{valeur efficace} = (A^2 + B^2)^{1/2}$$

2.10.2.3 Valeur de crête de la tension de service

Les DISTANCES DANS L'AIR minimales et les tensions d'essai de rigidité diélectrique dépendent des VALEURS DE CRETE DES TENSIONS DE SERVICE.

Lorsqu'on détermine une VALEUR DE CRETE DE TENSION DE SERVICE, les règles suivantes doivent être utilisées:

– la valeur de crête mesurée doit être utilisée pour toutes les formes d'onde; la valeur de crête de toute ondulation (jusqu'à 10 %) sur la TENSION EN COURANT CONTINU doit être incluse;

– les transitoires non répétitifs (par exemple dus aux perturbations atmosphériques) ne doivent pas être pris en compte;

– lorsqu'on détermine la VALEUR DE CRETE DE LA TENSION DE SERVICE entre des CIRCUITS PRIMAIRE et SECONDAIRE, la tension de tout CIRCUIT TBT, TBTS OU TNT (y compris signaux de sonnerie de téléphone) doit être considérée comme zéro.

2.10.3 Distances dans l'air

2.10.3.1 Généralités

Les DISTANCES DANS L'AIR doivent être dimensionnées de telle façon que les surtensions y compris les transitoires qui peuvent entrer dans le matériel et les tensions crêtes qui peuvent être produites à l'intérieur du matériel ne détruisent pas la DISTANCE DANS L'AIR.

Il est permis d'utiliser soit les exigences de 2.10.3 pour les catégories de surtensions I ou II utilisant la valeur de crête de la tension de service ou les exigences de l'Annexe G pour les catégories de surtensions I, II, III ou IV en utilisant la TENSION DE TENUE PRESCRITE pour un composant ou un sous-ensemble particulier ou pour le matériel de son ensemble.

Ces exigences s'appliquent au matériel destiné à fonctionner jusqu'à 2 000 m au dessus du niveau de la mer. Pour les matériels destinés à être utilisés à plus de 2 000 m au-dessus du niveau de la mer, les DISTANCES DANS L'AIR minimales doivent être multipliées par le facteur donné au Tableau A.2 de la CEI 60664-1. L'interpolation linéaire est autorisée entre les deux points les plus proches du Tableau A.2. La DISTANCE DANS L'AIR minimale calculée en utilisant ce facteur de multiplication doit être arrondie à l'échelon de 0,1 mm immédiatement supérieur.

NOTE 1 On considère comme bonne pratique le fait de concevoir une ISOLATION SOLIDE pour des surtensions transitoires plus élevées que les DISTANCES DANS L'AIR associées.

NOTE 2 La Chine a des exigences particulières pour choisir les facteurs de multiplication à des altitudes supérieures à 2 000 m.

Les DISTANCES DANS L'AIR minimales spécifiées sont soumises aux valeurs minimales absolues suivantes:

– 10 mm pour un intervalle d'air assurant une ISOLATION RENFORCEE entre une partie sous TENSION DANGEREUSE et une partie conductrice accessible de l'ENVELOPPE d'un matériel reposant sur le sol ou de la surface supérieure non verticale d'un matériel à poser sur un bureau;

– 2 mm pour un intervalle d'air des contacts servant d'ISOLATION PRINCIPALE entre une partie sous TENSION DANGEREUSE et une partie conductrice accessible reliée à la terre de l'ENVELOPPE de MATERIELS DE TYPE A RACCORDES PAR PRISE DE COURANT.

NOTE ~~2~~ 3 Les deux DISTANCES DANS L'AIR minimales ci-dessus ne s'appliquent pas entre une partie sous TENSION DANGEREUSE et la SURFACE FRONTIERE d'une ENVELOPPE non conductrice.

A l'exception de ce qui est prescrit en 2.8.7.1, les DISTANCES DANS L'AIR minimales spécifiées ne s'appliquent pas à la distance entre les contacts de THERMOSTATS, de COUPE-CIRCUIT THERMIQUES, de dispositifs de protection contre les surcharges, d'interrupteurs à faible distance d'ouverture des contacts et dispositifs analogues, lorsque la distance varie avec les contacts.

NOTE ~~3~~ 4 Pour la distance entre les contacts des interrupteurs de verrouillage, voir 2.8.7.1. Pour la distance entre les contacts des dispositions de déconnexion, voir 3.4.2.

– Les DISTANCES DANS L'AIR entre la SURFACE FRONTIERE d'un connecteur et les parties conductrices à l'intérieur du connecteur qui sont connectées à une TENSION DANGEREUSE doivent être conformes aux exigences D'ISOLATION RENFORCEE. A titre exceptionnel, pour les connecteurs qui sont

– fixés au matériel; et

– situés à l'intérieur de l'ENVELOPPE extérieure du matériel; et sont

– uniquement accessibles après retrait d'un sous-ensemble qui peut être remplacé par l'UTILISATEUR qui doit être en place en fonctionnement normal,

ces DISTANCES DANS L'AIR doivent être conformes aux exigences pour l'ISOLATION PRINCIPALE.

NOTE ~~4~~ 5 Les essais de 2.1.1.1 pour l'accès aux parties dangereuses s'appliquent à de tels connecteurs après le retrait du sous-ensemble.

Pour toutes les autres DISTANCES DANS L'AIR dans les connecteurs, y compris les connecteurs qui ne sont pas fixés au matériel, les valeurs minimales spécifiées en 2.10.3.3 ou 2.10.3.4 s'appliquent.

Les DISTANCES DANS L'AIR minimales ci-dessus pour les connecteurs ne s'appliquent pas aux connecteurs qui sont conformes à une norme harmonisée avec la CEI 60083, la CEI 60309, la CEI 60320, la CEI 60906-1 ou la CEI 60906-2. Voir aussi 1.5.2.

La vérification de conformité à 2.10.3.3 et 2.10.3.4 est effectuée par des mesures, en tenant compte de l'Annexe F. Les conditions suivantes s'appliquent:

– *les parties mobiles sont placées dans leurs positions les plus défavorables;*

– *Pour le matériel équipé de CÂBLES D'ALIMENTATION FIXES A DEMEURE ordinaires, les mesures de DISTANCES DANS L'AIR sont effectuées avec des conducteurs d'alimentation de la plus forte section spécifiée en 3.3.4 et aussi sans conducteurs.*

NOTE ~~5~~ 6 Les essais de force de 4.2.2, 4.2.3 et 4.2.4 s'appliquent.

– *lorsque les DISTANCES DANS L'AIR, à partir de la SURFACE FRONTIERE d'une ENVELOPPE en matière isolante, sont mesurées à travers une fente ou une ouverture dans l'ENVELOPPE ou à travers une ouverture dans un connecteur accessible, la surface accessible doit être considérée comme conductrice comme si elle était recouverte d'une feuille de métal partout où elle peut être touchée par le doigt d'épreuve de la Figure 2A (voir 2.1.1.1), appliqué sans force appréciable (voir Figure F.12, point X).*

Il n'existe pas d'essai de rigidité diélectrique pour vérifier les distances dans l'air à l'exception de ce qui est exigé dans la Note c du Tableau 2M et en 5.3.4 b).

2.10.3.2 Tensions transitoires du réseau

a) RESEAU D'ALIMENTATION EN COURANT ALTERNATIF

Pour les matériels destinés à être alimentés par le RESEAU D'ALIMENTATION EN COURANT ALTERNATIF, la valeur de la TENSION TRANSITOIRE DU RESEAU dépend de la catégorie de surtension et de la tension du RESEAU D'ALIMENTATION EN COURANT ALTERNATIF. En général, les DISTANCES DANS L'AIR dans les matériels destinés à être connectés au RESEAU D'ALIMENTATION EN COURANT ALTERNATIF doivent être prévues pour la catégorie de surtension II.

NOTE 1 Se reporter à l'Annexe Z pour les lignes directrices supplémentaires concernant la détermination de la catégorie de surtensions.

Les matériels qui, une fois installés, sont susceptibles de subir des surtensions transitoires dépassant celles de leur catégorie de surtension de conception devront être équipés d'une protection supplémentaire à prévoir à l'extérieur du matériel. Dans ce cas, les instructions d'installation doivent indiquer la nécessité d'une telle protection extérieure.

La valeur applicable de la TENSION TRANSITOIRE DU RESEAU doit être déterminée à partir de la catégorie de surtension et de la tension du RESEAU D'ALIMENTATION EN COURANT ALTERNATIF, à l'aide du Tableau 2J.

Tableau 2J – Tensions transitoires du réseau en courant alternatif

TENSION DU RESEAU D'ALIMENTATION EN COURANT ALTERNATIF [a] jusqu'à et y compris	TENSION TRANSITOIRE DU RESEAU [b] V crête	
	Catégorie de surtension	
V efficace	I	II
50	330	500
100	500	800
150 [c]	800	1 500
300 [d]	1 500	2 500
600 [e]	2 500	4 000

[a] Pour les matériels conçus pour être connectés à une alimentation triphasée à trois fils dans laquelle il n'y a pas de conducteur neutre, la tension d'ALIMENTATION DU RESEAU EN COURANT ALTERNATIF est la tension entre phases. Dans tous les autres cas où il existe un conducteur neutre, il s'agit de la tension entre phase et neutre

[b] La TENSION TRANSITOIRE DU RESEAU est toujours l'une des valeurs du tableau. L'interpolation n'est pas autorisée.

[c] Y compris 120/208 V et 120/240 V.

[d] Y compris 230/400 V et 277/480 V.

[e] Y compris 400/690 V.

NOTE 2 Au Japon, la valeur des TENSIONS TRANSITOIRES SUR LE RESEAU pour une tension nominale du RESEAU D'ALIMENTATION EN COURANT ALTERNATIF de 100 V est déterminée à partir de la ligne applicable pour une tension du RESEAU D'ALIMENTATION EN COURANT ALTERNATIF de 150 V.

b) ALIMENTATIONS DU RESEAU EN COURANT CONTINU reliées à la terre

Si une ALIMENTATION DE RESEAU EN COURANT CONTINU est connectée à la terre de protection et se trouve entièrement à l'intérieur d'un même bâtiment, la TENSION TRANSITOIRE DU RESEAU doit être prise comme égale à 71 V, valeur de crête. Si cette connexion se situe à l'intérieur de l'appareil en essai, elle doit être conforme à 2.6.1 d).

NOTE 3 La connexion à une terre de protection peut se situer à la source du RESEAU D'ALIMENTATION EN COURANT CONTINU ou à l'emplacement du matériel, ou les deux (voir la Recommandation UIT-T K.27).

c) ALIMENTATIONS DU RESEAU EN COURANT CONTINU non reliées à la terre

Si une alimentation du RESEAU EN COURANT CONTINU n'est pas reliée à la terre et est située comme indiqué en b) ci-dessus, la TENSION TRANSITOIRE DU RESEAU doit être prise comme égale à la TENSION TRANSITOIRE DU RESEAU dans le RESEAU D'ALIMENTATION EN COURANT ALTERNATIF qui fournit le RESEAU D'ALIMENTATION EN COURANT CONTINU.

d) Fonctionnement sur batteries

Si le matériel est alimenté par une batterie dédiée qui ne dispose d'aucun dispositif de charge à partir d'un RESEAU D'ALIMENTATION externe, la TENSION TRANSITOIRE DU RESEAU doit être prise comme 71 V, valeur de crête.

2.10.3.3 Distances dans l'air dans les circuits primaires

Pour l'isolation dans les CIRCUITS PRIMAIRES, entre CIRCUITS PRIMAIRES et la terre et entre CIRCUITS PRIMAIRES et CIRCUITS SECONDAIRES, les règles suivantes s'appliquent.

Pour un RESEAU D'ALIMENTATION EN COURANT ALTERNATIF ne dépassant pas 300 V en valeur efficace (420 V valeur de crête):

a) si la VALEUR DE CRETE DE LA TENSION DE SERVICE ne dépasse pas la valeur de crête d'une TENSION DU RESEAU D'ALIMENTATION EN COURANT ALTERNATIF, les DISTANCES DANS L'AIR minimales sont déterminées à partir du Tableau 2K;

b) la VALEUR DE CRETE DE LA TENSION DE SERVICE dépasse la valeur de crête de la tension du RESEAU D'ALIMENTATION EN COURANT ALTERNATIF, la DISTANCE DANS L'AIR minimale est la somme des deux valeurs suivantes:

- la DISTANCE DANS L'AIR minimale du Tableau 2K; et
- la DISTANCE DANS L'AIR supplémentaire appropriée du Tableau 2L.

NOTE Une DISTANCE DANS L'AIR minimale obtenue en utilisant le Tableau 2L se situe entre les valeurs prescrites pour les champs homogènes et non homogènes. En conséquence, elle peut ne pas passer avec succès l'essai de rigidité diélectrique approprié si le champ est substantiellement non homogène.

Pour une ALIMENTATION DE RESEAU EN COURANT ALTERNATIF supérieure à 300 V en valeur efficace (420 V valeur de crête), les DISTANCES DANS L'AIR minimales sont déterminées à partir du Tableau 2K.

Tableau 2K – Distances dans l'air minimales pour l'isolation dans les circuits primaires et entre circuits primaires et secondaires

DISTANCES DANS L'AIR en mm

~~TENSION DE SERVICE DE CRETE~~ VALEUR DE CRETE DE LA TENSION DE SERVICE [a] Jusques et y compris	TENSION TRANSITOIRE DU RESEAU														
	1 500 V [c]						2 500 V [c]						4 000 V [c]		
	Degré de pollution														
	1 et 2 [b]			3			1 et 2 [b]			3			1, 2 [b] et 3		
V	F	B/S	R	F	B/S	R	F	B/S	R	F	B/S	R	F	B/S	R
71 [a]	0,4	1,0 (0,5)	2,0 (1,0)	0,8	1,3 (0,8)	2,6 (1,6)	1,0	2,0 (1,5)	4,0 (3,0)	1,3	2,0 (1,5)	4,0 (3,0)	2,0	3,2 (3,0)	6,4 (6,0)
210 [a]	0,5	1,0 (0,5)	2,0 (1,0)	0,8	1,3 (0,8)	2,6 (1,6)	1,4	2,0 (1,5)	4,0 (3,0)	1,5	2,0 (1,5)	4,0 (3,0)	2,0	3,2 (3,0)	6,4 (6,0)
420 [a]	F 1,5 B/S 2,0 (1,5) R 4,0 (3,0)												2,5	3,2 (3,0)	6,4 (6,0)
840	F 3,0 B/S 3,2 (3,0) R 6,4 (6,0)														
1 400	F/BS 4,2 R 6,4														
2 800	F/B/S/R 8,4														
7 000	F/B/S/R 17,5														
9 800	F/B/S/R 25														
14 000	F/B/S/R 37														
28 000	F/B/S/R 80														
42 000	F/B/S/R 130														

Les valeurs du tableau sont applicables à l'ISOLATION FONCTIONNELLE (F) si cela est requis par 5.3.4 a) (voir 2.10.1.3), à l'ISOLATION PRINCIPALE (B), à l'ISOLATION SUPPLEMENTAIRE (S) et à l'ISOLATION RENFORCEE (R).

Les valeurs entre parenthèses s'appliquent à l'ISOLATION PRINCIPALE, à l'ISOLATION SUPPLEMENTAIRE ou à l'ISOLATION RENFORCEE uniquement si la fabrication est soumise à un programme de contrôle de la qualité qui fournit un niveau d'assurance au moins égal à celui de l'exemple donné à l'Article R.2. La DOUBLE ISOLATION et l'ISOLATION RENFORCEE doivent être soumises à un ESSAI INDIVIDUEL DE SERIE pour la rigidité diélectrique.

Si la ~~TENSION DE SERVICE DE CRETE~~ VALEUR DE CRETE DE LA TENSION DE SERVICE dépasse la valeur de crête de la tension du RESEAU D'ALIMENTATION EN COURANT ALTERNATIF, l'interpolation linéaire est autorisée entre les deux points les plus proches, la DISTANCE DANS L'AIR minimale calculée étant arrondie à l'échelon de 0,1 mm immédiatement supérieur.

[a] Si la ~~TENSION DE SERVICE DE CRETE~~ VALEUR DE CRETE DE LA TENSION DE SERVICE dépasse la valeur de crête de la tension du RESEAU D'ALIMENTATION EN COURANT ALTERNATIF, ~~voir~~ utiliser la valeur de crête de la tension du RESEAU D'ALIMENTATION EN COURANT ALTERNATIF dans cette colonne et utiliser le Tableau 2L conformément à 2.10.3.3 b) concernant les DISTANCES DANS L'AIR supplémentaires.

[b] Il n'est pas exigé de passer avec succès les essais de 2.10.10 pour le degré de pollution 1.

[c] La relation entre la TENSION TRANSITOIRE DU RESEAU et la tension du RESEAU D'ALIMENTATION EN COURANT ALTERNATIF est donnée au Tableau 2J.

Tableau 2L – Distances dans l'air supplémentaires dans les circuits primaires

DISTANCES DANS L'AIR en mm

TENSION TRANSITOIRE DU RESEAU						
1 500 V [c]				2 500 V [c]		
Degrés de pollution 1 et 2 [b]	Degré de pollution 3	ISOLATION FONCTIONNELLE [a], PRINCIPALE ou SUPPLEMENTAIRE	ISOLATION RENFORCEE	Degrés de pollution 1, 2 et 3 [b]	ISOLATION FONCTIONNELLE [a], PRINCIPALE ou SUPPLEMENTAIRE	ISOLATION RENFORCEE
VALEUR DE CRETE DE LA TENSION DE SERVICE jusqu'à et y compris V				VALEUR DE CRETE DE LA TENSION DE SERVICE jusqu'à et y compris V		
210 (210)	210 (210)	0,0	0,0	420 (420)	0,0	0,0
298 (288)	294 (293)	0,1	0,2	493 (497)	0,1	0,2
386 (366)	379 (376)	0,2	0,4	567 (575)	0,2	0,4
474 (444)	463 (459)	0,3	0,6	640 (652)	0,3	0,6
562 (522)	547 (541)	0,4	0,8	713 (729)	0,4	0,8
650 (600)	632 (624)	0,5	1,0	787 (807)	0,5	1,0
738 (678)	715 (707)	0,6	1,2	860 (884)	0,6	1,2
826 (756)	800 (790)	0,7	1,4	933 (961)	0,7	1,4
914 (839)	885 (873)	0,8	1,6	1 006 (1 039)	0,8	1,6
1 002 (912)	970 (956)	0,9	1,8	1 080 (1 116)	0,9	1,8
1 090 (990)	1 055 (1 039)	1,0	2,0	1 153 (1 193)	1,0	2,0
1 178 (1 068)	1 140 (1 122)	1,1	2,2	1 226 (1 271)	1,1	2,2
1 266 (1 146)	1 225 (1 205)	1,2	2,4	1 300 (1 348)	1,2	2,4
1 354 (1 224)	1 310 (1 288)	1,3	2,6	1 374 (1 425)	1,3	2,6

Les DISTANCES DANS L'AIR supplémentaires du tableau s'appliquent si cela est prescrit en 2.10.3.3.b).

Les valeurs entre parenthèses doivent être utilisées:

- si les valeurs entre parenthèses du Tableau 2K sont utilisées; et
- pour l'isolation fonctionnelle si cela est prescrit en 5.3.4 a).

Pour les valeurs de tension ci-dessus, les valeurs de la VALEUR DE CRETE DE LA TENSION DE SERVICE données dans le tableau, l'extrapolation linéaire est autorisée.

Pour les valeurs de tension dans les limites des valeurs de la TENSION DE SERVICE DE CRETE données dans le tableau, l'interpolation linéaire est autorisée entre les deux points les plus proches, la valeur minimale calculée de la DISTANCE DANS L'AIR supplémentaire étant arrondie à l'échelon de 0,1 mm immédiatement supérieur.

[a] Il n'existe pas de DISTANCE DANS L'AIR minimale pour l'ISOLATION FONCTIONNELLE sauf si cela est prescrit en 5.3.4 a). Voir 2.10.1.3.

[b] Il n'est pas exigé de passer avec succès les essais de 2.10.10 pour le degré de pollution 1.

[c] La relation entre TENSION TRANSITOIRE DU RESEAU et tension du RESEAU D'ALIMENTATION EN COURANT ALTERNATIF est donnée au Tableau 2J.

2.10.3.4 Distances dans l'air dans les circuits secondaires

Les DISTANCES DANS L'AIR minimales dans les CIRCUITS SECONDAIRES sont déterminées à partir du Tableau 2M.

La VALEUR DE CRETE DE LA TENSION DE SERVICE pour utilisation dans le Tableau 2M est:

– la valeur de crête d'une tension sinusoïdale;

– la valeur de crête mesurée d'une tension sinusoïdale.

La surtension transitoire la plus élevée pour utilisation dans le Tableau 2M est soit

– le transitoire le plus élevé provenant du RESEAU D'ALIMENTATION, déterminé conformément à 2.10.3.6 ou à 2.10.3.7; soit

– le transitoire le plus élevé provenant d'un RESEAU DE TELECOMMUNICATIONS, déterminé conformément à 2.10.3.8, en prenant la valeur la plus élevée.

Tableau 2M – Distances dans l'air minimales dans les circuits secondaires

DISTANCES DANS L'AIR en mm

VALEUR DE CRETE DE LA TENSION DE SERVICE jusqu'à et y compris	Surtension transitoire la plus élevée dans le CIRCUIT SECONDAIRE (V crête)																	
	Jusqu'à 71 V inclus			Supérieure à 71 V jusqu'à 800 V inclus			Jusqu'à 800 V inclus			Supérieure à 800 V jusqu'à 1 500 V inclus						Supérieure à 1 500 V jusqu'à 2 500 V inclus [a]		
	Degré de pollution																	
	1 et 2 [b]						3			1 et 2 [b]			3			1, 2 [b] et 3		
V	F	B/S	R	F	B/S	R	F	B/S	R	F	B/S	R	F	B/S	R	F	B/S	R
71	0,2	0,4 (0,2)	0,8 (0,4)	0,2	0,7 (0,2)	1,4 (0,4)	0,8	1,3 (0,8)	2,6 (1,6)	0,5	1,0 (0,5)	2,0 (1,0)	0,8	1,3 (0,8)	2,6 (1,6)	1,5	2,0 (1,5)	4,0 (3,0)
140	0,2	0,7 (0,2)	1,4 (0,4)	0,2	0,7 (0,2)	1,4 (0,4)	0,8	1,3 (0,8)	2,6 (1,6)	0,5	1,0 (0,5)	2,0 (1,0)	0,8	1,3 (0,8)	2,6 (1,6)	1,5	2,0 (1,5)	4,0 (3,0)
210	0,2	0,7 (0,2)	1,4 (0,4)	0,2	0,9 (0,2)	1,8 (0,4)	0,8	1,3 (0,8)	2,6 (1,6)	0,5	1,0 (0,5)	2,0 (1,0)	0,8	1,3 (0,8)	2,6 (1,6)	1,5	2,0 (1,5)	4,0 (3,0)
280	0,2	1,1 (0,2)	2,2 (0,4)	F 0,8 B/S 1,4 (0,8) R 2,8 (1,6)												1,5	2,0 (1,5)	4,0 (3,0)
420	0,2	1,4 (0,2)	2,8 (0,4)	F 1,0 B/S 1,9 (1,0) R 3,8 (2,0)												1,5	2,0 (1,5)	4,0 (3,0)
700	F/B/S 2,5 R, 5,0																	
840	F/B/S 3,2 R, 5,0																	
1 400	F/B/S 4,2 R, 5,0																	
2 800	F/B/S/R 8,4 Voir [c]																	
7 000	F/B/S/R ~~7,5~~ 17,5 Voir [c]																	
9 800	F/B/S/R 25 voir [c]																	
14 000	F/B/S/R 37 Voir [c]																	
28 000	F/B/S/R 80 Voir [c]																	
42 000	F/B/S/R 130 Voir [c]																	

Les valeurs du tableau s'appliquent à l'ISOLATION FONCTIONNELLE (F), si cela est requis par 5.3.4 a) (voir 2.10.1.3), l'ISOLATION PRINCIPALE (B), l'ISOLATION SUPPLEMENTAIRE (S) et l'ISOLATION RENFORCEE (R).

Il est permis de procéder par interpolation linéaire entre les deux points les plus proches, les distances dans l'air minimales calculées étant arrondies à l'échelon de 0,1 mm immédiatement supérieur.

Si le chemin de la DISTANCE DANS L'AIR suit partiellement la surface d'isolation qui n'appartient pas au groupe de matériau I, la tension d'essai est appliquée à travers l'espace et le groupe de matériau I uniquement. La partie du chemin le long de la surface de tout matériau isolant est contournée.

Les valeurs entre parenthèses sont applicables à l'ISOLATION PRINCIPALE, à l'ISOLATION SUPPLEMENTAIRE ou à l'ISOLATION RENFORCEE uniquement si la fabrication est soumise à un programme de contrôle de la qualité qui fournit un niveau d'assurance au moins égal à celui de l'exemple donné à l'Article R.2 de l'Annexe R. La DOUBLE ISOLATION et l'ISOLATION RENFORCEE doivent être soumises à un ESSAI INDIVIDUEL DE SERIE pour la rigidité diélectrique.

[a] Pour les surtensions transitoires supérieures à 2 500 V en valeur de crête, soit le Tableau 2K doit être utilisé, soit la distance dans l'air minimale doit être déterminée en utilisant l'Annexe G.

[b] Il n'est pas exigé de passer avec succès les essais de 2.10.10 pour le degré de pollution 1.

[c] Dans un CIRCUIT SECONDAIRE, pour les VALEURS DE CRETE DES TENSIONS DE SERVICE supérieures à 1 400 V, la DISTANCE DANS L'AIR minimale est de 5 mm sous réserve que le chemin de la DISTANCE DANS L'AIR passe avec succès l'essai de rigidité diélectrique selon 5.2.2 en utilisant

- une tension d'essai en courant alternatif dont la valeur efficace est égale à 106 % de la VALEUR DE CRETE DE LA TENSION DE SERVICE (valeur de crête 150 % de la VALEUR DE CRETE DE LA TENSION DE SERVICE), ou
- une tension d'essai en courant continu égale à 150 % de la VALEUR DE CRETE DE LA TENSION DE SERVICE.

2.10.3.5 Distances dans l'air dans des circuits avec impulsions de démarrage

Pour un circuit qui génère des impulsions de démarrage pour allumer une lampe à décharge et si le circuit n'est pas un CIRCUIT A LIMITATION DE COURANT conforme à 2.4 (voir 2.10.1.7), la bonne adéquation des DISTANCES DANS L'AIR est déterminée par l'une des méthodes suivantes:

a) Déterminer la DISTANCE DANS L'AIR minimale conformément à l'Annexe G; ou

b) Effectuer des essais de rigidité diélectrique en utilisant une des procédures suivantes. Au cours des essais, les bornes des lampes sont court-circuitées ensemble.

- *Essai selon 5.2.2, en utilisant une tension d'essai de crête en courant alternatif ou une tension en courant continu égale à 150 % la VALEUR DE CRETE DE LA TENSION DE SERVICE; ou*
- *Appliquer 30 impulsions ayant une amplitude égale à 150 % de la VALEUR DE CRETE DE LA TENSION DE SERVICE provenant d'un générateur d'impulsions extérieur. La largeur d'impulsion doit être supérieure ou égale à celle de l'impulsion de démarrage générée en interne.*

NOTE Pour les TENSIONS DE SERVICE , voir 2.10.2.1 i).

2.10.3.6 Transitoires provenant d'un réseau d'alimentation en courant alternatif

A l'exception de ce qui est permis ci-dessous, le transitoire le plus élevé dans un CIRCUIT SECONDAIRE dû aux transitoires sur le RESEAU D'ALIMENTATION EN COURANT ALTERNATIF est la valeur mesurée conformément à 2.10.3.9 a).

Sinon, pour certains CIRCUITS SECONDAIRES, il est permis de supposer que le transitoire le plus élevé est soit:

- la valeur mesurée conformément à 2.10.3.9 a); soit
- un niveau en dessous dans la liste suivante par rapport à la TENSION TRANSITOIRE DU RESEAU du Tableau 2J dans le CIRCUIT PRIMAIRE:

330, 500, 800, 1 500, 2 500 et 4 000 V de crête.

Cela est autorisé dans les cas suivants:

- un CIRCUIT SECONDAIRE, dérivé d'une ALIMENTATION RESEAU EN COURANT ALTERNATIF, qui est connecté à la principale borne de mise à la terre de protection conformément à 2.6.1;
- un CIRCUIT SECONDAIRE, dérivé d'une ALIMENTATION DE RESEAU EN COURANT ALTERNATIF et séparé du CIRCUIT PRIMAIRE par un écran métallique qui est connecté à la principale borne de mise à la terre de protection conformément en 2.6.1.

2.10.3.7 Transitoires provenant d'un réseau d'alimentation en courant continu

NOTE 1 Un circuit connecté à une ALIMENTATION DE RESEAU EN COURANT CONTINU est considéré comme un CIRCUIT SECONDAIRE (voir 1.2.8.2).

Le transitoire le plus élevé dans un CIRCUIT SECONDAIRE dû aux transitoires sur une ALIMENTATION DE RESEAU EN COURANT CONTINU est

- la TENSION TRANSITOIRE DU RESEAU, si le CIRCUIT SECONDAIRE est directement connecté à l'ALIMENTATION DU RESEAU EN COURANT CONTINU; ou
- la valeur mesurée conformément à 2.10.3.9 a) dans d'autres cas sauf ceux de 2.10.3.2 b) et 2.10.3.2 c).

NOTE 2 Les deux options ci-dessus dépendent de la valeur de la TENSION TRANSITOIRE DU RESEAU. Dans certains cas, cette valeur est supposée égale à 71 V en valeur de crête [voir 2.10.3.2 b) ou d)]. La colonne appropriée du Tableau 2K est utilisée et aucune mesure n'est nécessaire.

2.10.3.8 Transitoires provenant des réseaux de télécommunications et des systèmes de distribution par câbles

Si la TENSION TRANSITOIRE DU RESEAU DE TELECOMMUNICATIONS est connue pour le réseau concerné, il est permis d'utiliser la valeur connue en 2.10.3.4.

Si la TENSION TRANSITOIRE DU RESEAU DE TELECOMMUNICATIONS n'est pas connue, la valeur suivante doit être utilisée:

– 1 500 V valeur de crête si le circuit relié au RESEAU DE TELECOMMUNICATIONS est un CIRCUIT TRT-1 ou un CIRCUIT TRT-3; et
– 800 V valeur de crête si le circuit relié au RESEAU DE TELECOMMUNICATIONS est un CIRCUIT TBTS ou un CIRCUIT TRT-2.

Si les transitoires entrants sont atténués à l'intérieur du matériel, il est permis d'utiliser la valeur mesurée selon 2.10.3.9 b).

L'effet du signal de sonnerie de téléphone n'est pas pris en compte.

L'effet des transitoires provenant d'un SYSTEME DE DISTRIBUTION PAR CABLES n'est pas pris en compte (voir toutefois 7.4.1).

2.10.3.9 Mesure des tensions transitoires

Les essais suivants sont effectués uniquement s'il est prescrit de déterminer si oui ou non la tension transitoire à travers la DISTANCE DANS L'AIR dans un circuit quelconque est plus faible que la normale (en raison, par exemple, de l'effet d'un filtre dans le matériel). La tension transitoire à travers la DISTANCE DANS L'AIR est mesurée à l'aide des procédures d'essai suivantes.

Pendant les essais, le matériel est relié à son unité d'alimentation séparée, s'il elle existe, mais n'est pas relié au réseau d'alimentation, ni à aucun RÉSEAU DE TÉLÉCOMMUNICATIONS, et tous les parasurtenseurs dans les CIRCUITS PRIMAIRES sont déconnectés.

Un dispositif de mesure de tension est connecté à travers la DISTANCE DANS L'AIR concernée.

a) Transitoires provenant d'un RESEAU D'ALIMENTATION

Pour mesurer une tension transitoire à travers une DISTANCE DANS L'AIR due aux tensions transitoires sur un RESEAU D'ALIMENTATION, le générateur d'impulsions d'essai, référence 2 du Tableau N.1 est utilisé pour produire des impulsions de 1,2/50 µs. U_c est égal à la TENSION TRANSITOIRE DU RESEAU donnée au Tableau 2J.

Trois à six impulsions de polarités alternées, avec des intervalles d'au moins 1 s entre les impulsions, sont appliquées entre tous les points suivants, lorsque c'est applicable:

Pour une ALIMENTATION DE RESEAU EN COURANT CONTINU

– *entre lignes;*
– *tous les conducteurs de ligne reliés galvaniquement ensemble et le neutre;*
– *tous les conducteurs de ligne reliés galvaniquement ensemble et la terre de protection;*
– *le neutre et la terre de protection.*

Pour une ALIMENTATION DE RESEAU EN COURANT CONTINU

– *les points positif et négatif de connexion d'alimentation;*
– *tous les points de connexion d'alimentation reliés galvaniquement ensemble et la terre de protection.*

b) Transitoires provenant d'un RESEAU DE TELECOMMUNICATIONS

Pour mesurer une tension transitoire à travers une DISTANCE DANS L'AIR due aux tensions transitoires sur un RESEAU DE TELECOMMUNICATIONS, le générateur d'impulsions d'essai, référence 1 du Tableau N.1 est utilisé pour produire des impulsions de 10/700 µs. U_c est égal à la TENSION TRANSITOIRE SUR LE RESEAU DE TELECOMMUNICATIONS déterminée en 2.10.3.8.

Trois à six impulsions de polarités alternées, avec des intervalles d'au moins 1 s entre les impulsions, sont appliquées entre tous les points de connexion suivants du RESEAU DE TELECOMMUNICATIONS d'un type d'interface unique:

- *chaque paire de bornes (par exemple A et B ou donnée et sonnerie) d'une interface;*
- *toutes les bornes d'un type d'interface unique reliées ensemble et la terre.*

Lorsqu'il existe plusieurs circuits identiques, un seul est soumis aux essais.

2.10.4 Lignes de fuite

2.10.4.1 Généralités

Les LIGNES DE FUITE doivent être dimensionnées de telle façon que, pour UNE VALEUR EFFICACE DE TENSION DE SERVICE donnée et un degré de pollution, il n'y ait ni contournement ni rupture de l'isolation (par exemple dû au cheminement).

2.10.4.2 Groupe de matériau et indice de résistance au cheminement

Les groupes de matériaux dépendent de l'indice de résistance au cheminement (IRC) et sont classés comme suit:

Groupe de matériau I		IRC ≥ 600
Groupe de matériau II	400 ≤	IRC < 600
Groupe de matériau IIIa	175 ≤	IRC < 400
Groupe de matériau IIIb	100 ≤	IRC < 175

Le groupe de matériau est vérifié par l'évaluation des données d'essai pour le matériau conformément à la CEI 60112 en utilisant 50 gouttes de la solution A.

Lorsque le groupe de matériau n'est pas connu, il est supposé être le groupe de matériau IIIb.

Si un IRC supérieur ou égal à 175 est nécessaire et si les données ne sont pas disponibles, le groupe de matériau peut être établi avec un essai pour l'indice de tenue au cheminement (ITC) comme détaillé dans la CEI 60112. Un matériau peut être inclus dans un groupe si son ITC établi par ces essais est supérieur ou égal à la valeur la plus faible de l'IRC spécifiée pour le groupe.

2.10.4.3 Lignes de fuite minimales

Les LIGNES DE FUITE ne doivent pas être inférieures aux valeurs minimales appropriées spécifiées dans le Tableau 2N.

Si la valeur minimale de la LIGNE DE FUITE provenant du Tableau 2N est inférieure à la DISTANCE DANS L'AIR minimale applicable, la valeur pour cette DISTANCE DANS L'AIR doit être appliquée comme valeur minimale pour la LIGNE DE FUITE.

Pour le verre, le mica, la céramique vitrifiée ou d'autres matériaux inorganiques similaires, si la LIGNE DE FUITE minimale est supérieure à la DISTANCE DANS L'AIR minimale applicable, il est permis d'appliquer cette valeur de DISTANCE DANS L'AIR minimale comme LIGNE DE FUITE minimale.

Les LIGNES DE FUITE entre la SURFACE FRONTIERE d'un connecteur et les parties conductrices à l'intérieur du connecteur qui sont connectées à une TENSION DANGEREUSE doivent être conformes aux exigences D'ISOLATION RENFORCEE. A titre exceptionnel, pour les connecteurs qui sont

– fixés au matériel; et
– situés à l'intérieur de l'ENVELOPPE extérieure du matériel; et
– uniquement accessibles après retrait d'un sous-ensemble qui peut être remplacé par l'UTILISATEUR qui doit être en place en fonctionnement normal,

ces LIGNES DE FUITE doivent être conformes aux exigences pour l'ISOLATION PRINCIPALE.

NOTE Les essais de 2.1.1.1 pour l'accès aux parties dangereuses s'appliquent à de tels connecteurs après le retrait du sous-ensemble.

Pour toutes les autres LIGNES DE FUITE dans les connecteurs, y compris les connecteurs qui ne sont pas fixés au matériel, les valeurs minimales spécifiées au Tableau 2N s'appliquent.

Les LIGNES DE FUITE minimales ci-dessus pour les connecteurs ne s'appliquent pas aux connecteurs qui sont conformes à une norme harmonisée avec la CEI 60083, la CEI 60309, la CEI 60320, la CEI 60906-1 ou la CEI 60906-2, voir aussi 1.5.2.

La vérification est effectuée par des mesures, en tenant compte de l'Annexe F. Les conditions suivantes s'appliquent:

– *les parties mobiles doivent être placées dans la position la plus défavorable;*
– *pour le matériel équipé de CÂBLES D'ALIMENTATION FIXES A DEMEURE ordinaires, les mesures de LIGNES DE FUITE sont effectuées avec des conducteurs d'alimentation de la plus forte section spécifiée en 3.3.4 pour la borne concernée et aussi sans conducteurs; et*
– *lorsque les LIGNES DE FUITE, à partir de la SURFACE FRONTIERE d'une ENVELOPPE en matière isolante, sont mesurées à travers une fente ou une ouverture dans l'ENVELOPPE ou à travers une ouverture dans un connecteur accessible, la surface accessible est considérée comme conductrice comme si elle était recouverte d'une feuille de métal partout où elle peut être touchée par le doigt d'épreuve de la Figure 2A (voir 2.1.1.1), appliqué sans force appréciable (voir Figure F.12, point X).*

Tableau 2N – Lignes de fuite minimales

LIGNES DE FUITE en mm

VALEUR EFFICACE DE LA TENSION DE SERVICE jusqu'à et y compris V	Degré de pollution 1[a] – Groupe de matériaux – Cartes imprimées – I, II, IIIa, IIIb	Degré de pollution 2 – Cartes imprimées – I, II, IIIa	Degré de pollution 1[a] – Autres matériaux – I, II, IIIa, IIIb	Degré de pollution 2 – Autres matériaux – I	2 – II	2 – IIIa, IIIb	Degré de pollution 3 – Autres matériaux – I	3 – II	3 – IIIa, IIIb (voir Note)
10	0,025	0,04	0,08	0,4	0,4	0,4	1,0	1,0	1,0
12,5	0,025	0,04	0,09	0,42	0,42	0,42	1,05	1,05	1,05
16	0,025	0,04	0,1	0,45	0,45	0,45	1,1	1,1	1,1
20	0,025	0,04	0,11	0,48	0,48	0,48	1,2	1,2	1,2
25	0,025	0,04	0,125	0,5	0,5	0,5	1,25	1,25	1,25
32	0,025	0,04	0,14	0,53	0,53	0,53	1,3	1,3	1,3
40	0,025	0,04	0,16	0,56	0,8	1,1	1,4	1,6	1,8
50	0,025	0,04	0,18	0,6	0,85	1,2	1,5	1,7	1,9
63	0,04	0,063	0,2	0,63	0,9	1,25	1,6	1,8	2,0
80	0,063	0,10	0,22	0,67	0,9	1,3	1,7	1,9	2,1
100	0,1	0,16	0,25	0,71	1,0	1,4	1,8	2,0	2,2
125	0,16	0,25	0,28	0,75	1,05	1,5	1,9	2,1	2,4
160	0,25	0,40	0,32	0,8	1,1	1,6	2,0	2,2	2,5
200	0,4	0,63	0,42	1,0	1,4	2,0	2,5	2,8	3,2
250	0,56	1,0	0,56	1,25	1,8	2,5	3,2	3,6	4,0
320	0,75	1,6	0,75	1,6	2,2	3,2	4,0	4,5	5,0
400	1,0	2,0	1,0	2,0	2,8	4,0	5,0	5,6	6,3
500	1,3	2,5	1,3	2,5	3,6	5,0	6,3	7,1	8,0
630	1,8	3,2	1,8	3,2	4,5	6,3	8,0	9.0	10
800	2,4	4,0	2,4	4,0	5,6	8,0	10	11	12,5
1 000	3,2	5,0	3,2	5,0	7,1	10	12,5	14	16
1 250			4,2	6,3	9,0	12,5	16	18	20
1 600			5,6	8,0	11	16	20	22	25
2 000			7,5	10	14	20	25	28	32
2 500			10	12,5	18	25	32	36	40
3 200			12,5	16	22	32	40	45	50
4 000			16	20	28	40	50	56	63
5 000			20	25	36	50	63	71	80
6 300			25	32	45	63	80	90	100
8 000			32	40	56	80	100	110	125
10 000			40	50	71	100	125	140	160
12 500			50	63	90	125			
16 000			63	80	110	160			
20 000			80	100	140	200			
25 000			100	125	180	250			
32 000			125	160	220	320			
40 000			160	200	280	400			
50 000			200	250	360	500			
63 000			250	320	450	600			

Les valeurs du tableau s'appliquent à l'ISOLATION FONCTIONNELLE, si cela est requis par 5.3.4 a) (voir 2.10.1.3), l'ISOLATION PRINCIPALE et l'ISOLATION SUPPLEMENTAIRE. Pour l'ISOLATION RENFORCEE, les valeurs sont le double de celles du tableau.

Il est permis de procéder par interpolation linéaire entre les deux points les plus voisins, la LIGNE DE FUITE calculée étant arrondie à l'échelon de 0,1 mm immédiatement supérieur. Pour l'ISOLATION RENFORCEE, la valeur calculée de l'ISOLATION PRINCIPALE doit être doublée d'abord avant d'arrondir.

NOTE Le groupe de matériau IIIb n'est pas recommandé pour les applications en degré de pollution 3 avec une VALEUR EFFICACE DE LA TENSION DE SERVICE supérieure à 630 V.

[a] Il est permis d'utiliser les valeurs du degré de pollution 1 si un échantillon passe avec succès les essais de 2.10.10.

VALEUR EFFICACE DE LA TENSION DE SERVICE Jusques et y compris V	Degré de pollution						
	1[a]	2			3		
	Groupe de matériaux						
	I, II, IIIa, IIIb	I	II	IIIa, IIIb	I	II	IIIa, IIIb (voir Note)
10	0,08	0,4	0,4	0,4	1,0	1,0	1,0
12,5	0,09	0,42	0,42	0,42	1,05	1,05	1,05
16	0,1	0,45	0,45	0,45	1,1	1,1	1,1
20	0,11	0,48	0,48	0,48	1,2	1,2	1,2
25	0,125	0,5	0,5	0,5	1,25	1,25	1,25
32	0,14	0,53	0,53	0,53	1,3	1,3	1,3
40	0,16	0,56	0,8	1,1	1,4	1,6	1,8
50	0,18	0,6	0,85	1,2	1,5	1,7	1,9
63	0,2	0,63	0,9	1,25	1,6	1,8	2,0
80	0,22	0,67	0,9	1,3	1,7	1,9	2,1
100	0,25	0,71	1,0	1,4	1,8	2,0	2,2
125	0,28	0,75	1,05	1,5	1,9	2,1	2,4
160	0,32	0,8	1,1	1,6	2,0	2,2	2,5
200	0,42	1,0	1,4	2,0	2,5	2,8	3,2
250	0,56	1,25	1,8	2,5	3,2	3,6	4,0
320	0,75	1,6	2,2	3,2	4,0	4,5	5,0
400	1,0	2,0	2,8	4,0	5,0	5,6	6,3
500	1,3	2,5	3,6	5,0	6,3	7,1	8,0
630	1,8	3,2	4,5	6,3	8,0	9,0	10
800	2,4	4,0	5,6	8,0	10	11	12,5
1 000	3,2	5,0	7,1	10	12,5	14	16
1 250	4,2	6,3	9,0	12,5	16	18	20
1 600	5,6	8,0	11	16	20	22	25
2 000	7,5	10	14	20	25	28	32
2 500	10	12,5	18	25	32	36	40
3 200	12,5	16	22	32	40	45	50
4 000	16	20	28	40	50	56	63
5 000	20	25	36	50	63	71	80
6 300	25	32	45	63	80	90	100
8 000	32	40	56	80	100	110	125
10 000	40	50	71	100	125	140	160
12 500	50	63	90	125			
16 000	63	80	110	160			
20 000	80	100	140	200			
25 000	100	125	180	250			
32 000	125	160	220	320			
40 000	160	200	280	400			
50 000	200	250	360	500			
63 000	250	320	450	600			

Les valeurs du tableau s'appliquent à l'ISOLATION FONCTIONNELLE si elle est requise par 5.3.4 a) (voir 2.10.1.3), à l'ISOLATION PRINCIPALE et à l'ISOLATION SUPPLEMENTAIRE. Pour l'ISOLATION RENFORCEE, les valeurs sont égales à deux fois celles du tableau.

L'interpolation linéaire peut être utilisée entre les deux points les plus proches, la valeur minimale calculée de LIGNE DE FUITE étant arrondie à l'échelon immédiatement supérieur spécifié, ou la valeur dans la rangée suivante, la plus petite de ces deux valeurs étant retenue. Pour les valeurs:

- ne dépassant 0,5 mm, l'échelon spécifié est 0,01mm; et
- pour celles supérieures à 0,5 mm, l'échelon spécifié est 0,1 mm.

Pour l'ISOLATION RENFORCEE, la valeur calculée pour l'ISOLATION PRINCIPALE doit être doublée d'abord avant d'arrondir.

NOTE Le groupe de matériaux IIIb n'est pas recommandé pour les applications en degré de pollution 3 avec une VALEUR EFFICACE DE LA TENSION DE SERVICE supérieure à 630 V.

[a] Il est permis d'utiliser les valeurs du degré de pollution 1 si un échantillon passe avec succès les essais de 2.10.10.

2.10.5 Isolation solide

2.10.5.1 Généralités

En 2.10.5, les exigences pour l'ISOLATION SOLIDE (à l'exception de celles pour les matériaux en fines feuilles) et pour les composés isolant s'appliquent également aux matériaux à base de gel utilisés à cet effet.

L'isolation solide doit être:

– dimensionnée de telle façon que les surtensions, y compris les transitoires qui entrent dans le matériel, et les tensions crêtes qui peuvent être produites à l'intérieur du matériel ne détruisent pas l'ISOLATION SOLIDE; et

– disposée de telle manière que la probabilité d'une rupture due à la présence de micro-trous dans les couches fines d'isolation soit limitée.

L'émail à base de solvant est accepté uniquement sur les fils de bobinage tels que décrits en 2.10.5.13.

Sauf dans les cas des cartes imprimées, l'ISOLATION SOLIDE doit soit

– être conforme aux distances minimales à travers l'isolation conformément à 2.10.5.2; ou

– satisfaire aux exigences et subir avec succès les essais de 2.10.5.3 à 2.10.5.13, tels qu'applicables.

NOTE 1 Pour les cartes imprimées, voir 2.10.6.

NOTE 2 Pour l'ISOLATION SOLIDE sur les câblages internes, voir 3.1.4.

La vérification de conformité aux exigences des Paragraphes 2.10.5.2 à 2.10.5.14 pour l'adéquation de l'ISOLATION SOLIDE est effectuée par examen et par des mesures en tenant compte de l'Annexe F, par les essais de rigidité diélectrique de 5.2 et par les essais supplémentaires exigés de 2.10.5.4 à 2.10.5.14.

2.10.5.2 Distances à travers l'isolation

Si une conception est fondée sur des distances à travers l'isolation, ces distances doivent être dimensionnées selon l'application de l'isolation (voir 2.9) et comme suit (voir Figure F.14):

– si la VALEUR DE CRETE DE LA TENSION DE SERVICE ne dépasse pas 71 V, il n'y a pas d'exigence pour la distance à travers l'isolation;

– si la VALEUR DE CRETE DE LA TENSION DE SERVICE dépasse 71 V, les règles suivantes s'appliquent:

- pour l'ISOLATION FONCTIONNELLE et l'ISOLATION PRINCIPALE, il n'existe pas de distance minimale à travers l'isolation;
- l'ISOLATION SUPPLEMENTAIRE ET l'ISOLATION RENFORCEE doivent avoir une distance à travers l'isolation supérieure ou égale à 0,4 mm fournie par une couche unique.

Pour les critères de conformité, voir 2.10.5.1.

2.10.5.3 Composé isolant comme isolation solide

NOTE 1 Pour les cartes imprimées, voir 2.10.6 et pour les composants bobinés, voir 2.10.5.11, 2.10.5.12, 2.10.5.13 et 2.10.5.14.

Il n'existe pas de DISTANCE DANS L'AIR OU DE LIGNE DE FUITE interne minimale si le composé isolant remplit complètement le boîtier d'un composant ou d'un sous-ensemble sous réserve que chaque distance à travers l'isolation d'un composant ou d'un sous-ensemble satisfasse aux exigences de 2.10.5.2 et qu'un échantillon unique passe avec succès les essais de 2.10.10.

NOTE 2 Quelques exemples d'un tel traitement sont connus sous les termes d'enrobage, mise sous boîtier rempli et imprégnation sous vide.

NOTE 3 Les constructions ci-dessus peuvent contenir des joints scellés, auquel cas 2.10.5.5 s'applique aussi.

Pour les critères de conformité, voir 2.10.5.1.

2.10.5.4 Dispositifs à semiconducteurs

Il n'existe pas de distance minimale à travers l'isolation pour l'isolation supplémentaire ou l'isolation renforcée faite d'un composé isolant remplissant le boîtier d'un composant à semiconducteur (par exemple un optocoupleur, voir la Figure F.17), sous réserve que le composant satisfasse à l'une des conditions suivantes, a) ou b):

a) – satisfait aux ESSAIS DE TYPE et aux critères d'examen de 2.10.11; et

– est soumis à des ESSAIS INDIVIDUELS DE SERIE pour la rigidité diélectrique pendant la fabrication, avec la valeur appropriée de tension d'essai de 5.2.2; ou

b) pour un optocoupleur uniquement, est conforme aux exigences de la CEI 60747-5-5[1)], où les tensions d'essai comme spécifié en 5.2.6 (de la CEI 60747-5-5):

– la tension $V_{ini,a}$ pour les ESSAIS DE TYPE, et

– la tension $V_{ini,b}$ pour les ESSAIS DE TYPE,

doivent être la valeur appropriée de la tension d'essai en 5.2.2 de la présente norme.

NOTE Les constructions ci-dessus peuvent contenir des joints scellés, auquel cas 2.10.5.5 s'applique aussi.

Comme alternative à a) et b) ci-dessus, il est permis de traiter un semiconducteur selon 2.10.5.3, si cela est applicable.

Pour les critères de conformité, voir 2.10.5.1.

2.10.5.5 Joints scellés

Lorsque le chemin entre des parties conductrices est rempli avec un composé isolant et que ce composé isolant forme un joint scellé entre deux parties non conductrices (voir Figure F.18) ou entre une partie non conductrice et lui-même (voir Figures F.16 et F.17), un des poins suivants a), b) ou c) s'applique.

a) La distance le long du chemin entre deux parties conductrices ne doit pas être inférieure aux DISTANCES DANS L'AIR et aux LIGNES DE FUITE minimales pour le degré de pollution 2. Les exigences pour la distance à travers l'isolation de 2.10.5.2 ne s'appliquent pas le long du joint.

b) La distance le long du chemin entre deux parties conductrices ne doit pas être inférieure aux DISTANCES DANS L'AIR et aux LIGNES DE FUITE minimales pour le degré de pollution 1. De plus, un échantillon doit passer avec succès l'essai de 2.10.10. Les exigences pour la distance à travers l'isolation de 2.10.5.2 ne s'appliquent pas le long du joint.

c) Les exigences pour la distance à travers l'isolation de 2.10.5.2 s'appliquent entre les parties conductrices le long du joint. De plus, trois échantillons doivent passer avec succès l'essai de 2.10.11.

Pour a) et b) ci-dessus, si les matériaux isolants concernés sont de groupes de matériaux différents, c'est le cas le plus défavorable qui est utilisé. Lorsque le groupe de matériau n'est pas connu, il est supposé être le groupe de matériau IIIb.

Pour b) et c) ci-dessus, les essais de 2.10.10 et 2.10.11 ne sont pas appliqués à une carte imprimée réalisée en utilisant du prépreg si la température de la carte imprimée mesurée au cours de l'essai ~~d'échauffement~~ de 4.5.2 ne dépasse pas 90 °C en tout point du matériau de la carte imprimée.

1) A publier.

NOTE 1 Il n'existe pas de DISTANCE DANS L'AIR ou de LIGNE DE FUITE à moins que le joint n'éclate, par exemple, suite au vieillissement. Pour couvrir cette possibilité, les exigences et les essais du c) s'appliquent si les DISTANCES DANS L'AIR et les LIGNES DE FUITE selon a) ou b) sont satisfaites.

NOTE 2 Ci-dessous quelques exemples de joints scellés:

- entre deux parties non conductrices scellées ensemble, par exemple deux couches d'une carte imprimée multicouches (voir Figure F.16) ou la bobine séparée d'un transformateur là où la cloison est fixée par de l'adhésif (voir Figure F.18);
- entre des couches d'isolation enroulées en spirale sur un fil de bobinage, scellées par de l'adhésif;
- entre le boîtier non conducteur d'un optocoupleur et le composé isolant remplissant le boîtier (voir Figure F.17).

Pour les critères de conformité, voir 2.10.5.1.

2.10.5.6 Matériaux en couches minces – Généralités

Il n'existe pas d'exigence de dimension ou de construction pour l'isolation dans les matériaux en fines feuilles utilisés comme ISOLATION FONCTIONNELLE OU ISOLATION PRINCIPALE.

L'isolation en fines feuilles est permise pour l'ISOLATION SUPPLEMENTAIRE ET l'ISOLATION RENFORCEE (voir Figure F.15), quelle que soit la distance à travers l'isolation, sous réserve que l'ensemble de ce qui suit s'applique:

– deux couches au moins sont utilisées;
– l'isolation se trouve à l'intérieur de l'ENVELOPPE du matériel;
– l'isolation n'est pas soumise à des manipulations ou à l'abrasion au cours de la maintenance par l'OPERATEUR; et
– les exigences et les essais de 2.10.5.7 (pour des couches séparées) ou de 2.10.5.8 (pour des couches non séparées) sont satisfaites.

Il n'est pas exigé que les deux ou plus de deux couches soient fixées à la même partie conductrice. Ces deux ou plus de deux couches peuvent être

– fixées à l'une des parties conductrices exigeant la séparation, ou
– partagées entre les deux parties conductrices, ou
– sans fixation sur aucune partie conductrice.

2.10.5.7 Matériau en fines feuilles séparables

Pour l'isolation des couches en fines feuilles séparables, en plus des exigences de 2.10.5.6,

– l'ISOLATION SUPPLEMENTAIRE doit comprendre au moins deux couches de matériau, chacune d'elles satisfaisant à l'essai de rigidité diélectrique pour l'ISOLATION SUPPLEMENTAIRE; ou
– l'ISOLATION SUPPLEMENTAIRE doit comprendre trois couches de matériau dans lesquelles toutes les combinaisons de deux couches ensemble satisfont à l'essai de rigidité diélectrique pour l'ISOLATION SUPPLEMENTAIRE; ou
– l'ISOLATION RENFORCEE doit comprendre au moins deux couches de matériau, chacune d'elles satisfaisant à l'essai de rigidité diélectrique pour l'ISOLATION RENFORCEE; ou
– l'ISOLATION RENFORCEE doit comprendre trois couches de matériau dans lesquelles toutes les combinaisons de deux couches ensemble satisfont à l'essai de rigidité diélectrique pour l'ISOLATION RENFORCEE.

Il est permis que différentes couches d'isolation soient en matériaux différents ou d'épaisseurs différentes, ou les deux à la fois.

La vérification est effectuée par examen et par l'essai de rigidité diélectrique de 2.10.5.9 ou de 2.10.5.10.

2.10.5.8 Matériaux en couches minces non séparables

Pour les isolations en matériaux en couches minces non séparables, les modalités d'essai du Tableau 2P s'appliquent en complément des exigences de 2.10.5.6.

Il est permis que différentes couches d'isolation soient en matériaux différents ou d'épaisseurs différentes, ou les deux à la fois.

La conformité est vérifiée par examen et par les essais spécifiés au Tableau 2P.

Tableau 2P – Essais pour l'isolation en couches non séparables

Nombre de couches	Procédure d'essai
ISOLATION SUPPLEMENTAIRE Deux ou plus de deux couches	La procédure d'essai de 2.10.5.9 est appliquée [a].
ISOLATION RENFORCEE Deux couches:	La procédure d'essai de 2.10.5.9 est appliquée [a].
Trois ou plus de trois couches	Les procédures d'essai de 2.10.5.9 et l'Annexe AA sont appliquées [a].
[a] La procédure d'essai alternative de 2.10.5.10 ne peut pas être utilisée pour les couches non séparables. NOTE L'objet des essais de l'Annexe AA est d'assurer que le matériau a une solidité adéquate pour résister aux dommages lorsqu'il est intégré dans des couches intérieures de l'isolation. Par conséquent, les essais ne sont pas appliqués à l'isolation en deux couches. Les essais de l'Annexe AA ne sont pas appliqués à l'ISOLATION SUPPLEMENTAIRE.	

2.10.5.9 Matériaux en fines feuilles – modalité d'essai normalisée

Pour les couches séparables ou non séparables, les essais de rigidité diélectrique sont appliqués conformément à 5.2.2 à toutes les couches ensemble. La tension d'essai est:

- *200 % de U_{essai} si deux couches sont utilisées; ou*
- *150 % de U_{essai} si trois couches sont utilisées; ou*

lorsque U_{essai} est la tension d'essai spécifiée en 5.2.2 pour l'ISOLATION SUPPLEMENTAIRE ou l'ISOLATION RENFORCEE selon ce qui est approprié.

NOTE A moins que toutes les couches soient du même matériau et aient la même épaisseur, il est possible que la tension d'essai soit partagée de manière égale entre les couches en provoquant une rupture d'une couche qui aurait passé l'essai avec succès si elle avait été soumise à l'essai séparément.

2.10.5.10 Matériaux en fines feuilles – modalité d'essai alternative

Si les couches peuvent être séparées pour des essais individuels, l'alternative suivante à la procédure d'essai normalisée de 2.10.5.9 est autorisée.

Les essais de rigidité diélectrique sont appliqués conformément à 5.2.2 en utilisant des tensions d'essai égales à la tension d'essai spécifiée en 5.2.2 pour l'ISOLATION SUPPLEMENTAIRE ou l'ISOLATION RENFORCEE, selon ce qui est approprié.

Si deux couches sont utilisées, chaque couche doit passer l'essai avec succès.

Si trois ou plus de trois couches sont utilisées, chaque combinaison de deux couches doit passer l'essai avec succès.

Si trois ou plus de trois couches sont utilisées, il est permis de diviser ces couches en deux ou trois groupes pour les essais. Dans les essais de rigidité diélectrique ci-dessus, deux ou trois groupes sont soumis aux essais à la place de deux ou trois couches.

Un essai sur une couche ou un groupe de couches n'est pas répété sur une couche ou un groupe identique.

2.10.5.11 Isolation des composants bobinés

Les transformateurs planaires ne sont pas considérés comme des composants bobinés.

NOTE 1 Les transformateurs planaires sont soumis aux exigences de construction des cartes imprimées, voir 2.10.6.

Il n'existe pas d'exigence de dimension ou de construction pour l'ISOLATION FONCTIONNELLE d'un composant bobiné.

Il est permis que l'ISOLATION PRINCIPALE, l'ISOLATION SUPPLEMENTAIRE ou l'ISOLATION RENFORCEE à l'intérieur d'un composant soit assurée par

- l'isolation sur un fil de bobinage ou un autre fil (voir 2.10.5.12 ou 2.10.5.13); ou
- une autre isolation (voir 2.10.5.14); ou
- une combinaison des deux.

NOTE 2 De tels composants bobinés peuvent contenir des joints scellés, auquel cas 2.10.5.5 s'applique aussi.

Pour une DOUBLE ISOLATION entre le conducteur d'un fil et une autre partie conductrice, il est permis que l'ISOLATION PRINCIPALE soit assurée par une isolation conforme à 2.10.5.12 sur l'un des fils et par une ISOLATION SUPPLEMENTAIRE par une isolation supplémentaire conforme à 2.10.5.14 ou vice versa.

Pour les critères de conformité, voir 2.10.5.1.

En outre, l'ISOLATION PRINCIPALE, l'ISOLATION SUPPLEMENTAIRE et l'ISOLATION RENFORCEE dans les composants bobinés finis doivent passer avec succès les ESSAIS INDIVIDUELS DE SERIE pour la rigidité diélectrique conformément à 5.2.2.

2.10.5.12 Fil dans les composants bobinés

Les exigences suivantes s'appliquent au fil de bobinage et aux autres fils dont l'isolation assure l'ISOLATION PRINCIPALE, l'ISOLATION SUPPLEMENTAIRE ou l'ISOLATION RENFORCEE, selon ce qui est exigé.

L'émail à base de solvant n'est pas considéré comme fournissant une ISOLATION PRINCIPALE, SUPPLEMENTAIRE ou RENFORCEE. L'émail à base de solvant est accepté uniquement s'il est utilisé sur l'isolation de fils de bobinage comme cela est décrit en 2.10.5.13.

NOTE 1 Pour l'isolation fournie en plus de celle sur le fil de bobinage, voir 2.10.5.14.

Si la VALEUR DE CRETE DE LA TENSION DE SERVICE ne dépasse pas 71 V, il n'y a pas d'exigence de dimension ou de construction.

Si la VALEUR DE CRETE DE LA TENSION DE SERVICE dépasse 71 V, l'un des points suivants a), b) ou c) s'applique:

a) Pour l'ISOLATION PRINCIPALE qui n'est pas sous contrainte (par exemple tension de bobinage), il n'y a pas d'exigence de dimension ou de construction. Pour l'isolation principale qui est soumise à une telle contrainte, b) ou c) s'applique.

NOTE 2 L'exception en a) ne s'applique pas à l'ISOLATION SUPPLEMENTAIRE ou à l'ISOLATION RENFORCEE.

b) Pour l'ISOLATION PRINCIPALE, l'ISOLATION SUPPLEMENTAIRE OU l'ISOLATION RENFORCEE, l'isolation sur le fil doit
   - soit avoir une épaisseur d'au moins 0,4 mm assurée par une seule couche; soit
   - être conforme à 2.10.5.6 et à l'Annexe U.

c) Le fil de bobinage doit être conforme à l'Annexe U. En outre, le nombre minimal de couches qui se chevauchent d'une bande enroulée en spirale ou de couches extrudées d'isolation doit être comme suit:

– pour l'ISOLATION PRINCIPALE: une couche;

– pour l'ISOLATION SUPPLEMENTAIRE: deux couches;

– pour l'ISOLATION RENFORCEE: trois couches.

Pour l'isolation entre deux fils de bobinage adjacents, une couche sur chaque conducteur est considérée comme fournissant une ISOLATION SUPPLEMENTAIRE.

Un ruban enroulé en spirale avec moins de 50 % de chevauchement est considéré comme constituant une couche.

Un ruban enroulé en spirale avec plus de 50 % de chevauchement est considéré comme constituant deux couches.

Un ruban enroulé en spirale doit être scellé et doit passer avec succès les essais de 2.10.5.5 a), b) ou c).

NOTE 3 Pour les fils isolés par un processus d'extrusion, le scellement est inhérent au processus.

Lorsque deux fils de bobinage ou un fil de bobinage et un autre fil sont en contact à l'intérieur d'un composant bobiné et se croisent avec un angle compris entre 45° et 90° et sont soumis à la tension de l'enroulement, une protection contre les contraintes mécaniques doit être prévue. Cette protection peut être obtenue, par exemple, en fournissant une séparation physique sous la forme d'un manchon isolant ou d'un matériau en feuille, ou en utilisant le double du nombre de couches d'isolants prescrit.

Pour les critères de conformité, voir 2.10.5.1. Si les essais de l'Annexe U sont nécessaires, ils ne sont pas répétés si les données du matériau confirment la conformité.

2.10.5.13 Fil avec émail à base de solvant dans des composants bobinés

Il est permis d'utiliser de l'émail à base de solvant sur le fil de bobinage pour assurer la séparation électrique qui est considérée comme satisfaisant aux exigences de 2.3.2.1.

NOTE 1 L'émail à base de solvant n'est pas considéré comme fournissant une ISOLATION PRINCIPALE, SUPPLEMENTAIRE OU RENFORCEE, voir 2.10.5.12.

L'isolation de tous les conducteurs doit être en émail conforme aux exigences pour un fil de bobinage de niveau 2 selon l'une des normes de la série de la CEI 60317 avec l'ESSAI DE TYPE réalisé à une tension d'essai qui n'est pas inférieure à celle exigée en 5.2.2.

La vérification est effectuée par examen et par les essais suivants.

Le composant fini est soumis à un ESSAI DE TYPE pour la résistance diélectrique (entre enroulements et entre les enroulements et le noyau (voir l'Article C.2) conformément à 5.2.2.

Le composant fini doit être soumis aux essais individuels de série de rigidité diélectrique d'une séparation électrique conformément à 5.2.2 en utilisant la tension d'essai de 1 000 V.

Les exigences de dimension et de construction de 2.10 et de l'Annexe G ne s'appliquent pas pour la conformité à 2.10.5.13.

NOTE 2 Dans certains cas, 6.1.2.1 s'applique aussi.

NOTE 3 En Finlande, en Norvège et en Suède, il existe des exigences complémentaires d'isolation, voir 6.1.2.1 Note 2 et 6.1.2.2 Note.

2.10.5.14 Isolation supplémentaire des composants bobinés

Les exigences suivantes s'appliquent à l'isolation dans un composant bobiné, fournie en plus de l'isolation sur le fil de bobinage ou l'autre fil. Cela inclut, par exemple:

– l'isolation entre bobinages; et

– l'isolation entre un fil de bobinage ou un autre fil et toute autre partie conductrice dans le composant bobiné.

NOTE Pour l'isolation sur le fil de bobinage lui-même, voir 2.10.5.12.

Si la VALEUR DE CRETE DE LA TENSION DE SERVICE ne dépasse pas 71 V, il n'y a pas d'exigence de dimension ou de construction.

Si la VALEUR DE CRETE DE LA TENSION DE SERVICE dépasse 71 V,

– pour l'ISOLATION PRINCIPALE qui n'est pas soumise à une contrainte mécanique, il n'y a pas d'exigence de dimension ou de construction;

– l'ISOLATION SUPPLEMENTAIRE ou l'ISOLATION RENFORCEE doit
  - soit avoir une épaisseur d'au moins 0,4 mm assurée par une seule couche; soit
  - être conforme à 2.10.5.6.

2.10.6 Construction des cartes imprimées

NOTE 2.10.6 s'applique aux enroulements d'un transformateur planaire et d'un transformateur en céramique.

2.10.6.1 Cartes imprimées sans revêtement

L'isolation entre les conducteurs sur les surfaces extérieures d'une carte imprimée sans revêtement doit être conforme aux exigences de DISTANCE DANS L'AIR minimale de 2.10.3 (ou de l'Annexe G) et de LIGNE DE FUITE minimale de 2.10.4.

La vérification est effectuée par examen et par des mesures.

2.10.6.2 Cartes imprimées avec revêtement

Pour les cartes imprimées dont les surfaces extérieures doivent être revêtues d'un matériau adapté, les exigences suivantes s'appliquent aux parties conductrices avant qu'elles ne soient revêtues:

– les distances minimales de séparation du Tableau 2Q doivent être respectées; et

– la fabrication est soumise à un programme de contrôle de la qualité qui fournit au moins le même niveau d'assurance que l'exemple donné à l'Article A.1 de l'Annexe R. La DOUBLE ISOLATION et l'ISOLATION RENFORCEE doivent passer avec succès les ESSAIS INDIVIDUELS DE SERIE pour la rigidité diélectrique.

L'une des deux parties conductrices ou les deux, et au minimum 80 % des distances sur la surface entre les parties conductrices, doivent être revêtues.

Le mode de revêtement, le matériau de revêtement et le matériau de base doivent être tels qu'une qualité uniforme soit assurée et que les distances d'isolation considérées soient effectivement protégées.

Les DISTANCES DANS L'AIR minimales de 2.10.3 (ou de l'Annexe G) et les LIGNES DE FUITE minimales de 2.10.4 s'appliquent

– si les conditions ci-dessus ne sont pas satisfaites;

– entre deux parties conductrices quelconques sans revêtement; et

– sur l'extérieur du revêtement.

La vérification est effectuée par examen et par des mesures en tenant compte de la Figure F.11 et par les essais de 2.10.8.

Tableau 2Q – Distances minimales de séparation pour les cartes imprimées avec revêtement

~~VALEUR DE CRETE DE LA TENSION DE SERVICE~~ ~~jusqu'à et y compris~~ ~~V crête~~	~~ISOLATION FONCTIONNELLE, PRINCIPALE OU SUPPLEMENTAIRE~~ ~~mm~~	~~ISOLATION RENFORCEE~~ ~~mm~~
~~90~~	~~0,1~~	~~0,2~~
~~180~~	~~0,2~~	~~0,4~~
~~230~~	~~0,3~~	~~0,6~~
~~285~~	~~0,4~~	~~0,8~~
~~355~~	~~0,6~~	~~1,2~~
~~455~~	~~0,8~~	~~1,6~~
~~570~~	~~1,0~~	~~2,0~~
~~710~~	~~1,3~~	~~2,6~~
~~895~~	~~1,8~~	~~3,6~~
~~1 135~~	~~2,4~~	~~3,8~~
~~1 450~~	~~2,8~~	~~4,0~~
~~1 800~~	~~3,4~~	~~4,2~~
~~2 300~~	~~4,1~~	~~4,6~~
~~2 850~~	~~5,0~~	~~5,0~~
~~3 550~~	~~6,3~~	~~6,3~~
~~4 550~~	~~8,2~~	~~8,2~~
~~5 700~~	~~10~~	~~10~~
~~7 100~~	~~13~~	~~13~~
~~8 950~~	~~16~~	~~16~~
~~11 350~~	~~20~~	~~20~~
~~14 200~~	~~26~~	~~26~~
~~18 000~~	~~33~~	~~33~~
~~23 000~~	~~43~~	~~43~~
~~28 500~~	~~55~~	~~55~~
~~35 500~~	~~70~~	~~70~~
~~45 500~~	~~86~~	~~86~~

~~Il est permis de procéder par interpolation linéaire entre les deux points les plus proches, la distance minimale de séparation étant arrondie à l'échelon de 0,1 mm immédiatement supérieur.~~

~~Si la valeur minimale de la LIGNE DE FUITE spécifiée au Tableau 2N est inférieure à la distance de séparation minimale spécifiée ci-dessus, c'est la distance la plus faible qui s'applique.~~

VALEUR DE CRETE DE LA TENSION DE SERVICE **Jusques et y compris** **V crête**	ISOLATION PRINCIPALE ou ISOLATION SUPPLEMENTAIRE **mm**	ISOLATION RENFORCEE **mm**
71 [a]	0,025	0,05
89 [a]	0,04	0,08
113 [a]	0,063	0,125
141 [a]	0,1	0,2
177 [a]	0,16	0,32
227 [a]	0,25	0,5
283 [a]	0,4	0,8
354 [a]	0,56	1,12
455 [a]	0,75	1,5
570	1,0	2,0
710	1,3	2,6
895	1,8	3,6
1 135	2,4	3,8
1 450	2,8	4,0
1 770	3,4	4,2
2 260	4,1	4,6
2 830	5,0	5,0
3 540	6,3	6,3
4 520	8,2	8,2
5 660	10,0	10,0
7 070	13,0	13,0
8 910	16,0	16,0
11 310	20,0	20,0
14 140	26,0	26,0
17 700	33,0	33,0
22 600	43,0	43,0
28 300	55,0	55,0
35 400	70,0	70,0
45 200	86,0	86,0

interpolation linéaire peut être utilisée entre les deux points les plus proches, la distance minimale de séparation calculée étant arrondie à l'échelon immédiatement supérieur spécifié, ou la valeur dans la rangée suivante, la plus petite de ces deux valeurs étant retenue. Pour les valeurs:

- ne dépassant 0,5 mm, l'échelon spécifié est 0,01 mm; et
- pour celles supérieures à 0,5 mm, l'échelon spécifié est 0,1 mm.

[a] L'essai de 2.10.8 n'est pas requis.

2.10.6.3 Isolation entre conducteurs sur la même surface interne d'une carte imprimée

Sur une surface interne d'une carte imprimée multi couches (voir Figure F.16), le chemin entre l'un des deux conducteurs doit être conforme aux exigences pour un joint scellé en 2.10.5.5.

2.10.6.4 Isolation entre conducteurs sur différentes surfaces d'une carte imprimée

L'ISOLATION SUPPLEMENTAIRE ou l'ISOLATION RENFORCEE entre parties conductrices sur différentes surfaces dans des cartes imprimées double face à couche unique, dans des cartes imprimées multi couches et dans des cartes imprimées à noyau métallique, doivent:

– soit avoir une épaisseur minimale de 0,4 mm; soit
– être conformes à l'une des spécifications et passer avec succès les essais correspondants du Tableau 2R.

Il n'existe pas d'exigence correspondante pour l'ISOLATION FONCTIONNELLE ou l'ISOLATION PRINCIPALE.

La vérification est effectuée par examen et par des mesures et, lorsque c'est approprié, par des essais.

Tableau 2R – Isolation dans les cartes imprimées

Spécification de l'isolation	ESSAIS DE TYPE [a]	ESSAIS INDIVIDUELS DE SERIE pour l'essai de rigidité diélectrique [c]
Deux couches de matériau isolant en feuilles y compris le prépreg [b]	Non	Oui
Trois couches ou plus de matériau isolant en feuilles y compris le prépreg [b]	Non	Non
Un système d'isolation avec revêtement en céramique sur un substrat métallique, traité à ≥500 °C	Non	Oui
Un système d'isolation avec deux revêtements ou plus dans une matière autre que la céramique sur un substrat métallique, traité à <500 °C	Oui	Oui

NOTE 1 Prépreg est le terme utilisé pour une couche de tissu de verre imprégné d'une résine préconditionnée.

NOTE 2 Pour la définition de la céramique, voir le VEI 212-05-24.

[a] Le conditionnement thermique de 2.10.8.2 suivi par l'essai de rigidité diélectrique de 5.2.2.

[b] Les couches sont comptées avant traitement.

[c] L'essai de rigidité diélectrique est effectué sur la carte imprimée finie.

2.10.7 Terminaisons externes des composants

Il est permis d'utiliser des revêtements sur les terminaisons externes des composants pour augmenter les DISTANCES DANS L'AIR et les LIGNES DE FUITE efficaces (voir la Figure F.10). Les distances minimales de séparation du Tableau 2Q s'appliquent au composant avant application du revêtement et le revêtement doit satisfaire à toutes les exigences de 2.10.6.2 y compris les dispositions relatives au contrôle de la qualité.

L'arrangement mécanique et la rigidité des terminaisons doivent être suffisants pour assurer que, pendant la manipulation normale, l'assemblage dans le matériel et l'utilisation ultérieure, les terminaisons ne seront pas soumises à des déformations qui risqueraient de faire craquer le revêtement ou de réduire les distances de séparation entre parties conductrices au-dessous des valeurs du Tableau 2Q (voir 2.10.6.2).

La vérification est effectuée par examen en tenant compte de la Figure F.10, et en effectuant la séquence d'essais couverte par 2.10.8.1, 2.10.8.2 et 2.10.8.3. Ces essais sont effectués sur un ensemble complet y compris le ou les composants.

De même, l'essai de résistance à l'abrasion de 2.10.8.4 est effectué sur une carte de circuit imprimé spécialement préparée comme décrit pour l'échantillon 3 de 2.10.8.1, excepté que la séparation entre les parties conductrices doit être représentative des séparations minimales et des différences de potentiel maximales utilisées dans l'ensemble.

2.10.8 Essais sur les cartes imprimées et les composants avec revêtement

2.10.8.1 Préparation des échantillons et examen préliminaire

Trois cartes échantillons (ou, pour les composants avec revêtement en 2.10.7, deux composants et une carte) identifiées comme échantillons 1, 2 et 3 sont nécessaires. L'emploi de cartes réelles ou d'échantillons fabriqués spécialement avec un revêtement représentatif et les séparations minimales est permis. Chaque carte échantillon doit être représentative des séparations minimales utilisées et est revêtue. Chaque carte échantillon est soumise à la séquence totale des opérations de fabrication, y compris le soudage et le nettoyage, auxquelles la carte est normalement soumise pendant l'assemblage du matériel.

Lors de l'examen visuel, les cartes ne doivent présenter ni micro-trous ni bulles dans le revêtement ni rupture des pistes conductrices aux coins.

2.10.8.2 Conditionnement thermique

L'échantillon 1 (voir 2.10.8.1) est soumis à la séquence du cycle thermique de 2.10.9.

L'échantillon 2 est vieilli dans une étuve ventilée à une température et pendant une durée choisies sur la Figure 2J, en utilisant la ligne d'indice de température qui correspond à la température maximale de fonctionnement de la carte imprimée. La température de l'étuve est maintenue à la température spécifiée ± 2 °C. La température utilisée pour déterminer la ligne d'indice de température est la température la plus élevée sur la carte lorsque la sécurité est impliquée.

Lorsqu'on utilise la Figure 2J, il est permis d'effectuer une interpolation entre les deux lignes d'indice de température les plus proches.

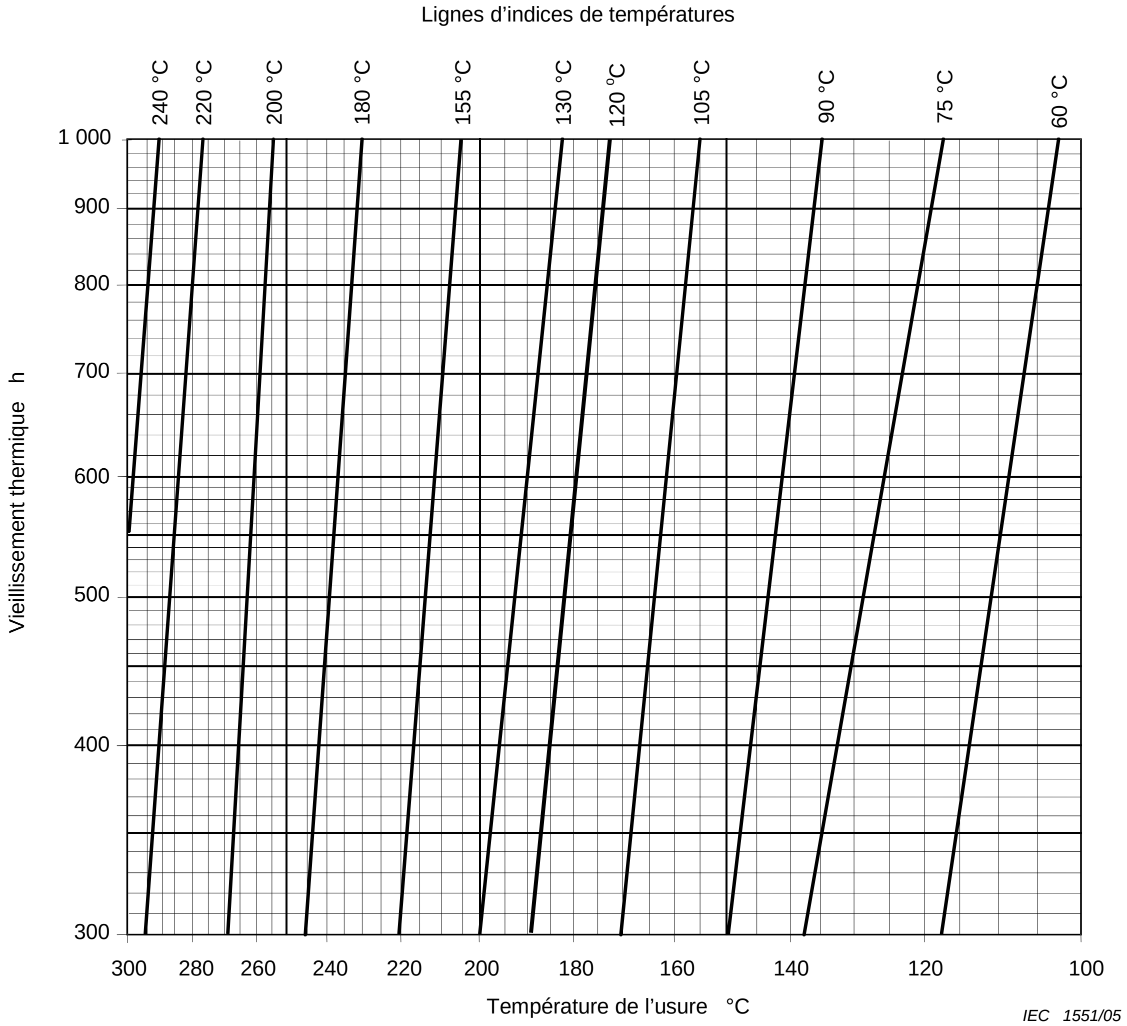


Figure 2J – Durée de vieillissement thermique

2.10.8.3 Essai de rigidité diélectrique

Les échantillons 1 et 2 (voir 2.10.8.1) sont ensuite soumis à l'épreuve hygroscopique de 2.9.2 puis doivent satisfaire à l'essai applicable de rigidité diélectrique entre conducteurs de 5.2.2.

2.10.8.4 Essai de résistance à l'abrasion

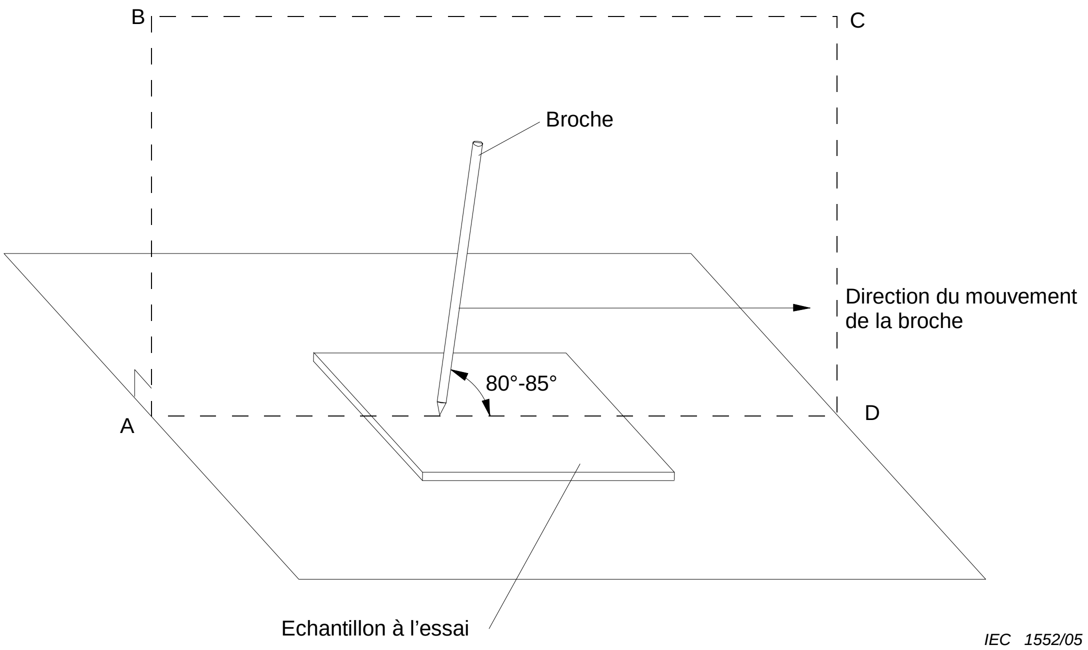
La carte échantillon 3 (voir 2.10.8.1) est soumise à l'essai suivant.

Des rayures sont faites à travers cinq paires de parties conductrices et les séparations intermédiaires aux points où les séparations seront soumises à la différence de potentiel maximale pendant les essais.

Les rayures sont faites au moyen d'une broche d'acier trempé dont l'extrémité a la forme d'un cône ayant un angle au sommet de 40°, la pointe étant arrondie et polie, avec un rayon de 0,25 mm ± 0,02 mm.

Les rayures sont faites en déplaçant la broche sur la surface dans un plan perpendiculaire aux conducteurs à une vitesse de 20 mm/s ± 5 mm/s comme indiqué sur la Figure 2K. La broche est appuyée de telle sorte que la force exercée suivant son axe soit de 10 N ± 0,5 N. Les rayures doivent être distantes d'au moins 5 mm et sont à au moins 5 mm du bord de l'échantillon.

Après cet essai, la couche de revêtement ne doit ni s'être relâchée ni s'être percée et elle doit satisfaire à un essai de rigidité diélectrique entre les conducteurs comme spécifié en 5.2.2. Dans le cas de cartes imprimées à noyau métallique, le substrat est l'un des conducteurs.



NOTE La broche est dans le plan ABCD qui est perpendiculaire à l'échantillon à l'essai.

Figure 2K – Essai de résistance à l'abrasion pour les couches de revêtement

2.10.9 Cycles thermiques

La séquence suivante de cycles thermiques est utilisée si cela est prescrit par 2.10.8.2, 2.10.10 ou 2.10.11.

Un échantillon d'un composant ou sous-ensemble est soumis à la séquence d'essais suivante. Pour les transformateurs, les coupleurs magnétiques et les dispositifs analogues dans lesquels la sécurité dépend de l'isolation, une tension de 500 V efficace à une fréquence de 50 Hz ou 60 Hz est appliquée entre les enroulements et également entre les enroulements et les autres parties conductrices pendant l'essai de cycles thermiques suivant.

L'échantillon est soumis dix fois au cycle thermique suivant:

	68 h à	T_1 *± 2 °C;*
	1 h à	*25 °C ± 2 °C;*
	2 h à	*0 °C ± 2 °C;*
pas moins de	*1 h à*	*25 °C ± 2 °C.*

$T_1 = T_2 + T_{ma} - T_{amb} + 10$ *K, mesurées conformément à 1.4.5 et, lorsque c'est applicable, à 1.4.13, ou 85 °C, suivant la valeur la plus élevée. Toutefois, la marge de 10 K n'est pas ajoutée si la température est mesurée par un thermocouple enfoui ou par la méthode par résistance.*

T_2 *est la température des parties mesurée pendant l'essai de 4.5.2.*

La signification de T_{ma} *et* T_{amb} *est donnée en 1.4.12.1.*

Le temps nécessaire pour le passage d'une température à une autre n'est pas spécifié, mais il est permis que le passage soit graduel.

Il ne doit pas y avoir de signe de rupture de l'isolation au cours du conditionnement.

2.10.10 Essai pour l'environnement de degré de pollution 1 et pour le composé isolant

L'essai est réalisé lorsque cela est exigé pour vérifier un environnement de degré de pollution 1 (lors de l'utilisation du Tableau 2N, 2.10.5.5 b) ou du Tableau G.2) ou lorsque cela est exigé en 2.10.5.3 ou en 2.10.12.

NOTE Il n'est pas exigé de passer cet essai avec succès en liaison avec les Tableaux 2K, 2L et 2M, lorsque les exigences pour le degré de pollution 1 sont les mêmes que pour le degré de pollution 2.

Un échantillon est soumis à la séquence de cycles thermique de 2.10.9. Après refroidissement jusqu'à la température ambiante, l'échantillon est soumis à l'épreuve hygroscopique de 2.9.2, suivie immédiatement de l'essai de rigidité diélectrique applicable de 5.2.2.

~~Les essais sont suivis d'un examen et de mesurages. Le matériau isolant ne doit pas présenter de craquelures. Pour la conformité à 2.10.5.3, l'échantillon est également divisé en sections et il ne doit pas y avoir de vides dans le matériau isolant.~~

Pour les éléments autres que les cartes imprimées, la vérification de la conformité est effectuée par examen de la section, et le matériau isolant ne doit pas présenter de vides, de trous ou de craquelures visibles.

En cas d'isolation entre les conducteurs situés sur la même surface interne de cartes imprimées et d'isolation entre les conducteurs situés sur des surfaces différentes de cartes imprimées multicouches, la vérification de la conformité est effectuée par examen visuel externe. Il ne doit pas y avoir de délamination affectant le degré de pollution.

2.10.11 Essais pour les dispositifs à semi-conducteurs et les joints scellés

Si cela est exigé par 2.10.5.4 ou 2.10.5.5 c), trois échantillons sont soumis à la séquence de cycles thermiques de 2.10.9. Avant l'essai du joint scellé, tout bobinage d'un fil en émail à base de solvant utilisé dans le composant est remplacé par la feuille métallique ou par quelques tours de fil nu placé à proximité du joint scellé.

Les trois échantillons sont alors essayés comme suit:

– *un des échantillons est soumis à l'essai applicable de rigidité diélectrique de 5.2.2, effectué immédiatement après la dernière période à la température T_1 °C au cours du cycle thermique mais la tension d'essai multipliée par 1,6;*

– *les autres échantillons sont soumis à l'essai applicable de rigidité diélectrique de 5.2.2 après l'épreuve hygroscopique de 2.9.2, mais la tension d'essai est multipliée par 1,6.*

~~*Les essais sont suivis d'un examen, comprenant le sectionnement, et de mesurages. Le matériau isolant ne doit pas présenter de vides, de trous ou de craquelures. Dans le cas des cartes imprimées multi couches, il ne doit pas y avoir de délamination.*~~

La vérification de la conformité est effectuée par examen et par des mesures.

Avec l'exception des joints scellés présents sur la même surface interne d'une carte imprimée, la vérification de la conformité est effectuée par examen de la section, et le matériau isolant ne doit pas présenter de vides, trous ou craquelures visibles.

En cas d'isolation entre les conducteurs situés sur la même surface interne de cartes imprimées et d'isolation entre les conducteurs situés sur des surfaces différentes de cartes *multicouches, la vérification de la conformité est effectuée par des mesures et par examen visuel externe. Il ne doit pas y avoir de délamination.*

2.10.12 Parties enfermées et scellées

Pour les composants ou sous-ensembles qui sont enfermés de façon adéquate par enveloppement ou par scellement hermétique pour empêcher la pénétration de la poussière ou de l'humidité, les valeurs pour le degré de pollution 1 s'appliquent aux DISTANCES DANS L'AIR et aux LIGNES DE FUITE internes.

NOTE Les parties situées dans des boîtes scellées hermétiquement par un adhésif ou un autre moyen et les parties enveloppées dans un revêtement épais sont quelques exemples de telles constructions.

La vérification est effectuée par examen depuis l'extérieur, par des mesures et, si nécessaire, par des essais. Un composant ou un sous-ensemble est considéré comme enfermé de façon adéquate si un échantillon satisfait aux essais de 2.10.10.

3 Câblage, connexions et alimentation

3.1 Généralités

3.1.1 Caractéristique assignée de courant et protection contre les surintensités

La section des conducteurs internes et des CABLES ASSURANT L'INTERCONNEXION doit être appropriée pour les courants qu'ils sont destinés à transporter lorsque le matériel fonctionne sous la CHARGE NORMALE de façon que la température maximale admissible pour leur isolation ne soit pas dépassée.

Tous les conducteurs internes (y compris les barres omnibus) et les CABLES ASSURANT L'INTERCONNEXION utilisés pour la distribution de l'alimentation primaire doivent être protégés contre les surintensités et les courts-circuits par des dispositifs de protection de caractéristiques nominales appropriées.

Les conducteurs qui ne sont pas directement impliqués dans le parcours de distribution sont exemptés de cette exigence lorsqu'on peut montrer qu'il n'y a pas de probabilité de création de dangers (par exemple circuits de signalisation).

NOTE 1 Des dispositifs de protection contre les surcharges des composants peuvent également assurer la protection des conducteurs associés.

NOTE 2 Des circuits internes connectés à un RESEAU D'ALIMENTATION peuvent nécessiter une protection individuelle compte tenu de la réduction de la section et de la longueur des conducteurs.

La vérification est effectuée par examen et par les essais appropriés de 4.5.2 et de 4.5.3.

3.1.2 Protection contre les dommages mécaniques

Les passages empruntés par les conducteurs doivent être lisses et ne doivent pas présenter d'arêtes vives. Les conducteurs doivent être protégés de façon qu'ils n'entrent pas en contact avec des aspérités, des ailettes de refroidissement, des parties mobiles, etc., susceptibles d'endommager leur isolation. Les trous dans le métal pour le passage des conducteurs isolés doivent être convenablement arrondis ou munis de traversées.

Dans les ensembles électroniques, les fils peuvent être en contact très proche avec les broches recevant des connexions enroulées et analogues si une défaillance de l'isolation ne peut avoir pour résultat un état de risque, ou si une protection mécanique appropriée est prévue par le système d'isolation.

La conformité est vérifiée par examen.

3.1.3 Fixation des conducteurs internes

Les conducteurs internes doivent être guidés, supportés, fixés ou assujettis de telle façon qu'ils empêchent:

– une contrainte excessive sur les conducteurs et sur le raccordement aux bornes;

– le desserrage du raccordement aux bornes;

– l'endommagement de l'isolation des conducteurs.

La conformité est vérifiée par examen.

3.1.4 Isolation des conducteurs

Excepté ce qui est couvert par 2.1.1.3 b), l'isolation des conducteurs individuels du câblage interne doit être conforme aux exigences de 2.10.5 et être capable de supporter l'essai applicable de rigidité diélectrique spécifié en 5.2.2.

Quand un câble d'alimentation dont les propriétés d'isolation satisfont aux types de câbles de 3.2.5 est utilisé à l'intérieur d'un matériel, soit comme une extension du câble d'alimentation extérieur, soit comme un conducteur indépendant, sa gaine est considérée comme une ISOLATION SUPPLEMENTAIRE adéquate dans le cadre de 3.1.4.

NOTE Les exigences concernant les couleurs de l'isolation sont données en 2.6.3.5.

La vérification est effectuée par examen et par évaluation des résultats des essais applicables montrant qu'il n'y a pas eu de perforation de l'isolation.

En l'absence de résultats d'essais applicables, la vérification est effectuée par l'essai de rigidité diélectrique effectué sur un échantillon d'environ 1 m de long auquel la tension d'essai correspondante est appliquée comme suit:

– *pour l'isolation d'un conducteur: suivant la méthode d'essai décrite à l'Article 3 de la CEI 60885-1, en utilisant la tension d'essai de 5.2.2 de la présente norme correspondant au type de l'isolation étudiée; et*

– *pour l'ISOLATION SUPPLEMENTAIRE (par exemple manchon autour d'un groupe de conducteurs): entre un conducteur inséré dans la gaine et une feuille métallique enroulée serrée autour de la gaine sur une longueur d'environ 100 mm.*

3.1.5 Perles isolantes et isolant céramique

Les perles isolantes et pièces similaires isolantes en matière céramique entourant des conducteurs doivent:

– être fixées ou supportées de façon à ne pas pouvoir changer leur position de telle façon qu'il pourrait se produire un risque; et

– ne doivent pas être posées sur des arêtes vives ou des angles aigus.

Si les perles isolantes sont placées à l'intérieur de conduits métalliques flexibles, elles doivent être revêtues d'une gaine isolante, sauf si le conduit est monté ou fixé de telle façon qu'un mouvement en usage normal ne produise pas de risque.

La vérification est effectuée par examen et, si nécessaire, par l'essai suivant.

Une force de 10 N est appliquée à l'isolant ou sur le conduit. Le déplacement résultant, s'il y en a un, ne doit pas produire de risque au sens de la présente norme.

3.1.6 Vis exerçant une pression sur un contact électrique

Lorsqu'une pression est prescrite pour un contact électrique, une vis doit engager au moins deux filets complets dans une tôle métallique, un écrou métallique ou un insert métallique.

Les vis en matériau isolant ne doivent pas être utilisées lorsque les connexions électriques, y compris la mise à la terre de protection, sont concernées, ou lorsque leur remplacement par des vis métalliques peut affecter L'ISOLATION SUPPLEMENTAIRE ou L'ISOLATION RENFORCEE.

Lorsque des vis en matériau isolant contribuent à d'autres aspects de la sécurité, elles doivent avoir au moins deux filets complètement engagés.

NOTE Voir également 2.6.5.7 pour les vis utilisées pour la liaison à la terre de protection.

La conformité est vérifiée par examen.

3.1.7 Matériaux isolants dans les connexions électriques

Les connexions électriques, y compris celles pour la mise à la terre de protection (voir 2.6), doivent être conçues de façon que la pression de contact ne se transmette pas par l'intermédiaire de matériaux isolants sauf si un retrait éventuel ou une déformation de la matière isolante sont susceptibles d'être compensés par une élasticité suffisante des parties métalliques.

La conformité est vérifiée par examen.

3.1.8 Vis auto taraudeuses et vis à grand pas

Les vis à grand pas ne doivent pas être utilisées pour la connexion des parties transportant le courant, sauf si elles serrent directement ces parties l'une contre l'autre et sont pourvues d'un dispositif de blocage approprié.

Les vis auto taraudeuses (par enlèvement ou par repoussage de matière) ne doivent pas être utilisées pour la connexion électrique des parties transportant le courant, sauf si elles donnent naissance à un filetage normal. De plus, ces vis ne doivent pas être utilisées si elles sont manœuvrées par l'UTILISATEUR ou l'installateur, à moins que le filetage ne soit formé par emboutissage.

NOTE Voir également 2.6.5.7 pour les vis utilisées pour la liaison à la terre de protection.

La conformité est vérifiée par examen.

3.1.9 Terminaisons des conducteurs

Les conducteurs doivent être munis de dispositifs (par exemple barrière ou écran de fixation), ou raccordés de telle manière, qu'ils ne puissent, eux et leurs connexions (par exemple bornes de sonnerie et bornes à connexion rapide, etc.) se placer, en utilisation normale, de telle façon que les DISTANCES DANS L'AIR ou les LIGNES DE FUITE soient réduites à des valeurs inférieures à celles spécifiées en 2.10 (ou à l'Annexe G).

Il est permis d'utiliser des connexions réalisées par soudage, brasage, sertissage, contacts à pousser (sans vis) et des terminaisons similaires pour la connexion des conducteurs. Dans le cas des connexions soudées, le conducteur doit être disposé ou fixé de façon que son maintien en position ne dépende pas seulement du soudage.

Dans les prises multi contacts, et dans la mesure où un court-circuit pourrait se produire, le dispositif doit éviter un contact entre les CIRCUITS TBTS ou CIRCUITS TRT et les parties à TENSION DANGEREUSE dû au desserrage d'une borne ou à la cassure d'un fil de la terminaison.

La vérification est effectuée par examen, par des mesures et, si nécessaire, par l'essai suivant.

Une force de 10 N est appliquée sur le conducteur près de ces points de connexion. Le conducteur ne doit pas se détacher ou pivoter dans sa connexion à tel point que les

DISTANCES DANS L'AIR ou les LIGNES DE FUITE soient réduites à des valeurs inférieures à celles spécifiées en 2.10 (ou à l'Annexe G).

Pour l'évaluation de la conformité il est supposé que:

- *deux fixations indépendantes ne se desserreront pas simultanément; et*
- *les parties fixées par vis et écrous avec rondelles autobloquantes ou autres moyens de blocage ne sont pas susceptibles de prendre de jeu.*

NOTE Les rondelles à ressort ou équivalent peuvent fournir un blocage satisfaisant.

Exemples de constructions respectant l'ensemble des exigences:

- *manchons ajustés (par exemple une gaine thermo rétractable ou caoutchouc), appliqués autour des câbles et leurs connexions;*
- *conducteurs connectés par soudage et tenus en place près de la connexion, indépendamment de la soudure;*
- *conducteurs connectés par soudage et «crochetés» avant de souder, pourvu que le trou à travers lequel passe le conducteur ne soit pas exagérément gros;*
- *conducteurs connectés par bornes à vis, avec une fixation supplémentaire près de la borne qui maintient, dans le cas de conducteurs à âme câblée, l'isolation et pas seulement les conducteurs;*
- *conducteurs connectés par bornes à vis et munis de terminaisons (par exemple cosse à œillet sur les conducteurs ou équivalent) qui ne sont pas susceptibles de se libérer. Le pivotement de telles terminaisons est examiné;*
- *conducteurs courts et rigides qui restent en position lorsque la vis de fixation est perdue.*

3.1.10 Manchons sur les câbles

Lorsqu'un manchon est utilisé comme ISOLATION SUPPLEMENTAIRE sur des conducteurs internes, il doit être maintenu en position par des moyens efficaces.

La conformité est vérifiée par examen.

Exemples de constructions qui sont considérés comme respectant cette exigence:

- *un manchon qui ne peut être retiré qu'en cassant ou en coupant le câble ou le manchon;*
- *un manchon qui est fixé à ses deux extrémités;*
- *un manchon thermo rétractable qui renforce l'isolation d'un câble;*
- *un manchon qui est d'une longueur telle qu'il ne peut glisser.*

3.2 Raccordement à une alimentation du réseau

3.2.1 Moyens de connexion

3.2.1.1 Raccordement à une alimentation du réseau en courant alternatif

Afin d'assurer une connexion sûre et fiable à un RESEAU D'ALIMENTATION EN COURANT ALTERNATIF, le matériel doit être pourvu d'un des moyens suivants:

- des bornes à une connexion à demeure à l'alimentation;
- UN CABLE D'ALIMENTATION FIXE A DEMEURE pour une connexion permanente à l'alimentation ou pour un raccordement à l'alimentation par l'intermédiaire d'une fiche de prise de courant;

NOTE Dans de nombreux pays, il existe une obligation légale de fournir une fiche qui soit conforme aux règles nationales d'installation.

- un socle connecteur pour le raccordement d'un CABLE D'ALIMENTATION NON FIXE A DEMEURE;
- une fiche de prise de courant qui est une partie d'un MATERIEL ENFICHABLE DIRECTEMENT.

La conformité est vérifiée par examen.

3.2.1.2 Raccordement à une alimentation du réseau en courant continu

Afin d'assurer une connexion sûre et fiable à une ALIMENTATION DU RESEAU EN COURANT CONTINU, le matériel doit être pourvu de l'un des moyens suivants:

- des bornes à une connexion à demeure à l'alimentation;
- UN CABLE D'ALIMENTATION FIXE A DEMEURE pour une connexion permanente à l'alimentation ou pour un raccordement à l'alimentation par l'intermédiaire d'une fiche de prise de courant;
- un socle connecteur pour le raccordement d'un CABLE D'ALIMENTATION NON FIXE A DEMEURE;

Les fiches de prises de courant et les socles de connecteurs ne doivent pas être d'un type utilisé pour un RESEAU D'ALIMENTATION EN COURANT ALTERNATIF si un danger peut être créé par leur usage. Leur conception doit être telle qu'elle empêche des connexions en polarité inverse si ces connexions peuvent créer un danger.

Il est permis que l'un des pôles du RESEAU D'ALIMENTATION EN COURANT CONTINU soit connecté à la fois à une borne d'entrée d'alimentation et à la borne principale de mise à la terre de protection du matériel, si elle existe, pourvu que les instructions d'installation du matériel donnent les détails pour une mise à la terre correcte du système.

La conformité est vérifiée par examen.

3.2.2 Raccordements multiples à l'alimentation

Lorsque le matériel est muni de plus d'une possibilité de raccordement à l'alimentation (par exemple pour différentes tensions ou fréquences ou pour l'alimentation de secours), la conception doit être telle que toutes les conditions suivantes soient remplies:

- des moyens de raccordement séparés sont prévus pour les différents circuits; et
- les raccordements de la prise de courant de l'alimentation, s'il en existe, ne sont pas interchangeables, si un danger risque de survenir du fait d'un raccordement incorrect; et
- des parties nues d'un CIRCUIT TBT ou des parties sous TENSIONS DANGEREUSES, telles que les contacts des fiches, ne sont pas accessibles à un OPERATEUR lorsqu'on déconnecte une ou plusieurs prises mobiles de connecteurs.

La vérification est effectuée par examen et pour l'accessibilité, si nécessaire, par un essai avec le doigt d'épreuve, Figure 2A (voir 2.1.1.1).

3.2.3 Matériels reliés à demeure

Le MATERIEL RELIE A DEMEURE doit être muni soit:

- d'un ensemble de bornes comme spécifié en 3.3; soit
- d'un câble d'alimentation fixé à demeure.

Le MATERIEL RELIE A DEMEURE ayant un ensemble de bornes doit:

- permettre le raccordement des conducteurs d'alimentation après que le matériel a été fixé sur son support; et
- être pourvu d'entrées de câbles, d'entrées de conduits, d'entrées défonçables ou de presse-étoupe, qui permettent le raccordement des types appropriés de câbles ou de conduits.

Pour le matériel de COURANT NOMINAL ne dépassant pas 16 A, les entrées de câbles doivent être appropriées pour des câbles ou des conduits ayant un diamètre externe indiqué dans le Tableau 3A.

Les entrées de conduits, les entrées de câbles et les entrées défonçables pour le raccordement au réseau doivent être conçues ou placées de façon que l'introduction du conduit ou du câble n'affecte pas la protection contre les chocs électriques ou n'abaisse pas les LIGNES DE FUITE et les DISTANCES DANS L'AIR au-dessous des valeurs spécifiées en 2.10 (ou à l'Annexe G).

La vérification est effectuée par examen, par un essai d'installation effective et par des mesures.

Tableau 3A – Dimensions des câbles et conduits pour les matériels de courant nominal ne dépassant pas 16 A

Nombre de conducteurs y compris le CONDUCTEUR DE MISE A LA TERRE DE PROTECTION lorsqu'il existe	Diamètre extérieur mm	
	Câble	Conduit
2	13,0	16,0 (22,2)
3	14,0	16,0 (22,2)
4	14,5	20,0 (27,8)
5	15,5	20,0 (27,8)
NOTE Au Canada et aux Etats-Unis, les dimensions entre parenthèses représentent la taille de l'ouverture du conduit nécessaire pour les terminaisons nominales de 1/2 pouce et 3/4 pouce des conduits de dimensions commerciales.		

3.2.4 Socles de connecteurs

Les socles de connecteurs doivent être conformes à toutes les exigences suivantes:

- être situés ou enfermés de façon que des parties sous TENSIONS DANGEREUSES ne soient pas accessibles pendant l'introduction ou l'enlèvement de la prise mobile (les socles de connecteurs conformes à la CEI 60309 ou à la CEI 60320 sont considérés comme satisfaisant à cette exigence); et
- être placés de façon que la prise mobile puisse être introduite sans difficulté; et
- être placés de façon qu'après l'introduction de la prise mobile, le matériel ne soit pas supporté par la prise mobile quelle que soit sa position en usage normal sur une surface plane.

La vérification est effectuée par examen et, pour l'accessibilité, au moyen du doigt d'épreuve de la Figure 2A (voir 2.1.1.1).

NOTE Pour la Suisse, voir 3.2.1.1 Note.

3.2.5 Câbles d'alimentation

3.2.5.1 Câbles d'alimentation en courant alternatif

Un câble du RESEAU D'ALIMENTATION ~~pour le raccordement au RESEAU D'ALIMENTATION EN COURANT ALTERNATIF~~ doit être du type « sous gaine » et conforme à toutes les exigences suivantes~~, si c'est approprié~~:

- s'il a une ~~isolation~~ gaine en caoutchouc, être en caoutchouc synthétique et ne pas être plus léger que les câbles souples sous gaine ordinaire de caoutchouc conformément à la CEI 60245-1(désignation 60245 IEC 53); et
- s'il a une ~~isolation~~ gaine en PVC:
  - pour les matériels équipés d'un CABLE D'ALIMENTATION FIXE A DEMEURE, et de masse inférieure ou égale à 3 kg, ne pas être plus léger que les câbles souples sous gaine légère PVC conformément à la CEI 60227-1:2007 (désignation 60227 IEC 52);
  - pour les matériels équipés d'un CABLE D'ALIMENTATION FIXE A DEMEURE, et de masse supérieure à 3 kg, ne pas être plus léger que les câbles souples sous gaine ordinaire PVC conformément à la CEI 60227-1:2007 (désignation 60227 IEC 53);

NOTE 1 Il n'y a pas de limite de masse pour les matériels qui sont prévus pour être utilisés avec un CABLE D'ALIMENTATION NON FIXE A DEMEURE.

  - pour les matériels équipés d'un CABLE D'ALIMENTATION NON FIXE A DEMEURE, ne pas être plus léger que les câbles souples sous gaine légère PVC, conformément à la CEI 60227-1:2007 (désignation 60227 IEC 52); et

- pour les câbles blindés des matériels mobiles, l'essai de flexion de 3.1 de la CEI 60227-2:1997;

NOTE 2 Bien que les câbles blindés ne fassent pas partie du domaine d'application de la CEI 60227-2, les essais de flexion applicables de la CEI 60227-2 sont utilisés.

~~– être pourvu, dans le cas d'un matériel mis à la terre de protection, d'un conducteur de protection de terre vert et jaune; et~~

~~– avoir des conducteurs dont les sections nominales ne soient pas inférieures aux sections spécifiées dans le Tableau 3B.~~

~~NOTE 2 En Australie et en Nouvelle-Zélande, les tailles des conducteurs pour certaines gammes de courant sont différentes de celles spécifiées au Tableau 3B.~~

- d'autres types de câbles peuvent être utilisés s'ils présentent des propriétés électromécaniques et de sécurité incendie analogues ou supérieures à celles indiquées ci-dessus.

NOTE 3 Lorsque des normes nationales ou régionales existent, elles peuvent être utilisées pour démontrer la conformité à l'alinéa ci-dessus.

Pour le matériel devant avoir une mise à la terre de protection, un CONDUCTEUR DE MISE A LA TERRE DE PROTECTION doit être inclus dans le câble du RESEAU D'ALIMENTATION.

Un câble de RESEAU D'ALIMENTATION doit avoir des conducteurs de sections supérieures ou égales à celles spécifiées dans le Tableau 3B.

La conformité est vérifiée par examen ~~*et par des mesures. En outre, pour les câbles blindés, la vérification est effectuée par des essais de la CEI 60227 (toutes les parties). Toutefois, les essais de flexion ne sont nécessaires que sur les câbles d'alimentation blindés pour MATERIELS MOBILES.*~~

Pour ce qui concerne les câbles blindés, *l'endommagement du blindage du câble est permis, à condition que*

– *au cours de l'essai de flexion, le blindage ne fasse contact avec aucun conducteur, et*

– *après l'essai de flexion, l'échantillon satisfasse à l'essai de rigidité diélectrique effectué entre le blindage et tous les conducteurs.*

Tableau 3B – Dimensions des conducteurs

COURANT ASSIGNE du matériel A	Tailles minimales des conducteurs	
	Section nominale mm^2	AWG ou kcmil [section en mm^2] voir Note 2
Jusqu'à 6 inclus	0,75 [a]	18 [0,8]
De 6 à 10 inclus	(0,75) [b] 1,00	16 [1,3]
De 10 à 13 inclus	(1,0) [c] 1,25	16 [1,3]
De 13 à 16 inclus	(1,0) [c] 1,5	14 [2]
De 16 à 25 inclus	2,5	12 [3]
De 25 à 32 inclus	4	10 [5]
De 32 à 40 inclus	6	8 [8]
De 40 à 63 inclus	10	6 [13]
De 63 à 80 inclus	16	4 [21]
De 80 à 100 inclus	25	2 [33]
De 100 à 125 inclus	35	1 [42]
De 125 à 160 inclus	50	0 [53]
De 160 à 190 inclus	70	000 [85]
De 190 à 230 inclus	95	0000 [107]
De 230 à 260 inclus	120	250 kcmil [126]
De 260 à 300 inclus	150	300 kcmil [152]
De 300 à 340 inclus	185	400 kcmil [202]
De 340 à 400 inclus	240	500 kcmil [253]
De 400 à 460 inclus	300	600 kcmil [304]

NOTE 1 La CEI 60320 spécifie les combinaisons acceptables de raccordements de connecteurs et de câbles souples y compris ceux qui sont couverts par les Notes a, b et c ci-dessus. Toutefois, plusieurs pays ont indiqué qu'ils n'acceptent pas toutes les valeurs données dans le Tableau 3B, particulièrement les valeurs qui sont indiquées dans les Notes a, b et c.

NOTE 2 Les dimensions AWG et kcmil sont données pour information uniquement. Les sections associées, entre crochets, ont été arrondies pour ne montrer que des chiffres significatifs. Les AWG se réfèrent à l'American Wire Gauge et le terme «cmil» se réfère aux *mils circulaires* dans lesquels 1 cmil est égal à la surface d'un cercle ayant un diamètre de 1 mil (un millième de pouce). Ces termes sont employés communément en Amérique du Nord pour désigner des tailles de conducteurs.

[a] Pour un COURANT ASSIGNE jusqu'à 3 A, une section nominale de 0,5 mm^2 est permise dans certains pays, pourvu que la longueur du câble ne dépasse pas 2 m.

[b] La valeur entre parenthèses s'applique à des CABLES D'ALIMENTATION DETACHABLES équipés de prises mobiles de connecteurs de COURANT NOMINAL égal à 10 A conformément à la CEI 60320 (types C13, C15, C15A et C17), à condition que la longueur du câble ne dépasse pas 2 m.

[c] La valeur entre parenthèses s'applique à des CABLES D'ALIMENTATION DETACHABLES équipés de prises mobiles de connecteurs de COURANT NOMINAL égal à 16 A conformément à la CEI 60320 (types C19, C21, et C23), à condition que la longueur du câble ne dépasse pas 2 m.

3.2.5.2 Câbles d'alimentation en courant continu

Un câble d'alimentation pour le raccordement au RESEAU D'ALIMENTATION EN COURANT CONTINU doit être adapté à la tension, au courant et aux contraintes physiques qu'il est susceptible de rencontrer.

La conformité est vérifiée par examen.

3.2.6 Dispositifs d'arrêt de traction et relâchement des contraintes

Pour les matériels avec un CABLE D'ALIMENTATION FIXE A DEMEURE, un dispositif d'arrêt de traction et de torsion doit être fourni de telle manière que

– les points de connexion des conducteurs du câble soient protégés contre les contraintes, et
– le revêtement extérieur du câble soit protégé contre l'abrasion.

Il ne doit pas être possible de repousser le câble à l'intérieur du matériel à tel point que le câble ou ses conducteurs, ou les deux, soient endommagés ou que des parties internes du matériel soient déplacées.

Pour les CABLES D'ALIMENTATION FIXES A DEMEURE comportant un CONDUCTEUR DE MISE A LA TERRE DE PROTECTION, la construction doit être telle que, si le câble devait se libérer de son dispositif d'arrêt de traction et de torsion, provoquant une contrainte sur les conducteurs, le CONDUCTEUR DE MISE A LA TERRE DE PROTECTION soit le dernier à être soumis à la contrainte.

Le dispositif d'arrêt de traction et de torsion doit être fait d'un matériau isolant, ou bien être recouvert d'un matériau isolant conforme aux exigences pour l'ISOLATION SUPPLEMENTAIRE. Cependant, lorsque le dispositif d'arrêt de traction et de torsion est un manchon qui comprend la connexion électrique au blindage d'un câble blindé, cette exigence n'est pas applicable. La construction du dispositif d'arrêt de traction et de torsion doit être telle:

– que le remplacement du câble ne porte pas atteinte à la sécurité du matériel; et
– que pour les câbles à remplacement ordinaire, la façon de protéger contre les contraintes soit claire; et
– que le câble ne soit pas maintenu par une vis métallique qui appuie directement sur le câble, que le dispositif d'arrêt de traction et de torsion, y compris la vis, soit fait d'un matériau isolant et que la vis ait une taille comparable au diamètre du câble à maintenir; et
– que des méthodes telles qu'attacher le câble en faisant un nœud ou en mettant une ficelle ne soient pas utilisées; et
– que le câble ne puisse pas tourner par rapport au corps du matériel à un point tel que des contraintes mécaniques soient imposées aux connexions électriques.

La vérification est effectuée par examen et par les essais suivants qui sont effectués avec le type de câble fourni avec le matériel.

Le câble est soumis à une force de traction constante, dont la valeur est indiquée dans le Tableau 3C, appliquée dans la direction la plus défavorable. L'essai est réalisé 25 fois, chaque fois pendant 1 s.

Pendant les essais, le câble ne doit pas être endommagé. Cela est vérifié par examen visuel, et par un essai de rigidité diélectrique entre les conducteurs du câble d'alimentation et les parties conductrices accessibles, sous la tension d'essai appropriée pour l'ISOLATION RENFORCEE.

Après les essais, le câble d'alimentation ne doit pas d'être déplacé longitudinalement de plus de 2 mm et les connexions ne doivent pas être soumises à une contrainte appréciable et les LIGNES DE FUITE et DISTANCES DANS L'AIR ne doivent pas être réduites à des valeurs inférieures aux valeurs spécifiées en 2.10 (ou à l'Annexe G).

Tableau 3C – Essais physiques sur les câbles d'alimentation

Masse (M) du matériel **kg**	**Force de traction** **N**
Jusqu'à 1 inclus	30
De 1 à 4 inclus	60
Supérieure à 4	100

3.2.7 Protection contre les dommages mécaniques

Les câbles d'alimentation ne doivent pas être exposés à des arêtes vives ou des bords coupants à l'intérieur ou sur la surface du matériel ainsi qu'aux entrées de câble et aux traversées de câbles.

La gaine extérieure d'un CABLE D'ALIMENTATION FIXE A DEMEURE doit pénétrer à l'intérieur du matériel à travers une traversée ou un dispositif de protection et doit dépasser le dispositif de serrage de l'arrêt de traction et de torsion d'au moins la moitié du diamètre du câble.

Les traversées, lorsqu'elles sont utilisées, doivent

– être fixées de façon sûre, et
– ne pas pouvoir être enlevées sans l'aide d'un OUTIL.

On ne doit pas utiliser une traversée de câble métallique sur une ENVELOPPE non métallique.

Une traversée de câble ou un dispositif de protection de câble sur une partie conductrice sans protection de terre doit satisfaire aux exigences pour l'ISOLATION SUPPLEMENTAIRE.

La vérification est effectuée par examen et par des mesures.

3.2.8 Protection des câbles

Un dispositif de protection doit être prévu à l'entrée du câble d'alimentation sur le matériel équipé d'un CABLE D'ALIMENTATION FIXE A DEMEURE, et qui est un MATERIEL PORTATIF ou est destiné à être déplacé pendant l'utilisation. En variante, l'entrée du câble ou la traversée doit être munie d'un orifice en forme de cloche, soigneusement arrondi, dont le rayon de courbure est au moins égal à 1,5 fois le diamètre extérieur du câble de la plus grande section à raccorder.

Les dispositifs de protection doivent

– être conçus pour protéger le câble contre les pliages excessifs à l'entrée du matériel; et
– être en matériau isolant,
– être fixés de façon sûre, et
– dépasser à l'extérieur du matériel à partir de l'orifice d'entrée d'une longueur au moins égale à cinq fois le diamètre extérieur ou, pour les câbles plats, à cinq fois la plus grande dimension extérieure du câble.

La vérification est effectuée par examen, par des mesures et, lorsque c'est nécessaire, par l'essai suivant avec le câble fourni par le fabricant.

Le matériel est placé de façon que l'axe du dispositif de protection, au point de sortie du câble, fasse saillie d'un angle de 45° lorsque le câble est exempt de contraintes. Une masse *égale à 10 × D^2 g est alors attachée à l'extrémité libre du câble, D étant, en millimètres, le diamètre extérieur, ou, pour les câbles plats, la plus petite dimension extérieure du câble.*

Si le dispositif de protection est fait dans une matière sensible à la température, l'essai est effectué à 23 °C ± 2 °C.

Les câbles plats sont pliés dans le plan de la moindre résistance.

Immédiatement après l'accrochage de la masse, le rayon de courbure du câble ne doit être en aucun endroit inférieur à 1,5 D.

3.2.9 Espace pour l'installation des câbles d'alimentation

L'espace pour l'installation des câbles d'alimentation prévu à l'intérieur, ou en tant que partie, du matériel pour la connexion à demeure ou pour la connexion d'un CABLE D'ALIMENTATION ordinaire FIXE A DEMEURE doit être conçu:

– pour permettre l'introduction et le raccordement facile des conducteurs; et
– de façon que l'extrémité non isolée d'un conducteur ne soit pas susceptible de se libérer de sa borne ou, si elle le fait, qu'elle ne puisse venir en contact avec:
  - une partie conductrice accessible qui n'est pas reliée à la terre de protection; ou
  - une partie conductrice accessible d'un MATERIEL PORTATIF; et
– pour permettre de vérifier, avant la mise en place du couvercle éventuel, que les conducteurs sont correctement raccordés et disposés; et
– de façon que les couvercles éventuels puissent être mis en place sans risquer d'endommager les conducteurs d'alimentation ou leur isolation; et
– de façon que les couvercles éventuels donnant accès aux bornes puissent être enlevés avec un OUTIL d'emploi courant.

La vérification est effectuée par examen et par un essai d'installation avec des câbles de la plus forte section de la plage appropriée spécifiée en 3.3.4.

3.3 Bornes pour les conducteurs externes

3.3.1 Bornes

Les MATERIELS RELIES A DEMEURE et les matériels équipés d'un CABLE D'ALIMENTATION ordinaire FIXE A DEMEURE doivent être pourvus de bornes dans lesquelles les connexions sont assurées au moyen de vis, d'écrous ou d'autres moyens aussi efficaces (voir aussi 2.6.4).

La conformité est vérifiée par examen.

3.3.2 Raccordement des câbles d'alimentation fixés à demeure

Pour les matériels équipés d'un CABLE D'ALIMENTATION FIXE A DEMEURE, le raccordement des conducteurs individuels aux conducteurs internes du matériel doit être réalisé par tout moyen susceptible de fournir un raccordement mécanique et électrique fiable, sans dépasser les limites de température admissibles (voir aussi 3.1.9).

La vérification est effectuée par examen, et en mesurant la température de la connexion, qui ne doit pas dépasser les valeurs de 4.5.3, Tableau 4B.

3.3.3 Bornes à vis

Les vis et écrous pour le serrage des conducteurs externes d'alimentation doivent avoir un filetage conforme à l'ISO 261 ou à l'ISO 262, ou un filetage ayant un pas et une résistance mécanique comparables (par exemple les filetages unifiés). Ils ne doivent pas servir à fixer d'autres composants. Toutefois, ils peuvent serrer aussi des conducteurs internes, pourvu que les conducteurs internes soient disposés de façon qu'ils ne soient pas susceptibles d'être déplacés lors du raccordement des conducteurs d'alimentation. Pour les bornes de mise à la terre et de liaison à la terre de protection, voir aussi 2.6.4.2.

Il est permis d'utiliser les bornes d'un composant (par exemple un interrupteur) incorporé au matériel comme bornes pour les conducteurs externes d'alimentation, sous réserve qu'elles soient conformes aux exigences de 3.3.

La conformité est vérifiée par examen.

3.3.4 Dimensions des conducteurs à raccorder

Les bornes doivent permettre le raccordement de conducteurs ayant les sections nominales indiquées dans le Tableau 3D.

Lorsqu'il est fait usage de câbles avec des sections plus importantes, les bornes doivent être dimensionnées en conséquence.

La vérification est effectuée par examen, par des mesures et par le raccordement de câbles de la plus petite et de la plus grande section de la plage appropriée spécifiée dans le Tableau 3D.

Tableau 3D – Plage des dimensions des conducteurs à introduire dans les bornes

COURANT NOMINAL du matériel A	Section nominale mm²	
	Câbles souples	Autres câbles
Jusqu'à 3 inclus	0,5 à 0,75	1 à 2,5
De 3 à 6 inclus	0,75 à 1	1 à 2,5
De 6 à 10 inclus	1 à 1,5	1 à 2,5
De 10 à 13 inclus	1,25 à 1,5	1,5 à 4
De 13 à 16 inclus	1,5 à 2,5	1,5 à 4
De 16 à 25 inclus	2,5 à 4	2,5 à 6
De 25 à 32 inclus	4 à 6	4 à 10
De 32 à 40 inclus	6 à 10	6 à 16
De 40 à 63 inclus	10 à 16	10 à 25

3.3.5 Dimensions des bornes pour les conducteurs

Les bornes de type pilier à plot de contact ou à vis doivent être conformes aux exigences de taille minimale données au Tableau 3E.

La vérification est effectuée par examen et par des mesures.

Tableau 3E – Dimensions des bornes pour les conducteurs de l'alimentation et pour les conducteurs de mise à la terre de protection [a]

~~COURANT NOMINAL du matériel A~~	~~Diamètre nominal minimal de la partie filetée mm~~	
	~~Type pilier ou à plot~~	~~Type à vis b~~
~~Jusqu'à 10 inclus~~	~~3,0~~	~~3,5~~
~~De 10 à 16 inclus~~	~~3,5~~	~~4,0~~
~~De 16 à 25 inclus~~	~~4,0~~	~~5,0~~
~~De 25 à 32 inclus~~	~~4,0~~	~~5,0~~
~~De 32 à 40 inclus~~	~~5,0~~	~~5,0~~
~~De 40 à 63 inclus~~	~~6,0~~	~~6,0~~

~~a Ce tableau est également utilisé pour les dimensions des bornes pour les CONDUCTEURS DE LIAISON A LA TERRE DE PROTECTION si spécifié en 2.6.4.2~~

~~b «Type à vis" signifie une borne qui fixe le conducteur sous la tête de la vis avec ou sans rondelle.~~

COURANT ASSIGNE A **jusqu'à et y compris**	**Dimensions de conducteur** mm^2	**Diamètre nominal minimal de la partie filetée** mm		**Section** mm^2	
		Type pilier ou à plot	**Type à vis** [b]	**Type pilier ou à plot**	**Type à vis** [b]
10	1	3,0	3,5	7	9,6
16	1,5	3,5	4,0	9,6	12,6
25	2,5	4,0	5,0	12,6	19,6
32	4	4,0	5,0	12,6	19,6
40	6	5,0	5,0	19,6	19,6
63	10 [c]	6,0	6,0	28	28
80	16 [c]	7,9	7,9	49	49

[a] Ce tableau est également utilisé pour les dimensions des bornes pour les CONDUCTEURS DE LIAISON A LA TERRE DE PROTECTION, si spécifié en 2.6.4.2.

[b] "Type à vis" signifie une borne qui fixe le conducteur sous la tête de la vis, avec ou sans rondelle.

[c] Comme alternative aux exigences de ce tableau, le conducteur de mise à la terre de protection peut être fixé à des connecteurs particuliers, ou à des systèmes de fixation adaptés (par exemple, de type cosse plate retournée ou cosse à œillet; de type dispositif de serrage; de type dispositif de serrage à plaquette; de type dispositif de serrage à capot taraudé; etc.), fixés par un mécanisme de vis et d'écrous au châssis métallique du matériel. La somme des sections de la vis et de l'écrou ne doit pas être inférieure à trois fois la section des dimensions du conducteur du Tableau 2D ou du Tableau 3B, le cas échéant. Les bornes doivent être conformes à la CEI 60998-1 et à la CEI 60999-1 ou à la CEI 60999-2.

3.3.6 Conception des bornes pour les conducteurs

Les bornes doivent être conçues de façon que l'âme conductrice soit serrée entre des surfaces métalliques avec une pression de contact suffisante et sans dommage pour l'âme.

Les bornes doivent être conçues ou localisées de telle sorte que le conducteur ne puisse pas s'enlever lorsque les vis ou les écrous de serrage sont resserrés.

Les bornes doivent être pourvues des fixations appropriées des conducteurs (par exemple écrous et rondelles).

Les bornes doivent être fixées de telle sorte que lorsque le moyen de serrage du conducteur est resserré ou desserré:

– la borne elle-même ne se desserre pas,
– les conducteurs internes ne soient pas soumis à des contraintes; et
– les DISTANCES DANS L'AIR et les LIGNES DE FUITE ne soient pas réduites au-dessous des valeurs spécifiées en 2.10 (ou à l'Annexe G).

La vérification est effectuée par examen et par des mesures.

3.3.7 Groupement des bornes pour les conducteurs

Pour les CABLES D'ALIMENTATION FIXES A DEMEURE ordinaires, et pour les MATERIELS RELIES A DEMEURE, toutes les bornes du RESEAU D'ALIMENTATION EN COURANT ALTERNATIF associées doivent être placées au voisinage l'une de l'autre et de la borne de terre de protection éventuelle.

Pour les CABLES D'ALIMENTATION FIXES A DEMEURE ordinaires et pour les MATERIELS RELIES A DEMEURE, toutes les bornes du RESEAU D'ALIMENTATION EN COURANT CONTINU associées doivent être placées au voisinage l'une de l'autre. Elles n'ont pas besoin d'être placées au voisinage de la borne de terre de protection éventuelle, pourvu que les instructions d'installation du matériel donnent les détails pour une mise à la terre correcte du système.

La conformité est vérifiée par examen.

3.3.8 Conducteur à âme câblée

L'extrémité d'un conducteur à âme câblée ne doit pas être consolidée avec de la soudure tendre aux endroits où le conducteur est soumis à une pression de contact, à moins que la méthode de fixation ne soit conçue de façon à prévenir le risque d'un mauvais contact dû au fluage à froid de la soudure.

Les bornes à ressort qui compensent le fluage à froid sont considérées comme satisfaisant à cette exigence.

Le fait d'empêcher les vis de blocage de tourner n'est pas considéré comme suffisant.

Les bornes doivent être placées, protégées ou isolées de façon que, si un brin d'un conducteur souple vient à se détacher après le raccordement du conducteur, il n'y ait pas de risque de contact accidentel entre le brin et

– les parties conductrices accessibles, ou
– les parties conductrices non mises à la terre, séparées des parties conductrices accessibles par une ISOLATION SUPPLEMENTAIRE seulement.

La vérification est effectuée par examen et par l'essai suivant, à moins qu'un câble spécial ne soit préparé de façon à empêcher l'échappement de brins.

L''extrémité d'un conducteur souple ayant la section nominale appropriée est dépouillée de son enveloppe isolante sur une longueur d'environ 8 mm. Un brin du conducteur est décâblé et les autres brins sont introduits complètement et serrés dans la borne.

Le brin décâblé est plié, sans que l'enveloppe isolante soit déchirée, dans toutes les directions possibles, mais sans angles vifs le long de la protection.

Si le conducteur est sous une TENSION DANGEREUSE, le brin décâblé ne doit toucher aucune partie métallique accessible ou en liaison avec une partie métallique accessible ou, pour les *matériels à DOUBLE ISOLATION, aucune partie métallique séparée des parties métalliques accessibles par une ISOLATION SUPPLEMENTAIRE seulement.*

Si le conducteur est relié à une borne de terre, le brin décâblé ne doit toucher aucune partie sous TENSION DANGEREUSE.

3.4 Séparation de l'alimentation du réseau

3.4.1 Exigence générale

Un dispositif ou des dispositifs de sectionnement doivent être prévus pour séparer le matériel du réseau d'alimentation en vue de la maintenance.

NOTE On peut fournir des instructions pour permettre la maintenance des parties du matériel en ouvrant ou non le dispositif de sectionnement.

La conformité est vérifiée par examen.

3.4.2 Dispositifs de sectionnement

Pour les matériels destinés à être alimentés par un RESEAU D'ALIMENTATION EN COURANT ALTERNATIF de catégorie de surtension I, de catégorie de surtension II ou de catégorie de surtension III ou par un RESEAU D'ALIMENTATION EN COURANT CONTINU qui est à un niveau de TENSION DANGEREUSE, un dispositif de sectionnement doit avoir une séparation de contact d'au moins 3 mm. Pour un RESEAU D'ALIMENTATION EN COURANT ALTERNATIF de catégorie de surtension IV, se reporter à la CEI 60947-1.

Pour les matériels destinés à être alimentés par un D'ALIMENTATION EN COURANT CONTINU qui est à un niveau de TENSION DANGEREUSE, un dispositif de sectionnement doit avoir une séparation de contact au moins égale à la DISTANCE DANS L'AIR minimale pour l'ISOLATION PRINCIPALE.

NOTE Pour un RESEAU D'ALIMENTATION EN COURANT CONTINU, des mesures supplémentaires peuvent être nécessaires pour empêcher la formation d'arcs dans le dispositif de sectionnement, en fonction du circuit.

Si un dispositif de sectionnement est incorporé dans le matériel, il doit être connecté aussi près que possible de l'arrivée de l'alimentation.

Il est permis que les interrupteurs fonctionnels soient utilisés comme dispositifs de sectionnement pourvu qu'ils satisfassent à toutes les exigences pour les dispositifs de sectionnement. Cependant, ces exigences ne sont pas applicables aux interrupteurs fonctionnels lorsque d'autres moyens de sectionnement sont prévus.

Les types suivants de dispositifs de sectionnement sont permis:

– la fiche RESEAU du câble d'alimentation;
– une fiche de prise de courant RESEAU qui est une partie d’un MATERIEL ENFICHABLE DIRECTEMENT.
– un connecteur;
– un interrupteur sectionneur;
– un disjoncteur;
– pour un RESEAU D'ALIMENTATION EN COURANT CONTINU qui n'est pas à une TENSION DANGEREUSE, un fusible amovible, sous réserve de n'être accessible qu'au PERSONNEL DE MAINTENANCE;
– tout dispositif équivalent.

La conformité est vérifiée par examen.

3.4.3 Matériels reliés à demeure

Pour les MATERIELS RELIES A DEMEURE, le dispositif de sectionnement doit être incorporé dans le matériel, à moins que celui-ci ne soit accompagné d'une notice d'installation conforme à 1.7.2.1 indiquant qu'un dispositif de sectionnement approprié doit être prévu à l'extérieur du matériel.

NOTE Il n'est pas nécessaire de fournir les dispositifs de sectionnement externes avec le matériel.

La conformité est vérifiée par examen.

3.4.4 Parties qui restent sous tension

Les parties placées du côté alimentation d'un dispositif de sectionnement dans le matériel qui restent sous tension lorsque le dispositif est coupé doivent être protégées par une barrière pour éviter un contact accidentel du PERSONNEL DE MAINTENANCE.

La conformité est vérifiée par examen.

3.4.5 Interrupteurs dans les câbles souples

Les interrupteurs sectionneurs ne doivent pas être montés sur des câbles souples.

La conformité est vérifiée par examen.

3.4.6 Nombre de pôles – matériel monophasé et à courant continu

Un dispositif de sectionnement, s'il est prévu à l'intérieur ou comme partie du matériel, doit déconnecter les deux pôles simultanément avec les exceptions suivantes:

– s'il est possible de se fier à l'identification d'un conducteur relié à la terre dans le RESEAU D'ALIMENTATION EN COURANT CONTINU, ou d'un neutre mis à la terre dans un RESEAU D'ALIMENTATION EN COURANT ALTERNATIF, il est permis d'utiliser un dispositif de sectionnement monophasé qui déconnecte le conducteur non relié à la terre, ou

– s'il n'est pas possible de se fier à l'identification d'un conducteur relié à la terre dans le RESEAU D'ALIMENTATION EN COURANT CONTINU ou d'un neutre mis à la terre dans un RESEAU D'ALIMENTATION EN COURANT ALTERNATIF et que le matériel n'est pas équipé d'un dispositif de sectionnement biphasé, les instructions d'installation doivent spécifier qu'un dispositif de sectionnement biphasé doit être fourni à l'extérieur du matériel.

NOTE Exemples de cas dans lesquels un dispositif de sectionnement biphasé est nécessaire à (parce que l'identification d'un conducteur relié à le terre dans le RESEAU D'ALIMENTATION n'est pas possible):

– matériel alimenté à partir d'un schéma d'alimentation IT;

– MATERIEL RACCORDE PAR PRISE DE COURANT alimenté par un connecteur réversible ou par une fiche de prise de courant réversible (à moins que la fiche elle-même ou le connecteur ne soit utilisé comme dispositif de sectionnement);

– matériel alimenté au travers d'un socle de polarité indéterminée ou non identifiée.

La conformité est vérifiée par examen.

3.4.7 Nombre de pôles – matériel triphasé

Pour un matériel triphasé, le dispositif de sectionnement doit déconnecter simultanément tous les conducteurs de ligne du RESEAU D'ALIMENTATION EN COURANT ALTERNATIF.

Pour un matériel nécessitant une connexion au neutre d'un système d'alimentation IT, le dispositif de sectionnement doit être un dispositif quadripolaire et doit déconnecter tous les conducteurs de ligne et le conducteur de neutre. Si ce dispositif quadripolaire n'est pas fourni dans le matériel, les instructions d'installation doivent spécifier la nécessité de le fournir hors du matériel.

Si un dispositif de sectionnement coupe le neutre, il doit déconnecter simultanément tous les conducteurs de ligne.

La conformité est vérifiée par examen.

3.4.8 Interrupteurs comme dispositifs de sectionnement

Lorsque le dispositif de sectionnement est un interrupteur incorporé dans le matériel, ses positions «MARCHE»/«ARRET» doivent être marquées conformément à 1.7.8.

La conformité est vérifiée par examen.

3.4.9 Fiches comme dispositifs de sectionnement

Lorsqu'une fiche sur le câble d'alimentation est utilisée comme dispositif de sectionnement, la notice d'installation doit être conforme à 1.7.2.1.

La conformité est vérifiée par examen.

3.4.10 Matériels interconnectés

Lorsqu'un groupe d'unités munies de moyens de connexion individuels est interconnecté de telle manière qu'il est possible que des TENSIONS DANGEREUSES ou des NIVEAUX D'ÉNERGIE DANGEREUX soient transmis entre unités, un dispositif de sectionnement doit être prévu pour couper les parties dangereuses susceptibles d'être touchées pendant la maintenance de l'unité considérée, à moins que ces parties ne soient protégées et ne portent des étiquettes d'avertissement appropriées. De plus, une étiquette en évidence doit être prévue sur chaque unité, donnant des instructions appropriées pour la coupure de toute l'alimentation de l'unité.

La conformité est vérifiée par examen.

3.4.11 Alimentations multiples

Lorsqu'une unité reçoit de l'énergie de plus d'une source (par exemple dans le cas de différentes tensions ou fréquences ou comme alimentation de secours), un marquage doit être placé en évidence sur chaque dispositif de sectionnement donnant des instructions appropriées pour la coupure de toute l'alimentation de l'unité.

Lorsque le dispositif de sectionnement n'est pas incorporé dans le matériel, le marquage doit être placé sur le matériel et à proximité des bornes d'entrée de l'ALIMENTATION.

La conformité est vérifiée par examen.

3.5 Interconnexion des matériels

3.5.1 Exigences générales

Lorsqu'un matériel est destiné à être connecté électriquement à un autre matériel, à un accessoire ou à un RESEAU DE TELECOMMUNICATIONS, les circuits d'interconnexion doivent être choisis pour fournir une conformité continue aux exigences de 2.2 pour les CIRCUITS TBTS, et à celles de 2.3 pour les CIRCUITS TRT, après avoir effectué la connexion.

NOTE 1 Cela est généralement obtenu en connectant les CIRCUITS TBTS aux CIRCUITS TBTS, et les CIRCUITS TRT aux CIRCUITS TRT.

De plus, les CIRCUITS TBTS des accès de données pour la connexion à d'autres matériels ou accessoires doivent limiter le risque d'incendie dans le matériel connecté comme spécifié en 3.5.4.

NOTE 2 Il est permis qu'un CABLE D'INTERCONNEXION contienne plus d'un type de circuit (par exemple CIRCUIT TBTS, CIRCUIT A LIMITATION DE COURANT, CIRCUIT TRT, CIRCUIT TBT, ou sous TENSION DANGEREUSE) pourvu qu'ils soient séparés comme prescrit dans la présente norme.

La conformité est vérifiée par examen.

3.5.2 Types de circuits d'interconnexion

Chaque circuit d'interconnexion doit être de l'un des types suivants:

– un circuit tbts ou un circuit à limitation de courant; ou
– un CIRCUIT TRT-1 , un CIRCUIT TRT-2 ou un CIRCUIT TRT-3; ou
– un circuit sous TENSION DANGEREUSE.

A l'exception de ce qui est permis en 3.5.3, les circuits d'interconnexion ne doivent pas être des CIRCUITS TBT.

La conformité est vérifiée par examen.

3.5.3 Circuits TBT comme circuits d'interconnexion

Lorsqu'un matériel supplémentaire est spécifiquement complémentaire d'un matériel hôte (premier) (par exemple un collecteur pour une machine à photocopier), il est permis que des CIRCUITS TBT servent de circuits d'interconnexion entre les matériels, pourvu que les matériels continuent de satisfaire aux exigences de la présente norme lorsqu'ils sont connectés ensemble.

La conformité est vérifiée par examen.

3.5.4 Accès de données pour matériel supplémentaire

Pour limiter le risque d'incendie dans un matériel ou un accessoire supplémentaire (par exemple un numériseur, une souris, un clavier, un lecteur de DVD, un lecteur de CD ROM ou une manette de jeu), les CIRCUITS TBTS d'un accès de données pour la connexion d'un tel matériel doivent être alimentés par une source de puissance limitée conforme à 2.5. Cette exigence ne s'applique pas si le matériel supplémentaire est connu comme étant conforme à 4.7.

NOTE Il est recommandé que les fabricants des accessoires et de leurs CABLES D'INTERCONNEXION intègrent une protection contre les courants de défaut jusqu'à 8 A à 100 VA, la valeur maximale fournie par une source de puissance limitée conformément au Tableau 2B.

La vérification est effectuée par examen et par un essai, si nécessaire.

4 Exigences physiques

4.1 Stabilité

Dans les conditions d'utilisation normale, le matériel ne doit pas devenir mécaniquement instable au point de risquer de présenter un danger pour un OPERATEUR et le PERSONNEL DE MAINTENANCE.

Lorsque des unités sont prévues pour être attachées l'une à l'autre sur le site et non pour être utilisées individuellement, la stabilité des unités individuelles est exemptée des exigences de 4.1.

Les exigences de 4.1 ne s'appliquent pas lorsque les instructions pour l'installation d'une unité spécifient que le matériel doit être fixé à la structure du bâtiment avant la mise en fonctionnement.

Lorsque des moyens de stabilisation sont nécessaires dans des conditions d'utilisation par l'OPERATEUR, ils doivent automatiquement fonctionner lors de l'ouverture des portes, des tiroirs, etc.

Pendant les interventions du PERSONNEL DE MAINTENANCE, les moyens de stabilisation, s'ils sont nécessaires, doivent fonctionner automatiquement, ou alors un marquage doit être fourni pour indiquer au PERSONNEL DE MAINTENANCE qu'il doit déployer ces moyens de stabilisation.

La vérification est effectuée par les essais suivants, lorsqu'ils s'appliquent. Chaque essai est effectué individuellement. Pendant les essais, les récipients contiennent la quantité de substance, dans la limite de leur capacité assignée, produisant les conditions les plus défavorables. Toutes les roulettes et tous les vérins, s'ils sont utilisés lors du fonctionnement normal, sont mis dans leur position la plus défavorable, avec les roues et les organes analogues fermés ou bloqués. Cependant, si les roulettes sont destinées uniquement au transport de l'unité et s'il est prescrit dans les instructions d'installation que les vérins doivent être baissés après l'installation, alors les vérins (et pas les roulettes) sont utilisés dans cet essai; les vérins sont mis dans leur position la plus défavorable, compatible avec une mise à niveau raisonnable de l'unité.

– *Une unité d'une masse supérieure ou égale à 7 kg ne doit pas se renverser lorsqu'elle est inclinée de 10° par rapport à sa position verticale normale. Les portes, tiroirs, etc., sont fermés pendant cet essai. Une unité dont les caractéristiques permettent des positions multiples doit être soumise à l'essai dans la position la plus défavorable permise par la construction. En variante, l'unité est placée dans sa position d'utilisation prévue sur un plan, incliné de 10° par rapport à l'horizontale, puis tournée lentement sur un angle de 360° autour de son axe vertical normal.*

  NOTE Cela pourrait être le plan qui tourne ou bien le plan pourrait être fixe et le matériel est mis en rotation.

– *Une unité reposant sur le sol, d'une masse au moins égale à 25 kg, ne doit pas se renverser lorsqu'une force égale à 20 % de son poids, mais ne dépassant pas 250 N, est appliquée dans n'importe quelle direction, sauf vers le haut, à la hauteur ne dépassant pas 2 m au-dessus du sol. Les portes, les tiroirs, etc., qui peuvent être déplacés pour la maintenance par l'OPERATEUR ou par le PERSONNEL DE MAINTENANCE, sont placés dans la position la plus défavorable, compatible avec les instructions d'installation.*

– *Une unité reposant sur le sol ne doit pas se renverser lorsqu'une force constante de 800 N, dirigée vers le bas, est appliquée au point de moment maximal, sur n'importe quelle surface horizontale d'au moins 125 mm par 200 mm, située à une hauteur jusqu'à 1 m au-dessus du sol. Les portes, tiroirs, etc. sont fermés pendant cet essai. La force de 800 N est appliquée avec un outil d'essai approprié ayant une surface plane d'environ 125 mm par 200 mm. La force dirigée vers le bas est appliquée avec la totalité de la surface plane de l'outil d'essai et en contact avec le matériel à l'essai; il n'est pas nécessaire que l'outil d'essai soit entièrement en contact avec des surfaces irrégulières, (par exemple des surfaces ondulées ou courbes).*

4.2 Résistance mécanique

4.2.1 Généralités

Les matériels doivent avoir une résistance mécanique appropriée et doivent être construits de façon à éviter tout risque dans le sens de cette norme lorsqu'ils sont manipulés dans des conditions attendues. Pour les exigences supplémentaires relatives au matériel monté dans des baies, voir Annexe DD.

Les essais de résistance mécanique ne sont pas exigés sur une barrière interne, un écran interne ou un dispositif analogue, prévu pour satisfaire aux exigences de 4.6.2, si l'ENVELOPPE assure la protection mécanique.

Une ENVELOPPE MECANIQUE doit être suffisamment complète pour contenir ou détourner des parties qui, à cause d'une défaillance ou pour toute autre raison, pourraient se relâcher, se séparer ou être projetées ~~à partir~~ d'une partie mobile.

~~NOTE Parmi les exemples de matériels pour lesquels de telles précautions peuvent être nécessaires, il y a les lecteurs de CD ROM et les lecteurs de DVD dont la vitesse de rotation est supérieure à 8 000 r.p.m.~~

La ~~vérification est effectuée~~ conformité est vérifiée par examen de la construction et des données disponibles et, lorsque cela est nécessaire, par les essais applicables de 4.2.2 à 4.2.7 comme spécifié.

Les essais ne sont pas effectués sur les poignées, leviers, boutons, le devant des tubes à rayons cathodiques (voir 4.2.8) ni sur les couvercles transparents ou translucides des dispositifs indicateurs ou des dispositifs de mesure à moins que des parties sous TENSIONS DANGEREUSES ne soient accessibles au moyen du doigt d'épreuve de la Figure 2A (voir 2.1.1.1), si la poignée, le levier, le bouton ou le couvercle est enlevé.

Pendant les essais de 4.2.2, 4.2.3 et 4.2.4, les ENVELOPPES conductrices, mises à la terre ou non, ne doivent pas ponter les parties entre lesquelles un NIVEAU D'ENERGIE DANGEREUX existe et ne doivent pas toucher une partie sous TENSION DANGEREUSE. Pour les tensions dépassant 1 000 V en courant alternatif ou 1 500 V en courant continu, le contact n'est pas permis et il doit rester un intervalle d'air entre les parties sous TENSION DANGEREUSE et l'ENVELOPPE. Cet intervalle d'air doit être au moins égal à la DISTANCE DANS L'AIR minimale spécifiée en 2.10.3 (ou à l'Annexe G) pour une ISOLATION PRINCIPALE, ou alors résister à l'essai de rigidité diélectrique approprié de 5.2.2.

Après les essais de 4.2.2 à 4.2.7, l'échantillon doit satisfaire aux exigences de 2.1.1, 2.6.1, 2.10, 3.2.6 et 4.4.1. Il ne doit présenter aucun signe de perturbation des dispositifs de sécurité tels que COUPE-CIRCUIT THERMIQUES, dispositifs de protection contre les surintensités ou dispositifs de verrouillage. En cas de doute, l'ISOLATION SUPPLEMENTAIRE ou l'ISOLATION RENFORCEE est soumise à un essai de rigidité diélectrique comme spécifié en 5.2.2.

Les endommagements de finition, les fissures, les bosses et les écaillages ne sont pas pris en considération s'ils n'affectent pas la sécurité de façon défavorable.

NOTE Si une ENVELOPPE séparée ou une partie d'ENVELOPPE est utilisée pour un essai, il peut être nécessaire de la ré-assembler dans le matériel dans le but de vérifier la conformité.

4.2.2 Essai de force constante, 10 N

Les composants et les parties autres que les parties servant d'ENVELOPPE (voir 4.2.3 et 4.2.4) sont soumis à une force constante de 10 N ± 1 N.

Les critères de conformité sont en 4.2.1.

4.2.3 Essai de force constante, 30 N

Les parties d'une ENVELOPPE située dans une ZONE D'ACCES DE L'OPERATEUR, qui sont protégées par un couvercle ou une porte satisfaisant aux exigences de 4.2.4, sont soumises pendant une durée de 5 s à une force constante de 30 N ± 3 N, appliquée au moyen d'une version droite et sans articulation du doigt d'épreuve de la Figure 2A (voir 2.1.1.1), à la partie sur ou dans le matériel.

Les critères de conformité sont en 4.2.1.

4.2.4 Essai de force constante, 250 N

Les ENVELOPPES externes sont soumises pendant une durée de 5 s à une force de 250 N ± 10 N appliquée tour à tour sur le dessus, le fond et les côtés de l'ENVELOPPE fixée au matériel, au moyen d'un outil d'essai convenable assurant un contact sur une surface plane circulaire de 30 mm de diamètre. Cependant, cet essai n'est pas applicable à l'ENVELOPPE des matériels de masse supérieure à 18 kg.

Les critères de conformité sont en 4.2.1.

4.2.5 Essai de choc

Pour les matériels autres que les matériels identifiés en 4.2.6, les surfaces externes des ENVELOPPES *dont la défaillance permettrait l'accès à des parties dangereuses sont essayées comme suit.*

*Un échantillon, constitué de l'*ENVELOPPE *complète ou d'une partie de celle-ci représentant la plus grande surface non renforcée, est fixé dans sa position normale. Une sphère massive d'acier poli, d'environ 50 mm de diamètre et d'une masse de 500 g ± 25 g, tombe librement sur l'échantillon d'une hauteur (H) de 1,3 m (voir Figure 4A) en partant du repos. (Les surfaces verticales sont exemptées de cet essai.)*

De plus, la sphère d'acier est suspendue par une corde et balancée comme un pendule tombant d'une distance verticale (H) de 1,3 m dans le but d'appliquer un choc horizontal (voir Figure 4A). (Les surfaces horizontales sont exemptées de cet essai.) En variante, l'échantillon est tourné de 90° autour de chacun de ses axes horizontaux et la sphère est lâchée comme dans l'essai du choc vertical.

Les fonds des ENVELOPPES *sont également soumis aux essais si le mode d'emploi permet une orientation dans laquelle le fond de l'*ENVELOPPE *devient le haut ou un côté de celle-ci.*

~~*L'essai n'est pas appliqué aux éléments suivants:*~~

- ~~*un moniteur à écran plat;*~~
- ~~*la face d'un tube à rayons cathodiques (voir 4.2.8);*~~
- ~~*la glace d'un matériel (par exemple sur une photocopieuse);*~~
- ~~*la surface de l'ENVELOPPE du MATERIEL FIXE, y compris MATERIEL A ENCASTRER, qui est inaccessible et protégée après installation.*~~

L'essai de choc n'est pas appliqué aux éléments suivants:

- *la face d'un tube à rayons cathodiques (voir 4.2.8);*
- *la glace d'un matériel (par exemple sur une photocopieuse);*
- *la surface de l'*ENVELOPPE *du* MATERIEL FIXE*, y compris* MATERIEL A ENCASTRER*, qui est inaccessible et protégée après installation;*
- *un moniteur à écran plat*
  - *ayant une surface de verre ne dépassant pas 0,1 m^2 ou avec une dimension majeure ne dépassant pas 450 mm; ou*
  - *en verre feuilleté; ou*

  NOTE Le verre feuilleté comprend les constructions telles que la pellicule plastique appliquée à un seul côté de la glace.

  - *qui a été évalué et est conforme à 19.5 de la CEI 60065.*

Les critères de conformité sont en 4.2.1.

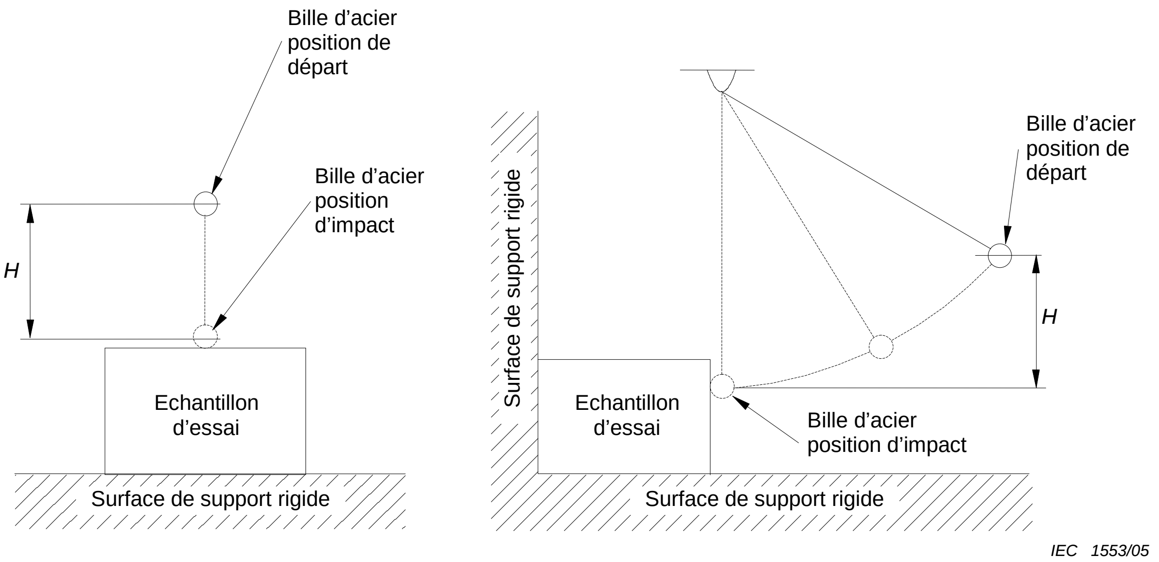


Figure 4A – Essai de choc utilisant la sphère d'acier

4.2.6 Essai de chute

Les matériels suivants sont soumis à un essai de chute:

- MATERIELS PORTATIFS;
- MATERIELS ENFICHABLES DIRECTEMENT;
- MATERIELS TRANSPORTABLES;
- matériels de masse inférieure ou égale à 5 kg, à poser sur un bureau et destinés à fonctionner avec un des sous ensembles suivants:
  - un combiné de téléphone relié par un câble; ou
  - un autre accessoire avec une fonction acoustique, tenu dans la main lors de son utilisation et relié par un câble; ou
  - un casque.
- MATERIEL MOBILE devant être levé ou manipulé par l'UTILISATEUR dans le cadre de son utilisation prévue.

NOTE Un exemple d'un tel matériel est une déchiqueteuse installée sur un bac qui doit être enlevée pour que ce bac puisse être vidé.

Un échantillon du matériel complet est soumis à trois impacts provoqués par leur chute sur une surface horizontale dans les positions susceptibles d'entraîner les résultats les plus défavorables.

La hauteur de chute doit être de:

- *750 mm ± 10 mm pour les matériels à poser sur un bureau comme décrit ci-dessus;*
- *750 mm ± 10 mm pour les matériels à poser sur un bureau comme décrit ci-dessus;*
- *1 000 mm ± 10 mm pour les MATERIELS PORTATIFS, les MATERIELS ENFICHABLES DIRECTEMENT et les MATERIELS TRANSPORTABLES.*

La surface horizontale est en bois dur d'au moins 13 mm d'épaisseur et montée sur deux couches de contreplaqué ayant chacune une épaisseur de ~~19 mm à 20 mm~~ 18 mm ± 2 mm, le tout étant posé sur un sol en béton ou en matériau non élastique équivalent.

Les critères de conformité sont en 4.2.1.

4.2.7 Essai de relâchement des contraintes

Les ENVELOPPES réalisées en matières plastiques thermomoulées ou thermoformées doivent être construites de façon que toute contraction ou déformation du matériau due au relâchement des contraintes internes entraînées par les opérations de moulage ou de formage ne risque pas de provoquer l'exposition de parties dangereuses ou de réduire les DISTANCES DANS L'AIR ou les LIGNES DE FUITE en dessous des valeurs specifiées en 2.10 (ou à l'Annexe G).

La ~~vérification est effectuée~~ conformité est vérifiée par l'essai de réduction des contraintes de moulage de la CEI 60695-10-3; ou par l'essai décrit ~~ci-dessus~~ ci-dessous, ou; le cas échéant, par examen de la construction et des données ~~disponibles~~.

Un échantillon constitué du matériel complet, ou de l'ENVELOPPE complète avec toutes les structures de support, est placé dans une étuve à circulation d'air ~~(conformément à la CEI 60216-4-1)~~ et porté pendant 7 h à une température supérieure de 10 K à la température maximale observées sur l'ENVELOPPE pendant l'essai de 4.5.2, mais en aucun cas inférieure à 70 °C, puis on le laisse refroidir jusqu'à la température ambiante.

Avec l'accord du fabricant, il est permis d'augmenter la durée d'essai ci-dessus.

Pour les matériels dont l'encombrement rend impossible l'essai de l'ENVELOPPE complète, il est permis d'utiliser la partie de l'ENVELOPPE représentative de l'assemblage complet quant à l'épaisseur, à la forme et à la présence éventuelle de pièces mécaniques de support.

NOTE Il n'est pas nécessaire de maintenir l'humidité relative à une valeur spécifique pendant cet essai.

Si l'essai ci-dessus est effectué, les critères de conformité de 4.2.1 s'appliquent.

4.2.8 Tubes à rayons cathodiques

Si un tube cathodique ayant une dimension maximale de face supérieure à 160 mm est à l'intérieur du matériel, le tube à rayons cathodiques ou l'ENVELOPPE avec le tube correctement installé doit être conforme aux exigences de l'Article 18 de la CEI 60065 concernant la résistance mécanique des tubes cathodiques.

NOTE L'Article 18 de la CEI 60065 exige que les tubes à rayons cathodiques passent avec succès les essais spécifiés en 18.1 ou soient conformes à la CEI 61965. Dans le futur amendement 2 à la CEI 60065:2001, envisagé pour 2006 au plus tôt, il est prévu que les tubes cathodiques à protection intrinsèque devront être conformes à la CEI 61965, sans option comme celle autorisée actuellement dans la septième édition. L'essai actuellement en 18.3 de la CEI 60065 continuera de s'appliquer aux tubes qui ne possèdent pas de protection intrinsèque qui ne font pas partie du Domaine d'application de la CEI 61965.

La vérification est effectuée par examen, par des mesures et, si nécessaire, par les exigences et les essais applicables de l'Article 18 de la CEI 60065.

4.2.9 Lampes à haute pression

L'ENVELOPPE MECANIQUE d'une lampe à haute pression doit avoir une résistance suffisante pour contenir une explosion de la lampe, de façon à empêcher tout dommage pour un OPERATEUR ou une personne placée près du matériel pendant son utilisation normale ou la maintenance par l'OPERATEUR.

Dans le cadre de la présente norme une «lampe à haute pression» signifie une lampe dans laquelle la pression dépasse 0,2 MPa à froid ou 0,4 MPa en fonctionnement.

La conformité est vérifiée par examen.

NOTE 2.10.3.5 peut également être appliqué dans certains cas.

4.2.10 Matériels fixés au mur ou au plafond

Les moyens de fixation du matériel prévu pour être fixé au mur ou au plafond doivent être adéquats.

La vérification est effectuée par examen de la construction et des données disponibles ou, lorsque c'est nécessaire, par l'essai suivant.

Le matériel est fixé conformément aux instructions du fabricant. En plus du poids du matériel, une force supplémentaire est appliquée vers le bas pendant 1 min à travers le centre de gravité du matériel. La force supplémentaire doit être égale à trois fois le poids du matériel mais pas moins de 50 N. Pendant l'essai, le matériel et ses moyens de fixations associés ne doivent pas se dissocier. A l'issue de cet essai, le matériel, y compris toute plaque de montage associée, ne doit pas être endommagé.

4.3 Conception et construction

4.3.1 Bords et coins

Lorsque les bords et les coins pourraient présenter un risque pour l'OPERATEUR à cause de leur emplacement ou de leur application dans le matériel, ils doivent être arrondis et rendus lisses.

Cette exigence ne s'applique pas aux bords et coins nécessaires au bon fonctionnement du matériel.

La conformité est vérifiée par examen.

4.3.2 Poignées et organes de contrôle manuels

Les poignées, les boutons, les manettes, les leviers et les organes analogues doivent être fixés de façon sûre de sorte qu'ils ne se desserrent pas en usage normal si cela peut créer un danger. Les matières de remplissage et les matières analogues autres que les résines durcissant à l'air ne doivent pas être utilisées pour éviter le desserrage.

Si les poignées, les boutons et les organes analogues sont utilisés pour indiquer la position des interrupteurs ou de composants analogues, ils ne doivent pas pouvoir être montés dans une position incorrecte si cela peut créer un danger.

La vérification est effectuée par examen, par un essai à la main et en essayant d'enlever la poignée, le bouton, la manette ou le levier par application pendant 1 min d'une force axiale comme indiqué ci-dessous.

Si la forme de ces parties est telle qu'il est improbable qu'un effort de traction axial soit appliqué en usage normal, la force est de:

- *15 N pour les organes de manœuvre des composants électriques; et*
- *20 N dans les autres cas.*

Si la forme est telle qu'un effort de traction axial est susceptible d'être appliqué, la force est de:

- *30 N pour les organes de manœuvre des composants électriques; et*
- *50 N dans les autres cas.*

4.3.3 Dispositifs de commande réglables

Le matériel doit être construit de façon que le réglage manuel d'un dispositif de contrôle, comme le dispositif de sélection des différentes tensions du RESEAU D'ALIMENTATION EN COURANT ALTERNATIF, nécessite l'aide d'un OUTIL si un danger peut résulter d'un mauvais réglage involontaire.

NOTE Les exigences de marquage pour le réglage de la tension d'alimentation sont en 1.7.4.

La vérification est effectuée par un essai à la main.

4.3.4 Fixation des composants

Les vis, les écrous, les rondelles, les ressorts ou les pièces analogues doivent être fixés de façon fiable pour résister aux contraintes mécaniques apparaissant lors d'un usage normal, si leur détachement ou leur desserrement risque de créer un danger ou si les LIGNES DE FUITE ou les DISTANCES DANS L'AIR pour l'ISOLATION SUPPLEMENTAIRE ou l'ISOLATION RENFORCEE risquent d'être réduites en dessous des valeurs spécifiées en 2.10 (ou à l'Annexe G).

NOTE 1 Les exigences concernant les fixations des conducteurs sont en 3.1.9.

La vérification est effectuée par examen, par des mesures et par un essai à la main.

Pour la vérification de la conformité:

– *il est supposé que deux fixations indépendantes ne se desserreront pas simultanément; et*
– *il est supposé que les parties fixées au moyen de vis ou d'écrous avec des rondelles de blocage ou d'autres moyens de blocage ne sont pas susceptibles de se desserrer.*

NOTE 2 Les rondelles à ressort ou équivalent peuvent fournir un blocage satisfaisant.

4.3.5 Connexion des fiches et des socles

A l'intérieur d'une unité ou d'un système du fabricant, les fiches et les socles susceptibles d'être manipulés par l'OPERATEUR ou le PERSONNEL DE MAINTENANCE ne doivent pas être utilisés d'une manière susceptible de créer un danger par suite d'une mauvaise connexion. En particulier, les connecteurs satisfaisant à la CEI 60083 ou à la CEI 60320 ne doivent pas être utilisés dans des CIRCUITS TBTS ou des CIRCUITS TRT. Sont considérés comme satisfaisant à cette exigence le clavetage, l'emplacement ou, dans le cas de connecteurs accessibles uniquement au PERSONNEL DE MAINTENANCE, un marquage en clair.

La conformité est vérifiée par examen.

4.3.6 Matériels enfichables directement

Les MATERIELS ENFICHABLES DIRECTEMENT ne doivent pas imposer une contrainte excessive au socle de prise de courant. La partie fiche doit satisfaire à la norme pour les fiches concernées.

La vérification est effectuée par examen et, en cas de doute, par l'essai suivant.

Le matériel est introduit, comme en usage normal, dans un socle du type prévu par le fabricant, qui peut pivoter autour d'un axe horizontal coupant les axes des alvéoles à une distance de 8 mm en arrière de la surface d'engagement du socle. Le couple de torsion supplémentaire qui est appliqué au socle pour maintenir la surface d'engagement dans le plan vertical ne doit pas dépasser 0,25 N·m.

NOTE 1 En Australie et en Nouvelle-Zélande, la conformité est vérifiée conformément à l'AS/NZS 3112.

NOTE 2 Au Royaume-Uni, l'essai de couple est réalisé en utilisant un socle conforme à la BS 1363 et la partie fiche du MATERIEL ENFICHABLE DIRECTEMENT doit être évaluée selon les articles appropriés de la BS 1363.

4.3.7 Eléments chauffants dans un matériel mis à la terre

Les éléments chauffants dans un matériel qui est mis à la terre pour des raisons de sécurité doivent être protégés de façon que, dans les conditions de défaut de terre, il ne puisse y avoir un danger d'incendie par élévation excessive de température. Dans de tels matériels, les dispositifs thermosensibles, s'ils sont fournis, doivent être placés dans tous les conducteurs de phase alimentant les éléments chauffants.

Les dispositifs thermosensibles doivent aussi couper le conducteur de neutre pour chacun des cas suivants:

a) sur le matériel alimenté à partir d'un schéma d'alimentation IT;

b) sur le MATERIEL RACCORDE PAR PRISE DE COURANT alimenté par un connecteur ou par une fiche de prise de courant réversible;

c) sur le matériel alimenté au travers d'un socle de polarité indéterminée.

Dans les cas b) et c), il est permis de satisfaire à cette exigence en connectant un THERMOSTAT dans un conducteur et un COUPE-CIRCUIT THERMIQUE dans l'autre conducteur.

Il n'est pas exigé de déconnecter tous les conducteurs simultanément.

La conformité est vérifiée par examen.

4.3.8 Piles ou batteries

NOTE 1 Les exigences concernant les marquages et les instructions sont données en 1.7.13.

NOTE 2 Les exigences pour la protection contre les surintensités sont données en 3.1.1 et en 5.3.1.

NOTE 3 Les exigences pour les batteries stationnaires (comme les batteries d'accumulateurs de grande taille installées dans une installation fixe à l'extérieur du matériel) sont données dans la CEI 60896-21, la CEI 60896-22 et la EN 50272-2.

Les accumulateurs alcalins ou autres accumulateurs à électrolyte non acide, potables, étanches (autres que boutons) doivent être conformes à la CEI 62133.

Les matériels utilisant des piles ou des batteries doivent être conçus pour réduire le risque d'incendie et d'explosion et de fuites chimiques, dans des conditions d'utilisation normale et après un premier défaut dans le matériel (voir 1.4.14)~~, y compris dans les circuits intégrés à la pile~~. Pour les piles remplaçables par l'UTILISATEUR, la conception doit réduire la probabilité d'installation en polarité inverse si cela risque de créer un danger.

Les circuits de la pile ou de la batterie doivent être conçus de façon que:

– les caractéristiques de sorties du circuit de recharge soient compatibles avec celles de la batterie rechargeable; et
– pour les piles non rechargeables, la décharge à un taux supérieur aux recommandations du fabricant et la charge non intentionnelle soient impossibles; et
– pour les batteries rechargeables, la charge et la décharge à un taux excédant les recommandations du fabricant et la charge en polarité inverse soient impossibles; et
– les batteries remplaçables par l'OPERATEUR doivent soit:
  - avoir des contacts qui ne puissent pas être court-circuités par le doigt d'épreuve de la Figure 2A, soit
  - être protégées de manière intrinsèque pour éviter de créer un danger au sens de la présente norme.

NOTE 4 La charge en polarité inverse d'une batterie rechargeable apparaît quand la polarité du circuit de recharge est inversée pour aider la décharge de la batterie.

Si une batterie contient un électrolyte liquide ou sous forme de gel, un coffre de batterie doit être prévu qui soit capable d'empêcher toute fuite de liquide à la suite de la formation d'une pression interne dans la batterie. Cette exigence de coffre de batterie ne s'applique pas si la construction de la batterie est telle qu'une fuite de l'électrolyte est improbable (voir aussi 1.3.6).

NOTE 5 Le type de batterie scellé à régulation par soupape est un exemple de construction de batterie pour lequel la fuite de l'électrolyte est considérée comme improbable.

Si un coffre de batterie est exigé, sa capacité doit être égale au moins au volume de l'électrolyte de tous les éléments de la batterie ou au volume d'un seul élément si la conception de la batterie est telle que la fuite simultanée de plusieurs éléments est improbable.

NOTE 6 Si plusieurs éléments (par exemple les six éléments d'une batterie plomb-acide de 12 V) se trouvent dans un seul boîtier, une rupture de celui-ci pourrait conduire à un volume de suite supérieur à celui d'un seul élément.

La vérification est effectuée par examen de la construction et des données fournies par le fabricant du matériel et le fabricant de la pile ou de la batterie.

Lorsque les données appropriées ne sont pas disponibles, la vérification est effectuée par des essais. Toutefois, les batteries qui sont intrinsèquement sûres pour les conditions données ne sont pas essayées dans ces conditions. Les piles ordinaires carbone-zinc ou alcalines non rechargeables sont considérées sûres dans les conditions de court-circuit et ne sont donc pas essayées pour les décharges, pas plus qu'elles ne le sont pour les fuites dans les conditions de stockage.

La pile utilisée pour les essais suivants est soit une nouvelle pile non rechargeable soit une batterie complètement rechargée fournie avec le matériel ou recommandée par le fabricant pour l'utilisation avec le matériel.

– ~~***Surcharge d'une batterie rechargeable**. La batterie est rechargée dans l'une des conditions suivantes tour à tour.*~~

  - ~~*Le circuit de charge de batterie est réglé avec la batterie déconnectée pour donner 106 % de la tension assignée de sortie du chargeur ou la tension de charge maximale du chargeur (sans simulation de défauts), en fonction de la valeur le plus forte qui peut être atteinte. La batterie est ensuite chargée pendant 7 h.*~~

  - ~~*Le circuit de charge de batterie est réglé avec la batterie déconnectée pour donner 100 % de la tension assignée de sortie du chargeur. La batterie est chargée tout en étant brièvement soumise à la simulation d'un premier défaut sur un composant qui pourrait survenir dans le circuit de charge et qui donnerait lieu à une surcharge de la batterie. Pour réduire la durée d'essai, la défaillance est choisie de manière à causer le courant de surcharge le plus élevé. La batterie est ensuite chargée pendant une durée unique de 7 h avec le défaut simulé en place.*~~

– ***Surcharge d'une batterie rechargeable**. La batterie est chargée tout en étant brièvement soumise à la simulation d'une CONDITION DE PREMIER DEFAUT qui est susceptible de survenir dans le circuit de charge et qui donne lieu à une surcharge de la batterie. Pour réduire au maximum la durée d'essai, la défaillance est choisie de manière à causer la condition de surcharge la plus défavorable. La batterie est ensuite chargée pendant une durée unique de 7 h avec la défaillance simulée en place.*

– ***Charge non intentionnelle d'une batterie non rechargeable**. La batterie est chargée tout en étant brièvement soumise à la simulation d'un premier défaut sur un composant qui pourrait survenir dans le circuit de charge et qui donnerait lieu à un chargement non intentionnel de la batterie. Pour réduire la durée d'essai, la défaillance est choisie de manière à causer le courant de charge le plus élevé. La batterie est ensuite chargée pendant une durée unique de 7 h avec le défaut simulé en place.*

– ***Charge en polarité inverse d'une batterie rechargeable**. La batterie est chargée en polarité inverse tout en étant brièvement soumise à la simulation d'un premier défaut sur un composant qui pourrait survenir dans le circuit de charge et qui donnerait lieu à un chargement en polarité inverse de la batterie. Pour réduire la durée d'essai, la défaillance est choisie de manière à causer le courant de charge en polarité inverse le plus élevé. La batterie est ensuite chargée en polarité inverse pendant une durée unique de 7 h avec le défaut simulé en place.*

– ***Vitesse de déchargement excessive d'une batterie**. La batterie est soumise à une décharge en créant un défaut de circuit ouvert ou un court-circuit à un dispositif de limitation de courant ou de limitation de tension dans le circuit de charge de la pile à l'essai.*

NOTE 7 Certains essais spécifiés peuvent être dangereux pour le personnel les effectuant. Il convient de prendre toutes les mesures appropriées de protection contre des dangers chimiques ou d'explosion.

Ces essais ne doivent pas avoir comme résultat une des conséquences suivantes:

– *des fuites chimiques provoquées par des fissures, des ruptures ou l'éclatement de l'enveloppe de la pile, si de telles fuites risquent d'altérer l'isolation prescrite; ou*
– *un débordement de liquide dû à un dispositif de réduction de la pression à l'intérieur de la batterie sauf si ce débordement est contenu par le matériel sans risque de dommage pour l'isolation ou pour l'UTILISATEUR; ou*
– *l'explosion de la pile si une telle explosion risque de blesser un UTILISATEUR; ou*
– *l'émission de flammes ou l'expulsion de métal fondu vers l'extérieur de l'ENVELOPPE du matériel.*

A l'issue des essais, le matériel est soumis aux essais de rigidité diélectrique de 5.3.9.2.

4.3.9 Huiles et graisses

Lorsque les conducteurs internes, les enroulements, les collecteurs, les bagues et les organes analogues, et l'isolation en général, sont exposés à l'huile, à la graisse ou à des substances similaires, l'isolation doit avoir des propriétés adéquates pour résister à la détérioration dans ces conditions.

La vérification est effectuée par examen et par évaluation des données pour le matériau isolant.

4.3.10 Poussière, poudres, liquides et gaz

Les matériels produisant de la poussière (par exemple de la poussière de papier) ou utilisant des poudres, des liquides ou des gaz doivent être construits de telle façon qu'il soit improbable qu'il y ait une concentration dangereuse de ces matières et qu'un danger au sens de la présente norme soit créé par la condensation, la vaporisation, les fuites, le débordement ou la corrosion pendant le fonctionnement normal, le stockage, le remplissage ou la vidange. Les DISTANCES DANS L'AIR et les LIGNES DE FUITE ne doivent pas être réduites au-dessous des valeurs spécifiées en 2.10 (ou à l'Annexe G).

La vérification est effectuée par examen, par des mesures et, lorsque le débordement de liquides pourrait affecter l'isolation électrique pendant le remplissage, par l'essai suivant et, pour les liquides inflammables, par les essais de 4.3.12.

Les matériels doivent être prêts à être utilisés suivant les instructions d'installation, mais ils ne doivent pas être mis sous tension.

Le réservoir du matériel est complètement rempli du liquide spécifié par le fabricant et une quantité supplémentaire, égale à 15 % de la capacité du récipient, est versée graduellement en 1 min. Pour les réservoirs dont la capacité ne dépasse pas 250 ml et pour les réservoirs sans évacuation et pour lesquels il n'est pas possible d'observer le remplissage de l'extérieur, une quantité supplémentaire de liquide égale à la capacité du réservoir est versée graduellement en 1 min.

Immédiatement après cette épreuve, le matériel doit satisfaire à un essai de rigidité diélectrique comme spécifié en 5.2.2 sur toute isolation sur laquelle un débordement aurait pu se produire et l'examen doit montrer que le liquide n'a pas créé de danger dans le sens de la présente norme.

Il est permis de placer le matériel pendant 24 h dans une atmosphère normale de salle d'essais avant de subir un nouvel essai diélectrique.

4.3.11 Réservoirs de liquides ou de gaz

Les matériels qui, en usage normal, contiennent un liquide ou un gaz doivent comporter des dispositions de sécurité appropriées contre l'apparition d'une pression excessive.

La vérification est effectuée par examen et, si nécessaire, par un essai approprié.

4.3.12 Liquides inflammables

Si un liquide inflammable est utilisé dans le matériel, le liquide doit être gardé dans un réservoir fermé sauf la quantité nécessaire pour le fonctionnement du matériel. La quantité maximale de liquide inflammable stockée dans un matériel ne doit pas en général être supérieure à 5 l. Toutefois, si la consommation de liquide est telle que plus de 5 l sont consommés en 8 h, il est permis d'augmenter la quantité stockée jusqu'à celle qui est nécessaire pour un fonctionnement de 8 h.

L'huile ou les fluides équivalents utilisés pour la lubrification ou dans un système hydraulique doivent avoir un point d'éclair au moins égal à 149 °C et leur réservoir doit être de construction hermétique. Le circuit doit être prévu pour permettre l'expansion du fluide et doit comporter des dispositifs pour la réduction de la pression. Cette exigence n'est pas applicable aux huiles de lubrification qui sont appliquées à des points de frottement en quantités qui ne constituent qu'un apport négligeable de combustible dans un incendie.

A l'exception des cas indiqués ci-dessous, les liquides qu'il faut recharger tels que les encres d'imprimerie doivent avoir un point d'éclair au moins égal à 60 °C, et ne doivent pas être soumis à une pression suffisante pour provoquer leur pulvérisation.

Il est permis d'utiliser des liquides inflammables qu'il faut recharger et qui ont un point d'éclair inférieur à 60 °C ou qui sont soumis à une pression suffisante pour provoquer leur pulvérisation, pourvu qu'un examen montre qu'il n'y a pas de risque de pulvérisations de liquide ou de formation de mélanges vapeur-air inflammables qui pourraient provoquer une explosion ou un risque d'incendie. Dans les conditions de fonctionnement normal, les matériels utilisant des liquides inflammables ne doivent produire aucun mélange vapeur-air avec une concentration dépassant un quart de la LIMITE D'EXPLOSION si le mélange est à proximité d'une source d'inflammation, ou la moitié de la LIMITE D'EXPLOSION si le mélange n'est pas à proximité d'une source d'inflammation. L'examen doit également prendre en compte l'intégrité du système de manutention du liquide. Le système de manutention du liquide doit être convenablement logé ou construit de façon à réduire le risque de feu ou d'explosion, même dans les conditions d'essai énumérées en 4.2.5.

La vérification est effectuée par examen et, si nécessaire, par l'essai suivant.

Le matériel est mis en fonctionnement conformément à 4.5.2 jusqu'à la stabilisation de sa température. Dans cette condition, le matériel est mis en fonctionnement d'une manière normale comme indiqué dans les instructions d'utilisation, et des échantillons de l'atmosphère au voisinage des composants électriques et autour du matériel sont prélevés pour permettre de déterminer la concentration de vapeurs inflammables présentes.

Les échantillons de l'atmosphère sont prélevés par intervalles de 4 min: quatre échantillons à prélever pendant le fonctionnement normal, puis sept échantillons après l'arrêt du matériel.

Si, après l'arrêt du matériel, il apparaît que la concentration de vapeurs inflammables est en train d'augmenter, on doit continuer à faire des prélèvements à des intervalles de 4 min jusqu'à ce que les résultats montrent que la concentration va en décroissant.

S'il est possible que le matériel fonctionne de façon anormale avec l'un quelconque de ses ventilateurs arrêté, cette condition est simulée pendant l'essai de conformité.

4.3.13 Rayonnements

4.3.13.1 Généralités

Les matériels doivent être conçus de façon que les risques d'effets nuisibles des rayonnements sur les personnes et de dommages aux matériaux affectant la sécurité soient réduits.

La vérification est effectuée par examen et comme détaillé en 4.3.13.2, 4.13.13.3, 4.3.13.4, 4.3.15.5 et 4.3.13.6, selon ce qui est approprié.

4.3.13.2 Rayonnements ionisants

Pour les matériels produisant des rayonnements ionisants, la vérification de la conformité est effectuée par l'essai décrit à l'Annexe H.

4.3.13.3 Effets des rayonnements ultraviolets (UV) sur les matériels

Les exigences suivantes s'appliquent seulement aux matériels contenant des lampes qui produisent un rayonnement UV significatif, c'est-à-dire ayant une émission prédominante dans le spectre de 180 nm à 400 nm, suivant la spécification du fabricant de lampes.

NOTE Les lampes incandescentes et fluorescentes d'utilisation générale, avec des ENVELOPPES en verre ordinaire, ne sont pas considérées comme émettant un rayonnement UV significatif. Une lampe qui a des UV dans le spectre de 180 nm à 400 nm comme émission de rayonnement prédominante (telle que spécifiée par le fabricant de la lampe), et émet un éclairement énergétique de plus de 0,001 W/m^2, est considérée produire un rayonnement « significatif ».

Les pièces non métalliques (par exemple des ENVELOPPES non métalliques et des matériaux internes dont les isolants des fils et câbles) qui sont exposées aux rayonnements UV d'une lampe dans le matériel doivent être suffisamment résistantes à la dégradation pour ne pas affecter la sécurité.

Tableau 4A – Limites minimales de rétention des propriétés après exposition UV

Pièces à soumettre à l'essai	Propriété	Norme à appliquer pour la méthode d'essai	Rétention minimale après essai
Pièces fournissant un support mécanique	Résistance à la traction [a] ou Résistance à la flexion [a] [b]	ISO 527	70 %
		ISO 178	70 %
Pièces fournissant une résistance aux chocs	Choc de Charpy [c] ou Choc Izod [c] ou Choc de traction [c]	ISO 179	70 %
		ISO 180	70 %
		ISO 8256	70 %
Toutes les pièces	Classification d'inflammabilité	Voir 1.2.12 et Annexe A	Voir [d]

[a] Les essais de résistance à la traction et de résistance à la flexion sont effectués sur des échantillons dont l'épaisseur n'est pas supérieure à l'épaisseur réelle.

[b] La face des échantillons exposés au rayonnement UV doit être en contact avec les deux points de charge quand on utilise la méthode aux trois points de charge.

[c] Les essais sont effectués sur des échantillons de 3,0 mm d'épaisseur pour l'essai de choc Izod et sur des échantillons de 4,0 mm d'épaisseur pour l'essai au choc de Charpy. Ils sont considérés comme représentatifs d'autres épaisseurs, descendant jusqu'à 0,8 mm.

[d] La classification vis-à-vis de l'inflammabilité peut changer tant qu'elle ne tombe pas en dessous de ce qui est spécifié à l'Article 4.

La vérification est effectuée par examen de la construction et des données disponibles concernant les caractéristiques de la résistance au rayonnement UV des pièces exposées au rayonnement UV dans le matériel. Si de telles données ne sont pas disponibles, les essais du Tableau 4A sont effectués sur ces pièces.

Les échantillons prélevés sur les pièces, ou constitués d'un matériau identique, sont préparés en conformité avec la norme pour l'essai à effectuer. Ils sont alors conditionnés selon l'Annexe Y. Après conditionnement, les échantillons ne doivent pas montrer de signes d'une détérioration significative, telles des craquelures ou des fissures. Ils sont alors maintenus dans les conditions de température ambiante de la pièce pendant au moins 16 h et pas plus de 96 h, après quoi ils sont soumis à l'essai applicable, en conformité avec la norme qui définit cet essai.

De manière à évaluer le pourcentage de rétention des propriétés après essai, les échantillons qui n'ont pas été conditionnés selon l'Annexe Y sont soumis aux essais en même temps que les échantillons conditionnés. La rétention doit être telle que spécifié dans le Tableau 4A.

4.3.13.4 Exposition du corps humain au rayonnement ultraviolet (UV)

Les exigences suivantes s'appliquent seulement aux matériels contenant des lampes qui produisent un rayonnement UV significatif, c'est-à-dire ayant une émission prédominante dans le spectre de 180 nm à 400 nm, suivant la spécification du fabricant de lampes.

NOTE 1 Les lampes incandescentes et fluorescentes d'utilisation générale, avec des enveloppes en verre ordinaire ne sont pas considérées comme émettant un rayonnement UV significatif. Une lampe qui a des UV dans le spectre de 180 nm à 400 nm comme émission de rayonnement prédominante (telle que spécifiée par le fabricant de la lampe), et émet un éclairement énergétique de plus de 0,001 W/m^2, est considérée produire un rayonnement « significatif ».

Un matériel qui produit une combinaison de lumière visible et ultraviolette qui est seulement émise à travers une lentille de mise au point en verre ayant un affaiblissement des UV de 90 % jusqu'à 400 nm est exempté s'il n'y a pas d'autres ouvertures par lesquelles le rayonnement visible est émis.

NOTE 2 Le verre d'épaisseur 2 mm satisfait en général à cette exigence.

Les matériels ne doivent pas émettre un rayonnement UV excessif.

Le rayonnement UV doit, soit

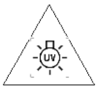
– être contenu de façon adéquate par l'ENVELOPPE de la lampe UV ou par l'ENVELOPPE du matériel, soit
– ne pas dépasser les limites applicables de la CEI 60825-9.

En fonctionnement normal, la limite applicable est celle qui s'applique à une exposition de 8 h.

Des limites plus élevées sont permises pour des périodes de temps limitées destinées à des opérations de maintenance et de nettoyage, s'il est nécessaire que la lampe UV fonctionne pendant ces opérations. Les limites applicables sont celles des durées prévues pour ces opérations, qui doivent être indiquées dans les instructions pour l'UTILISATEUR et pour la maintenance.

Toutes les portes et tous les couvercles auxquels l'UTILISATEUR a accès qui, s'ils sont ouverts, permettraient l'accès à des émissions plus élevées que celles permises ci-dessus doivent être marqués avec l'un des avertissements suivants (voir également 1.7.12):

– "ATTENTION: COUPER LA LAMPE UV AVANT D'OUVRIR", ou équivalent; ou

– le symbole  ou équivalent.

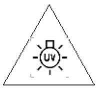
Il est permis que le symbole donné ci-dessus soit placé à côté d'une porte ou d'un couvercle ou sur une porte sous réserve que la porte soit fixée au matériel.

L'avertissement ci-dessus n'est pas requis pour une porte ou un couvercle équipé d'un VERROUILLAGE DE SECURITE à interrupteur (voir 2.8) interrompant l'alimentation de la lampe UV lorsque la porte ou le couvercle est ouvert, ou tout autre mécanisme qui empêche le rayonnement UV.

Si le symbole de rayonnement UV est utilisé sur le matériel, le symbole et un texte d'avertissement similaire à celui indiqué ci-dessus doivent également figurer tous les deux dans les instructions pour l'UTILISATEUR et pour la maintenance.

Si des émissions plus élevées que celles permises ci-dessus sont accessibles dans une ZONE D'ACCES POUR LA MAINTENANCE, et s'il est nécessaire que le matériel reste alimenté pendant la maintenance, le matériel doit être marqué avec l'un des avertissements suivants:

– "ATTENTION: UTILISER DES PROTECTIONS CONTRE LES UV POUR LES YEUX ET LA PEAU PENDANT LA MAINTENANCE", ou équivalent; ou

– le symbole  ou équivalent.

Le marquage doit être placé de façon à être facilement visible pendant l'opération de maintenance (voir également 1.7.12).

Si le symbole de rayonnement UV est utilisé sur le matériel, à la fois le symbole et un texte d'avertissement similaire à celui indiqué ci-dessus doivent figurer dans les instructions de maintenance.

La vérification est effectuée par examen et, si nécessaire, par des mesures.

Le rayonnement UV est mesuré avec un spectrographe à balayage ou un détecteur spécifique ayant une réponse spectrale égale à l'efficacité spectrale relative pour la bande UV.

L'exposition au rayonnement UV et l'éclairement énergétique effectif pendant un fonctionnement normal ne doivent pas dépasser les limites données dans la CEI 60825-9 pour une exposition de 8 h.

L'exposition au rayonnement UV et l'éclairement énergétique effectif durant les opérations de maintenance et de nettoyage ne doivent pas dépasser les limites de la CEI 60825-9 correspondant aux temps d'exposition indiqués dans les instructions applicables pour ces opérations. Le rayonnement maximal permis est celui qui s'applique pour 30 min d'exposition.

NOTE ~~2~~ 3 Le rayonnement permis est augmenté en fonction de la réduction du temps d'exposition.

Toutes les portes et les couvercles auxquels l'UTILISATEUR a accès, et les pièces telles que les lentilles, filtres et équivalents, si leur ouverture ou enlèvement peut provoquer une augmentation du rayonnement UV, doivent être ouverts ou enlevés pendant les mesures, à moins qu'ils ne soient équipés d'un VERROUILLAGE DE SECURITE à interrupteur interrompant l'alimentation de la lampe UV, ou tout autre mécanisme qui empêche le rayonnement UV.

NOTE ~~3~~ 4 Pour des informations sur les techniques de mesure, voir la Publication 63 de la CIE.

4.3.13.5 Lasers (y compris les diodes ~~électroluminescentes (DEL)~~ laser) et DEL

4.3.13.5.1 Lasers (y compris les diodes laser)

A l'exception de ce qui est permis ci-dessous, les matériels doivent être classifiés et ~~munis d'une étiquette conforme~~ étiquetés conformément à la CEI 60825-1, à la CEI 60825-2 et à la CEI 60825-12, selon ~~ce qui est~~ la cas applicable.

Un ~~équipement~~ matériel qui est par nature un appareil à laser de classe I, c'est-à-dire un ~~équipement~~ matériel ne contenant pas de laser ou de diode ~~électroluminescente (DEL)~~ laser de classe supérieure, n'a pas besoin d'avoir une étiquette d'avertissement ou autre indication propre aux lasers.

Les données pour les lasers ou les ~~DEL~~ diodes laser doivent confirmer que ces composants sont conformes à la Limite d'Emission Accessible (LEA) pour la classe I, mesurée suivant la CEI 60825-1, pour que les exceptions ci-dessus s'appliquent. Les données peuvent être obtenues du fabricant de composants (voir 1.4.15) et peuvent traiter du composant seul ou du composant dans l'application à laquelle il est destiné dans les matériels. Les lasers ou les ~~DEL~~ diodes laser doivent produire des rayonnements uniquement dans la bande de 180 nm à 1 mm.

La ~~vérification est effectuée~~ conformité est vérifiée par examen, par évaluation des données fournies par le fabricant et, si nécessaire, par des essais ~~en conformité avec~~ selon la CEI 60825-1

4.3.13.5.2 Diodes électroluminescentes (DEL)

Le matériel contenant des DEL qui produisent des rayonnements optiques dépassant les limites spécifiées dans la CEI 62471 dans la bande de 200 nm à 3 000 nm, tels que spécifiés par le fabricant de lampe, doit être pourvu de moyens (tels qu'un interverrouillage, des barrières, dispositifs de protection ou l'équivalent) pour réduire la probabilité d'apparition dans les zones accessibles à l'UTILISATEUR d'un rayonnement optique dépassant les limites spécifiées dans la CEI 62471. Il n'est pas nécessaire que les applications à faible puissance des DEL soient conformes à la CEI 62471.

NOTE 1 Des exemples d'applications à faible puissance des DEL qui seront normalement conformes, sont les applications dans lesquelles les DEL sont utilisées comme:

- voyants lumineux;
- dispositifs infrarouges tels que ceux utilisés dans les appareils domestiques de divertissement;
- dispositifs infrarouges pour la transmission de données, tels que ceux qui sont utilisés entre ordinateurs et périphériques;
- optocoupleurs; et
- autres dispositifs similaires de faible puissance.

La conformité est vérifiée par évaluation des fiches techniques de données disponibles et, si nécessaire, par des mesures.

NOTE 2 Pour un guide sur les techniques de mesure, voir la CEI 62471.

NOTE 3 Si le rayonnement optique est visible en bande large et si le rayonnement IR-A et la luminance de la source ne dépassent pas 10^4 cd/m^2, il est prévu que le rayonnement ne dépasse pas les limites d'exposition données en 4.3 de la CEI 62471:2006 (voir 4.1 de la CEI 62471:2006).

4.3.13.6 Autres types

Pour les autres types de rayonnement, la vérification est effectuée par examen.

4.4 Protection contre les parties mobiles dangereuses

4.4.1 Généralités

A l'exception des pales de ventilateurs mobiles, les parties mobiles dangereuses des matériels, c'est-à-dire les parties mobiles qui peuvent potentiellement entraîner une blessure, doivent être disposées, enfermées ou protégées de façon à réduire le risque de blessure sur les personnes. Les pales de ventilateurs mobiles sont évaluées conformément à 4.4.5.

Des COUPE-CIRCUIT THERMIQUES A REENCLENCHEMENT AUTOMATIQUE ou des dispositifs de protection contre les surintensités, des interrupteurs chronométriques à démarrage automatique, etc. ne doivent pas être incorporés si leur remise à zéro intempestive risque de créer un danger.

La vérification est effectuée par examen et comme détaillé en 4.4.2, 4.4.3 et 4.4.4.

4.4.2 Protection dans la zone d'accès de l'opérateur

Dans une ZONE D'ACCES DE L'OPERATEUR, la protection doit être assurée par une construction appropriée afin de réduire le risque d'accès aux parties mobiles dangereuses ou par une localisation des parties mobiles dans une ENVELOPPE pourvue d'un VERROUILLAGE DE SECURITE mécanique ou électrique qui supprime le danger lorsque l'accès a lieu. LES DECHIQUETEUSES DE DOCUMENTS/SUPPORTS A USAGE DOMESTIQUE ET DE BUREAU/MAISON doivent aussi être conformes à l'Annexe EE.

Lorsqu'il n'est pas possible de satisfaire entièrement aux exigences sur les accès ci-dessus tout en permettant au matériel de fonctionner comme prévu, l'accès est permis pourvu que:

– la partie mobile dangereuse en question soit impliquée directement dans la fonction du matériel (par exemple les parties mobiles d'une machine à détruire les documents); et
– le danger associé à cette partie soit évident pour l'OPERATEUR; et
– les mesures supplémentaires soient prises comme suit:
  - une indication doit être fournie dans la notice d'utilisation et un marquage doit être fixé sur le matériel, chacun contenant le texte suivant ou un texte similaire approprié:

ATTENTION
PARTIES MOBILES DANGEREUSES
TENIR LES DOIGTS ET LES AUTRES PARTIES DU CORPS ÉLOIGNÉS

  - lorsque les doigts, les bijoux, les vêtements, etc. peuvent être happés par les parties mobiles, un moyen d'arrêter cette partie mobile doit être fourni à l'OPERATEUR.

L'avertissement ci-dessus et le moyen d'arrêter la partie mobile, s'il existe, doivent être placés à un endroit en vue, rapidement visible et accessible à partir de l'endroit où le risque de blessure est le plus grand.

La vérification est effectuée par examen et, lorsque c'est nécessaire, par un essai avec le doigt d'épreuve de la Figure 2A (voir 2.1.1.1), après enlèvement des parties détachables par l'OPERATEUR, et avec ouverture des portes et couvercles accessibles à l'OPÉRATEUR.

A moins que des mesures supplémentaires n'aient été prises comme spécifié ci-dessus, il ne doit pas être possible de toucher les parties mobiles dangereuses avec le doigt d'épreuve appliqué sans force appréciable dans toutes les positions possibles.

Les ouvertures ne permettant pas l'entrée du doigt d'épreuve de la Figure 2A (voir 2.1.1.1) sont, de plus, essayées au moyen d'un doigt d'épreuve de mêmes dimensions mais droit et sans jointures avec une force de 30 N. Si ce dernier doigt d'épreuve pénètre, l'essai avec le *doigt d'épreuve de la Figure 2A (voir 2.1.1.1) est répété, le doigt étant enfoncé dans l'ouverture avec toute la force nécessaire, mais sans dépasser 30 N.*

4.4.3 Protection dans un emplacement à accès restreint

Pour les matériels prévus pour être installés dans un EMPLACEMENT A ACCES RESTREINT, les exigences et les critères de conformité de 4.4.2 pour les ZONES ACCES DE L'OPERATEUR s'appliquent.

4.4.4 Protection dans une zone d'accès pour la maintenance

Dans une ZONE D'ACCES POUR LA MAINTENANCE, il doit y avoir une protection afin de réduire le risque de contact non intentionnel avec des parties mobiles dangereuses lors des opérations de maintenance impliquant d'autres parties du matériel.

La conformité est vérifiée par examen.

4.4.5 Protection contre les pales de ventilateurs mobiles

4.4.5.1 Généralités

Le matériel doit avoir été construit de façon à réduire au maximum le risque de blessures occasionnées par les pales de ventilateurs mobiles.

La vraisemblance de blessure occasionnée par les pales de ventilateurs mobiles est déterminée en calculant le facteur K pour chaque pale de ventilateur, lequel facteur K est égal à:

$$K = 6 \times 10^{-7} (m\, r^2 N^2)$$

où

m est la masse (kg) de la partie mobile de l'ensemble ventilateur (pale, arbre et rotor);

r est le rayon (mm) de la pale de ventilateur à partir de l'axe médian du moteur (arbre) jusqu'à l'extrémité de la zone extérieure susceptible d'être touchée;

N est la vitesse de rotation (tr/min) de la pale de ventilateur.

La classification des pales de ventilateurs mobiles selon leur capacité à occasionner des blessures est comme suit:

a) une pale de ventilateur mobile n'est pas considérée susceptible d'occasionner des douleurs ou des blessures si

$$\frac{r\,/\mathrm{min}}{15\,000} + \frac{K\ \mathrm{factor}}{2\,400} \le 1$$

b) une pale de ventilateur mobile est considérée susceptible d'occasionner des douleurs mais n'est pas considérée susceptible d'occasionner des blessures si

$$\frac{r\,/\mathrm{min}}{22\,000} + \frac{K\ \mathrm{factor}}{3\,600} \le 1$$

c) une pale de ventilateur mobile qui ne satisfait pas à a) ou à b) ci-dessus est considérée susceptible d'occasionner des blessures.

4.4.5.2 Protection pour les utilisateurs

Une pale de ventilateur mobile classée selon 4.4.5.1 a) peut être placée dans une ZONE D'ACCES DE L'OPERATEUR. Dans une condition de premier défaut, une pale de ventilateur mobile classée selon 4.4.5.1 a) peut atteindre les limites autorisées pour une pale de ventilateur mobile classée selon 4.4.5.1 b).

Une pale de ventilateur mobile classée selon 4.4.5.1 b) ne doit pas être située dans une ZONE D'ACCES DE L'OPERATEUR au cours du fonctionnement normal. Dans une condition de premier défaut, une pale de ventilateur mobile classée selon 4.4.5.1 b) doit rester dans les limites de 4.4.5.1 b). Si une telle pale de ventilateur mobile est accessible uniquement au cours de la maintenance UTILISATEUR, un avertissement conforme à ce qui suit doit être fourni.

Soit le symbole , ou un symbole similaire combiné au signe d'avertissement en forme de triangle de l'ISO 3864-2, soit le libellé suivant ou un texte équivalent doit être utilisé.

AVERTISSEMENT Pièces mobiles dangereuses Se tenir éloigné des pales de ventilateurs mobiles

Une pale de ventilateur mobile classée selon 4.4.5.1 c) qui est disposée, située, enfermée ou protégée de façon à rendre improbable tout contact de l'UTILISATEUR avec des pièces mobiles au cours de la maintenance UTILISATEUR, doit être munie d'un avertissement tel que spécifié ci-dessus.

Dans les conditions de maintenance UTILISATEUR, où la protection du matériel contre l'accès à une pale de ventilateur mobile classée selon 4.4.5.1 b) ou 4.4.5.1 c) doit être neutralisée ou contournée pour exécuter la maintenance, une instruction doit être fournie pour déconnecter la source d'alimentation avant de neutraliser ou de contourner les moyens de protection du matériel et pour restaurer les moyens de protection du matériel avant de remettre l'alimentation électrique.

4.4.5.3 Protection pour le personnel de maintenance

Aucun plan de protection du matériel contre les pales de ventilateurs mobiles n'est requis pour la protection du PERSONNEL DE MAINTENANCE.

Au cours de la maintenance dans des zones où le PERSONNEL DE MAINTENANCE est susceptible de toucher par inadvertance une pale de ventilateur mobile classée selon 4.4.5.1 c), un marquage conforme à 4.4.5.2 doit être fourni pour identifier l'emplacement de la pale de ventilateur mobile, accompagné de toutes instructions nécessaires enjoignant au PERSONNEL DE MAINTENANCE d'éviter de toucher la pale de ventilateur mobile.

4.5 Exigences thermiques

4.5.1 Généralités

Le Paragraphe 4.5 spécifie les exigences prévues pour empêcher:

– les parties qui peuvent être touchées de dépasser certaines températures; et
– les composants, les parties, l'isolation et les matières plastiques de dépasser des températures qui pourraient dégrader les propriétés électriques, mécaniques ou autres propriétés lors d'une utilisation normale durant la vie entière du matériel.

On doit prendre en considération le fait que, à long terme, les propriétés électriques et mécaniques de certains matériaux isolants (voir 2.9.1) peuvent être détériorées (par exemple des plastifiants s'évaporant à des températures inférieures aux températures normales de ramollissement des matériaux).

Au cours des essais de 4.5.2, les amplificateurs audio sont mis en fonctionnement conformément au Paragraphe 4.2.4 de la CEI 60065.

4.5.2 Essais en température

Les matériaux utilisés dans les composants ou dans la fabrication du matériel doivent être sélectionnés de façon que, sous une CHARGE NORMALE, les températures ne dépassent pas des valeurs sûres au sens de la présente norme.

Les composants travaillant à haute température doivent être efficacement enveloppés ou isolés pour éviter les surchauffes des matériaux et composants avoisinants.

La vérification est effectuée par examen des données du matériau et par détermination et enregistrement des températures. Le matériel ou les parties du matériel sont mis en fonctionnement conformément à 1.4.5 sous la CHARGE NORMALE *jusqu'à la stabilisation de la température. Pour les limites de températures, voir 4.5.3 et 4.5.4.*

NOTE Voir aussi 1.4.4, 1.4.10, 1.4.12 et 1.4.13.

Il est permis d'essayer les composants et autres parties indépendamment sous réserve de respecter les conditions d'essai applicables au matériel.

Le matériel destiné à être encastré ou monté dans des baies, ou à être incorporé dans de plus grands équipements est essayé dans les conditions les plus défavorables, réelles ou simulées autorisées par les instructions d'installation.

La température de l'isolation électrique (autre que celle des enroulements, voir 1.4.13) dont la défaillance pourrait provoquer un danger est mesurée sur la surface de l'isolation en un point proche de la source de chaleur (voir note a du Tableau 4B). Pendant cet essai:

- *les* COUPE-CIRCUITS THERMIQUES *et les dispositifs de protection contre les surintensités ne doivent pas fonctionner;*
- *il est permis que les* THERMOSTATS *fonctionnent à condition qu'ils n'interrompent pas le fonctionnement normal du matériel;*
- *il est permis que les* LIMITEURS DE TEMPERATURE *fonctionnent;*
- *les matières de remplissage, si elles existent, ne doivent pas couler.*

4.5.3 Limites de température pour les matériaux

La température des matériaux et des composants ne doit pas dépasser les valeurs représentées au Tableau 4B.

Tableau 4B – Limites de température, matériaux et composants

Partie	Température maximale (T_{max}) °C
Isolations, y compris celles des enroulements: – en matériau de classe 105 (A) – en matériau de classe 120 (E) – en matériau de classe 130 (B) – en matériau de classe 155 (F) – en matériau de classe 180 (H) – en matériau de classe 200 – en matériau de classe 220 – en matériau de classe 250	 100 [a b c] 115 [a b c] 120 [a b c] 140 [a b c] 165 [a b c] 180 [a b] 200 [a b] 225 [a b]
Isolation en caoutchouc ou PVC des conducteurs internes et externes y compris les câbles d'alimentation: – sans marquage de température – avec marquage de température	 75 [d] Marquage de la température
Autre isolation thermoplastique	Voir [e]
Bornes, y compris les bornes de terre pour conducteurs externes de mise à la terre des MATERIELS FIXES à moins qu'elles ne soient munies d'un CABLE D'ALIMENTATION FIXE A DEMEURE	85
Parties en contact avec un liquide inflammable	Voir 4.3.12
Composants	Voir 1.5.1

[a] Si la température d'un enroulement est déterminée au moyen de thermocouples, ces valeurs sont réduites de 10 °C, sauf dans le cas

– d'un moteur, ou

– d'un enroulement avec thermocouples incorporés.

[b] Pour chaque matériau, on doit tenir compte des données de ce matériau afin de déterminer la température maximale appropriée.

[c] Les désignations A à H, attribuées précédemment dans la CEI 60085 aux classes thermiques 105 à 180, sont données entre parenthèses.

[d] En l'absence de marquage sur le fil, le marquage sur la bobine de fil ou la caractéristique de température assignée par le fabricant est considéré comme acceptable.

[e] En raison de leur grande variété, il n'est pas possible de spécifier des températures maximales autorisées pour les matériaux thermoplastiques. Ceux-ci doivent satisfaire aux essais spécifiés en 4.5.5.

4.5.4 Limites de température de contact

Les températures des parties accessibles dans les ZONES D'ACCES DE L'OPERATEUR ne doivent pas dépasser les valeurs représentées au Tableau 4C.

Tableau 4C – Limites de températures de contact

Parties situées dans les ZONES D'ACCES DE L'OPERATEUR	**Température maximale (T_{max}) °C**		
	Métal	**Verre, porcelaine et matière vitrifiée**	**Caoutchouc et matières plastiques** [b]
Poignées, boutons, manettes, etc., tenus ou touchés pendant de courtes périodes seulement	60	70	85
Poignées, boutons, manettes, etc., tenus de façon continue en usage normal	55	65	75
Surfaces extérieures du matériel qui peuvent être touchées [a]	70	80	95
Parties à l'intérieur du matériel qui peuvent être touchées [c]	70	80	95

[a] Les températures jusqu'à 100 °C sont autorisées sur les parties suivantes:

– zones sur la surface externe du matériel qui n'ont aucune dimension supérieure à 50 mm et qui ne sont pas susceptibles d'être touchées en utilisation normale, et

– une partie du matériel nécessitant de la chaleur pour la fonction prévue (par exemple une pelliculeuse de document), sous réserve que cette condition soit évidente pour l'UTILISATEUR. Un avertissement doit être marqué sur le matériel à un endroit en évidence près de la partie chaude.

L'avertissement doit être

- soit le symbole (IEC 60417-5041 (DB:2002-10)): 
- soit le libellé suivant ou un libellé similaire:

AVERTISSEMENT
SURFACE CHAUDE
NE PAS TOUCHER

[b] Pour chaque matériau, on doit tenir compte des données de ce matériau afin de déterminer la température maximale appropriée.

[c] Des températures dépassant les limites sont permises pourvu que les conditions suivantes soient remplies:

– un contact non intentionnel avec une telle partie est improbable; et

– la partie porte un marquage indiquant que cette partie est chaude. Il est permis d'utiliser le symbole suivant (IEC 60417-5041 (DB:2002-10)), pour fournir cette information.

Pour les matériels destinés à être installés dans un EMPLACEMENT À ACCÈS RESTREINT, les limites de température indiquées dans le Tableau 4C s'appliquent avec l'exception que pour les parties métalliques externes qui sont de toute évidence conçues comme des radiateurs ou qui portent un avertissement visible, une température de 90 °C est permise.

4.5.5 Résistance aux chaleurs anormales

Les parties thermoplastiques sur lesquelles sont montées directement des parties sous TENSION DANGEREUSE doivent être résistantes à une chaleur anormale.

La vérification consiste à soumettre la partie à l'essai à la bille conformément à la CEI 60695-10-2. L’essai n’est pas effectué si l'examen des caractéristiques physiques du matériau montre clairement qu'il satisfera aux exigences de cet essai.

L'essai est effectué dans une étuve à une température de $(T - T_{amb} + T_{ma} + 15\ °C) \pm 2\ °C$.

Toutefois, une partie thermoplastique supportant des parties dans un CIRCUIT PRIMAIRE est essayée à une température au moins égale à 125 °C.

Les significations de T, T_{ma} *et* T_{amb} *sont telles que donné en 1.4.12.1.*

4.6 Ouvertures dans les enveloppes

NOTE 1 Les Paragraphes 4.6.1 et 4.6.2 ne s'appliquent pas aux MATERIELS TRANSPORTABLES. Le Paragraphe 4.6.4 s'applique aux MATERIELS TRANSPORTABLES uniquement.

NOTE 2 Des exigences supplémentaires concernant les ouvertures dans les ENVELOPPES sont données en 2.1.1.

4.6.1 Ouvertures dans le dessus et dans les parois latérales

Pour les matériels prévus avec plusieurs orientations possibles (voir 1.3.6), les exigences de 4.6.1 s’appliquent pour chacune des orientations appropriées.

Les ouvertures dans la paroi supérieure ou les parois latérales des ENVELOPPES, à l’exclusion des ENVELOPPES des MATERIELS TRANSPORTABLES (voir 4.6.4), doivent être situées et construites de sorte qu’il soit peu probable que les objets puissent traverser les ouvertures et créer des dangers par contact avec des parties conductrices nues.

NOTE 1 Les dangers comprennent des énergies dangereuses, et ceux créés par le pontage de l’isolation ou par l’accès de l’OPERATEUR à des parties sous TENSIONS DANGEREUSES (par exemple à travers des bijoux métalliques).

Il n’est pas exigé que les ouvertures situées derrière des portes, des panneaux, des couvercles, etc. qui peuvent être ouverts ou enlevés par l'OPERATEUR soient conformes, à condition que les ouvertures du matériel le soient lorsque les portes, les panneaux et les couvercles sont fermés ou en place.

Lorsqu'une partie de la paroi latérale d'une ENVELOPPE CONTRE LE FEU tombe dans la zone délimitée par l'angle de 5° de la Figure 4E, les limitations de 4.6.2 sur les dimensions des ouvertures dans le fond des ENVELOPPES CONTRE LE FEU s'appliquent également à cette partie de la paroi latérale.

La vérification est effectuée par examen et par des mesures. A l’exception des parties de parois latérales d’une ENVELOPPE CONTRE LE FEU qui sont soumises aux exigences de 4.6.2 (voir l’alinéa ci-dessus), chacun des choix suivants est considéré comme pouvant satisfaire aux exigences (d’autres constructions ne sont pas exclues):

– *ouvertures n’ayant aucune dimension supérieure à 5 mm;*
– *ouvertures ayant moins de 1 mm de large quelle que soit la longueur;*
– *ouvertures dans le dessus à travers lesquelles l’entrée verticale des objets est impossible (voir exemples à la Figure 4B);*

– *ouvertures dans les parois latérales équipées de volets en grille-écran dont la forme empêche l'entrée des objets extérieurs tombant verticalement (voir exemples à la Figure 4C);*

– *ouvertures dans le dessus ou dans les parois latérales, comme indiqué à la Figure 4D, qui ne sont pas situées à la verticale ou dans un volume V délimité par la projection de 5° par rapport à la verticale jusqu'à la taille d'ouverture L, au-dessus des parties conductrices:*

- *sous* TENSION DANGEREUSE*; ou*
- *qui présentent un niveau d'énergie dangereuse au sens de 2.1.1.5.*

NOTE 2 Les exemples des Figures 4B, 4C, 4D et 4E ne sont pas destinés à être utilisés comme des dessins d'exécution mais ont seulement pour objet d'illustrer le but de ces exigences.

Figure 4B – Exemples de coupes d'ouvertures empêchant un accès vertical

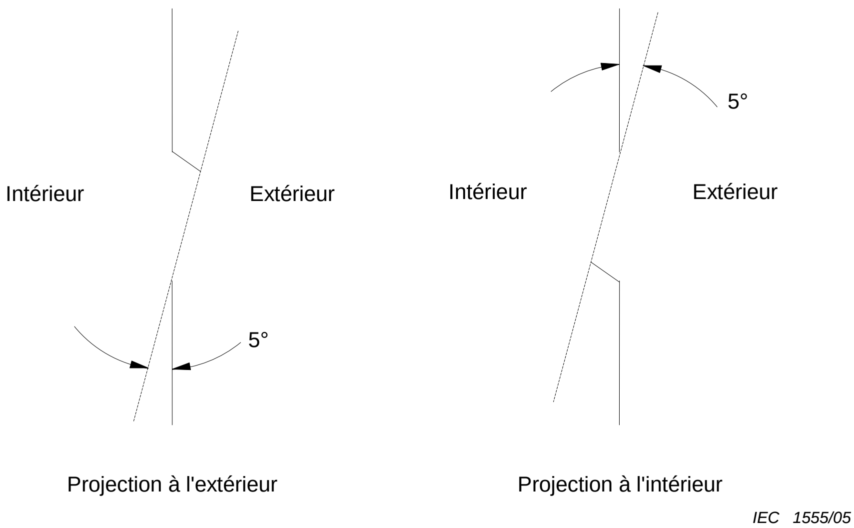
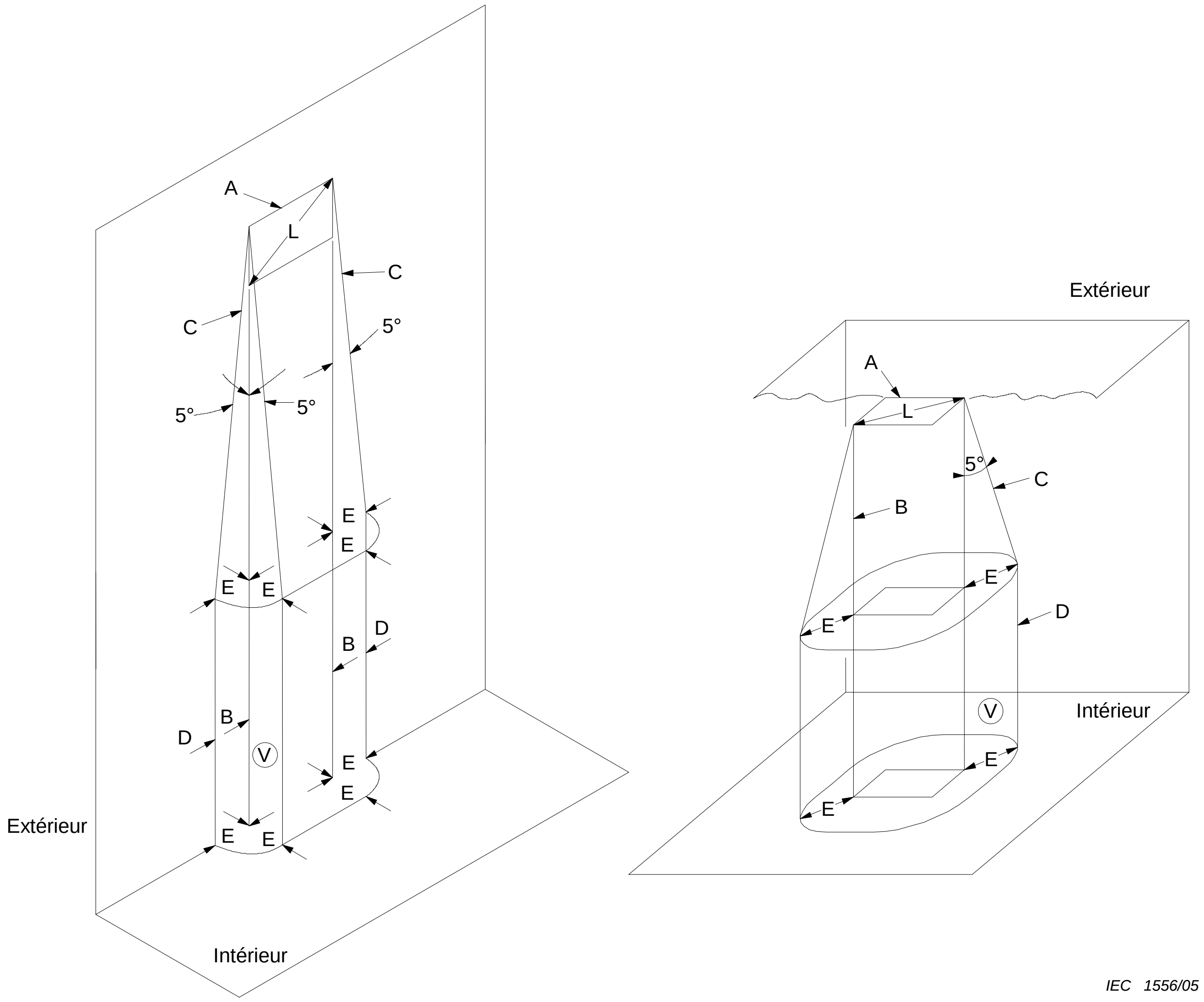


Figure 4C – Exemples de volets en grille-écran



A Ouverture d'une ENVELOPPE.

B Projection verticale des bords extérieurs de l'ouverture.

C Lignes inclinées qui se projettent à un angle de 5° des bords de l'ouverture à des points situés à une distance E de B.

D Ligne qui est projetée verticalement dans le même plan que l'ouverture latérale.

E Projection du bord extérieur de l'ouverture (B) et de la ligne inclinée (C) (qui ne doit pas être supérieure à L).

L Dimension maximale de l'ouverture de l'ENVELOPPE.

V Volume dans lequel les parties nues sous TENSION DANGEREUSE, ou qui présentent des niveaux d'énergie (voir 4.6.1), ne sont pas situées.

Figure 4D – Ouvertures dans une enveloppe

4.6.2 Fonds de l'enveloppe contre le feu

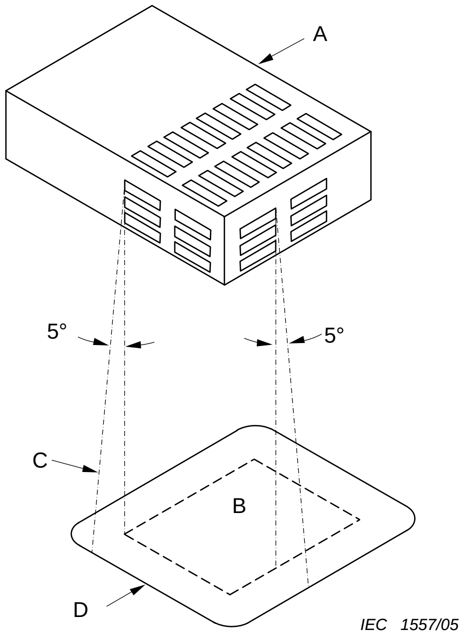
Pour les matériels prévus avec plusieurs orientations possibles (voir 1.3.6), les exigences de 4.6.2 s'appliquent pour chacune des orientations appropriées.

Le fond d'une ENVELOPPE CONTRE LE FEU (à l'exception de l'ENVELOPPE CONTRE LE FEU d'un MATERIEL TRANSPORTABLE) ou les barrières individuelles doivent assurer la protection sous toutes les parties internes, y compris les composants ou les ensembles partiellement enfermés, qui, dans les conditions de défaut, pourraient émettre des matières susceptibles d'enflammer la surface d'appui.

NOTE Voir 4.7.2.2 pour les parties qui ne nécessitent pas une ENVELOPPE CONTRE LE FEU.

Le fond ou la barrière doivent être situés conformément à la Figure 4E et leur surface ne doit pas être inférieure à ce qui est indiqué sur cette figure; ils doivent être soit horizontaux soit pourvus de lèvres ou autres façonnages pour assurer une protection équivalente.

Une ouverture doit être protégée par une chicane, un écran ou un moyen analogue de façon qu'il soit peu probable que du métal en fusion et des matériaux brûlants tombent à l'extérieur de l'ENVELOPPE CONTRE LE FEU.



A Partie d'un élément constituant sous laquelle une ENVELOPPE CONTRE LE FEU est exigée, par exemple sous les ouvertures dans un élément constituant ou un ensemble à travers lesquelles des particules enflammées pourraient être émises. Si l'élément constituant ou l'ensemble n'a pas sa propre ENVELOPPE CONTRE LE FEU, la surface à protéger est la surface totale occupée par l'élément constituant ou l'ensemble.

B Contour de la projection de la surface A effectuée verticalement de haut en bas sur le plan horizontal du point le plus bas de l'ENVELOPPE CONTRE LE FEU.

C Ligne inclinée qui trace un contour D sur le même plan que B. Se déplaçant autour du périmètre du contour B, cette ligne fait un angle de 5° par rapport à la ligne verticale qui part de chaque point du périmètre des ouvertures dans A et est orientée de manière à définir la plus grande surface possible.

D Contour minimal du fond de l'ENVELOPPE CONTRE LE FEU. Une partie d'une paroi latérale d'une ENVELOPPE CONTRE LE FEU qui se trouve à l'intérieur de la surface délimitée par l'angle de 5° est aussi considérée comme faisant partie du fond de l'ENVELOPPE CONTRE LE FEU.

Figure 4E – Fond typique d'une enveloppe contre le feu pour les composants ou ensembles partiellement enfermés

Les exigences de 4.6.2 ne s'appliquent pas aux MATERIELS FIXES prévus uniquement pour être utilisés dans un emplacement à accès restreint et pour être montés sur une surface en béton ou toute autre surface non combustible. De tels matériels doivent être marqués comme suit:

DESTINÉS UNIQUEMENT À ÊTRE MONTÉS SUR UNE SURFACE EN BÉTON OU SUR TOUTE AUTRE SURFACE NON COMBUSTIBLE

La vérification est effectuée par examen et, lorsque c'est nécessaire, par l'essai de l'Article A.3.

Les constructions suivantes sont considérées comme satisfaisant aux exigences sans essai:

– *aucune ouverture dans le fond d'une ENVELOPPE CONTRE LE FEU;*

– *ouvertures de toutes dimensions dans le fond sous une barrière interne, un écran interne ou un autre dispositif qui lui-même satisfait aux exigences pour les ENVELOPPES CONTRE LE FEU, voir aussi 4.2.1;*

– *ouvertures dans le fond ayant chacune une surface inférieure ou égale à 40 mm² sous des composants ou des parties satisfaisant aux exigences du* MATERIAU CELLULAIRE DE CLASSE V-1 *ou du* MATERIAU DE CLASSE HF-1 *ou sous le plus petit composant qui satisfait à l'essai du brûleur-aiguille de la CEI 60695-11-5 en utilisant une durée d'application de la flamme de 30 s;*
– *construction avec une plaque écran comme illustré sur la Figure 4F;*
– *fond métallique des* ENVELOPPES CONTRE LE FEU *conforme aux dimensions limites d'une ligne quelconque du Tableau 4D;*
– *grille de fond en métal ayant une maille dont la distance entre les lignes passant par le centre des ouvertures nominales est inférieure ou égale à 2 mm et dont le diamètre des fils est égal ou supérieur à 0,45 mm.*

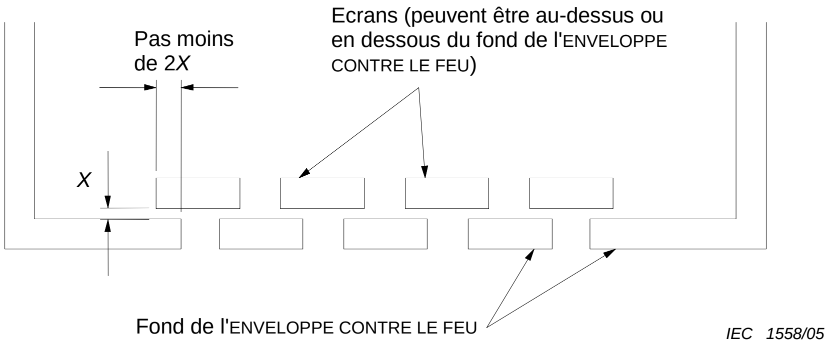


Figure 4F – Construction avec plaque écran

Tableau 4D – Dimensions et espacements des trous dans les fonds métalliques des enveloppes contre le feu

Applicable aux trous circulaires			Applicable aux autres formes d'ouvertures	
Epaisseur minimale du fond métallique mm	**Diamètre maximal des trous** mm	**Espacement minimal des trous (entraxe)** mm	**Surface maximale** mm^2	**Espacement minimal des ouvertures bord à bord** mm
0,66	1,1	1,7	1,1	0,56
0,66	1,2	2,3	1,2	1,1
0,76	1,1	1,7	1,1	0,55
0,76	1,2	2,3	1,2	1,1
0,81	1,9	3,1	2,9	1,1
0,89	1,9	3,1	2,9	1,2
0,91	1,6	2,7	2,1	1,1
0,91	2,0	3,1	3,1	1,2
1,0	1,6	2,7	2,1	1,1
1,0	2,0	3,0	3,2	1,0

4.6.3 Portes et couvercles dans les enveloppes contre le feu

Si une partie d'une ENVELOPPE CONTRE LE FEU comporte une porte ou un couvercle conduisant à une ZONE D'ACCES DE L'OPERATEUR, elle doit satisfaire à l'une des exigences suivantes:

– la porte ou le couvercle doivent être verrouillés pour satisfaire aux exigences de 2.8;

– une porte ou un couvercle destinés à être ouverts par l'OPERATEUR, en usage habituel, doivent satisfaire aux deux conditions suivantes:

- il ne doit pas être possible à l'OPERATEUR de les séparer de l'ENVELOPPE CONTRE LE FEU; et
- ils doivent être munis d'un dispositif qui les maintient fermés pendant le fonctionnement normal;

– il est permis qu'une porte ou un couvercle destinés seulement à un usage occasionnel par l'OPERATEUR, par exemple pour l'installation d'accessoires, soient amovibles pourvu que le mode d'emploi du matériel contienne des directives pour un enlèvement et une remise en place correcte de la porte ou du couvercle.

La conformité est vérifiée par examen.

4.6.4 Ouvertures dans les matériels transportables

Les risques d'inflammation causés par des petits objets métalliques, tels que des trombones ou des agrafes se déplaçant à l'intérieur des MATERIELS TRANSPORTABLES lors du transport doivent être réduits par des moyens tels que ces objets aient peu de probabilité de pénétrer dans le matériel et de ponter les parties conductrices qui peuvent être à l'origine d'un risque d'incendie. Sauf si cela est exigé en 4.6.4.3, de telles mesures ne sont pas nécessaires pour les parties conductrices nues entre lesquelles la puissance est limitée conformément à 2.5.

NOTE Les exigences ci-dessus ne s'appliquent qu'aux parties conductrices nues. Les parties conductrices présentant un revêtement ne sont pas considérées comme des parties conductrices nues.

La vérification est effectuée conformément à 4.6.4.1, 4.6.4.2 et 4.6.4.3 selon ce qui est approprié. Au cours de l'examen et des essais, toutes les portes et tous les couvercles sont fermés ou en place et les éléments ou ensembles périphériques, tels des lecteurs de disques, des batteries, etc., sont installés comme prévu.

4.6.4.1 Mesures de conception de la construction

Exemples de mesures de conception de construction acceptables:

– limiter la largeur des ouvertures à 1 mm quelle que soit la longueur; ou
– disposer une grille ayant une maille dont la distance entre les lignes passant par le centre des ouvertures est inférieure ou égale à 2 mm et construite avec un diamètre de fil ou de filament égal ou supérieur à 0,45 mm; ou
– ajouter des barrières internes; ou
– d'autres moyens de construction équivalents.

NOTE Les grilles prévues pour limiter l'entrée de petits objets font partie de l'ENVELOPPE et les exigences de 4.7 pour les ENVELOPPES CONTRE LE FEU peuvent s'appliquer, voir aussi 1.3.6.

La vérification est effectuée par examen et par des mesures et, si nécessaire, en simulant la pénétration d'objets qui pourraient ponter les parties conductrices nues.

4.6.4.2 Mesures d'évaluation pour ouvertures de grande taille

Des ouvertures de tailles supérieures à celles spécifiées en 4.6.4.1 sont autorisées (voir aussi 2.1.1.1), sous réserve que des essais de défaut soit réalisés pour simuler le pontage le long d'un chemin droit entre les parties conductrices nues (pour les parties métallisées, voir 4.6.4.3) situées à moins de 13 mm les unes des autres partout à l'intérieur du matériel ne satisfaisant pas aux critères de 4.6.4.1.

La vérification est effectuée par examen et par des mesures et par un essai de défaut simulé. Un pontage est considéré exister entre des parties conductrices nues qui peuvent être touchées simultanément en utilisant un objet métallique droit, de 1 mm de diamètre et ayant une longueur quelconque inférieure à 13 mm, appliqué sans force appréciable. Au cours des essais de défaut, il ne doit pas se produire d'inflammation de matériaux non métalliques ni d'émission de métal fondu.

4.6.4.3 Utilisation de parties métallisées

Lorsque des parties métallisées d'une barrière ou d'une ENVELOPPE plastique sont situées à une distance inférieure ou égale à 13 mm de parties de circuits dans lesquels la puissance disponible est supérieure à 15 VA, une des exigences suivantes a), b) ou c) s'applique:

a) l'accès d'un objet métallique extérieur doit être limité conformément à 4.6.4.1, que la puissance disponible satisfasse aux limites de 2.5 ou non; ou

b) il doit y avoir une barrière entre les parties conductrices nues et la barrière métallisée ou l'ENVELOPPE; ou

c) des essais de défauts doivent être effectués pour simuler un pontage entre une partie conductrice nue et la plus proche partie métallisée de la barrière ou de l'ENVELOPPE qui est située à moins de 13 mm de la partie conductrice nue.

NOTE Les exemples de barrières ou d'ENVELOPPES plastiques métallisées comprennent celles qui sont faites à partir de matériaux composites conducteurs ou qui sont recouvertes par électrolyse, par dépôt sous vide, par peinture ou par une feuille.

La vérification est effectuée par examen et par des mesures et, lorsque c'est approprié, par des essais. Si des essais de défaut simulés sont réalisés, il ne doit pas y avoir d'inflammation de la barrière métallisée ou de l'ENVELOPPE.

4.6.5 Adhésifs entrant dans la construction

Si une barrière ou un écran prévus pour satisfaire à 4.6.1, 4.6.2 ou 4.6.4 sont fixés avec de l'adhésif sur l'intérieur de l'ENVELOPPE ou sur d'autres parties à l'intérieur de l'ENVELOPPE, l'adhésif doit avoir des propriétés d'adhérence adéquates durant toute la vie du matériel.

La vérification est effectuée par examen de la construction et des données disponibles. Si de telles données ne sont pas disponibles, la vérification est effectuée par les essais suivants.

Un échantillon du matériel ou une partie de l'ENVELOPPE avec la barrière ou l'écran attaché est évalué dans une position de l'échantillon telle que la barrière ou l'écran soit placé en dessous.

Conditionner l'échantillon dans une étuve à l'une des températures suivantes pour les durées spécifiées:

100 °C ± 2 °C pendant une semaine; ou

90 °C ± 2 °C pendant trois semaines; ou

82 °C ± 2 °C pendant huit semaines.

A l'issue du conditionnement thermique, soumettre l'échantillon aux manipulations suivantes:

- *enlever l'échantillon de l'étuve et le laisser pendant 1 h à température quelconque entre 20 °C et 30 °C;*
- *placer l'échantillon dans un congélateur pendant 4 h à -40 °C ± 2 °C;*
- *enlever l'échantillon du congélateur et le laisser revenir sur une période de 8 h à une température quelconque entre 20 °C et 30 °C;*
- *placer l'échantillon pendant 72 h dans une étuve avec une humidité relative de 91 % à 95 %;*
- *enlever l'échantillon et le laisser pendant 1 h à une température quelconque entre 20 °C et 30 °C;*
- *placer l'échantillon dans l'étuve pendant 4 h à la température choisie dans le premier cycle;*
- *enlever l'échantillon et le laisser refroidir sur une période de 8 h à une température quelconque entre 20 °C et 30 °C.*

L'échantillon est alors soumis immédiatement aux essais de 4.2 qui sont applicables. La barrière ou l'écran ne doit pas tomber ou se détacher en partie à la suite de ces essais.

Avec l'accord du fabricant, il est permis d'augmenter toute durée indiquée ci-dessus.

4.7 Résistance au feu

Le présent paragraphe spécifie les exigences destinées à réduire le risque d'inflammation et la propagation de la flamme, tant à l'intérieur qu'à l'extérieur du matériel, par une utilisation appropriée des matériaux et des composants ainsi que par une construction convenable.

NOTE 1 Le risque d'inflammation est réduit en limitant la température maximale sur les composants dans des conditions normales et après un premier défaut (voir 1.4.14), ou en limitant l'énergie disponible dans le circuit.

NOTE 2 La propagation de la flamme dans le cas d'une inflammation est réduite par l'utilisation des matériaux et isolants ayant des propriétés de retard à l'inflammation et par une séparation adéquate.

NOTE 3 Pour un classement des matériaux suivant le degré d'inflammabilité, se référer aux notes de 1.2.12.1.

NOTE 4 En Australie et en Nouvelle-Zélande, un ensemble d'essais au feu alternatif est également accepté.

Les matières métalliques, céramiques et les verres doivent être considérés comme conformes sans essai.

4.7.1 Limitation du risque d'inflammation et de propagation du feu

Pour le matériel ou pour une portion du matériel, il y a deux méthodes pour obtenir la protection contre l'inflammation et la propagation de la flamme qui risquent d'affecter les matériaux, les câbles, les composants bobinés et les composants électroniques tels que les circuits intégrés, les transistors, les thyristors, les diodes, les résistances et les condensateurs.

Méthode 1 – Choix et utilisation de composants, de câbles et de matériaux qui réduisent la possibilité d'inflammation et de propagation de la flamme et, si nécessaire, utilisation d'une ENVELOPPE CONTRE LE FEU. Les exigences correspondantes figurent en 4.7.2 et en 4.7.3. De plus, les simulations de défauts de 5.3.7 s'appliquent à l'exception de 5.3.7 c) lorsque cette méthode est utilisée.

NOTE 1 La méthode 1 peut être préférée pour les matériels ou pour la partie des matériels comportant un grand nombre de composants.

Méthode 2 – Application de tous les essais de simulation de défauts de 5.3.7. Une ENVELOPPE CONTRE LE FEU n'est pas exigée pour le matériel ou la partie des matériels pour laquelle la méthode 2 est utilisée. En particulier, 5.3.7 c) s'applique. Il inclut des essais sur tous les composants concernés à la fois dans les CIRCUITS PRIMAIRES et les CIRCUITS SECONDAIRES.

NOTE 2 La méthode 2 peut être préférée pour les matériels ou pour la partie des matériels comportant un petit nombre de composants électroniques.

4.7.2 Conditions applicables à une enveloppe contre le feu

Une ENVELOPPE CONTRE LE FEU est exigée lorsque les températures des composants sous des conditions de défaut risquent d'être suffisantes pour provoquer une inflammation.

4.7.2.1 Composants nécessitant une enveloppe contre le feu

Sauf lorsque la méthode 2 de 4.7.1 est utilisée, ou comme permis en 4.7.2.2, les parties suivantes sont considérées comme ayant un risque d'inflammation et, donc, nécessitent une ENVELOPPE CONTRE LE FEU:

– composants dans un CIRCUIT PRIMAIRE;
– composants dans les CIRCUITS SECONDAIRES alimentés par des sources d'énergie qui dépassent les limites de 2.5;

– composants dans les CIRCUITS SECONDAIRES alimentés par des sources d’énergie limitée conformes à 2.5, mais non montés sur un matériau de CLASSE V-1;

– composants à l'intérieur d’une unité d’alimentation ou un ensemble fournissant une énergie conforme à 2.5, y compris les dispositifs de protection contre les surintensités, les impédances de limitation, les réseaux de régulation et tout le câblage jusqu'au point auquel les critères de sortie des sources à puissance limitée sont remplis;

– composants ayant des parties non enfermées sur lesquelles se forment des arcs, telles que les contacts ouverts des interrupteurs et des relais et les commutateurs, dans un circuit à TENSION DANGEREUSE ou à niveau D’ENERGIE DANGEREUX; et

– le câblage isolé.

4.7.2.2 Composants ne nécessitant pas une enveloppe contre le feu

Les parties suivantes ne nécessitent pas une ENVELOPPE CONTRE LE FEU:

– moteurs;

– transformateurs;

– composants électromécaniques conformes à 5.3.5;

– conducteurs et câbles à isolant PVC, TFE, PTFE, FEP, polychloroprène ou polyimide;

– fiches et connecteurs faisant partie d'un cordon d'alimentation ou d'un CABLE D'INTERCONNEXION;

– composants, y compris les connecteurs, satisfaisant aux exigences de 4.7.3.2, qui remplissent une ouverture dans une ENVELOPPE CONTRE LE FEU;

– connecteurs dans les CIRCUITS SECONDAIRES alimentés par une source d’énergie limitée au maximum à 15 VA (voir 1.4.11) dans des conditions normales d’utilisation et après un premier défaut dans le matériel (voir 1.4.14);

– connecteurs dans des CIRCUITS SECONDAIRES alimentés par des sources à puissance limitée conformes à 2.5;

– autres composants dans des CIRCUITS SECONDAIRES:

  • alimentés par des sources à puissance limitée conformes à 2.5 et montés sur des matériaux de CLASSE V-1;

  • alimentés par des sources d’énergie internes ou externes limitées au maximum à 15 VA (voir 1.4.11) dans des conditions d’utilisation normales et après un premier défaut (voir 1.4.14) dans le matériel, et montés sur un MATERIAU DE CLASSE HB75 si la plus petite épaisseur significative de ce matériau est <3 mm ou de CLASSE HB40 si la plus petite épaisseur significative de ce matériau est ≥3 mm;

NOTE Au Canada et aux Etats-Unis, des exigences supplémentaires peuvent s'appliquer, voir Article 6 Note 5.

  • conformes à la méthode 2 de 4.7.1;

– matériel, ou partie du matériel, ayant un interrupteur à contact temporaire que l'utilisateur doit activer en permanence, et dont le relâchement coupe toute alimentation du matériel ou une partie.

La vérification de la conformité à 4.7.2.1 et à 4.7.2.2 est effectuée par examen et par évaluation des données fournies par le fabricant. Dans le cas où aucune donnée n'est fournie, la conformité est vérifiée par des essais.

4.7.3 Matériaux

4.7.3.1 Généralités

Les ENVELOPPES, les composants et les autres parties doivent être construits de façon telle ou doivent utiliser des matériaux tels que la propagation du feu soit réduite.

LES MATERIAUX DE CLASSE VTM-0, de CLASSE VTM-1 et de CLASSE VTM-2 sont considérés comme équivalents aux MATERIAUX DE CLASSE V-0 , DE CLASSE V-1 et DE CLASSE V-2, respectivement en ce qui concerne leur propriétés d'inflammabilité. Leurs propriétés électriques et mécaniques ne sont pas nécessairement équivalentes.

Lorsqu'un MATERIAU DE CLASSE HB40, DE CLASSE HB75 ou CELLULAIRE DE CLASSE HBF est exigé, un matériau satisfaisant à l'essai avec le fil incandescent à 550 °C selon la CEI 60695-2-11 est acceptable comme variante.

Quand il n'est pas possible en pratique de protéger les composants contre des échauffements en condition de défaut, les composants doivent être montés sur des MATERIAUX DE CLASSE V-1. De plus, de tels composants doivent être séparés des matériaux de classe inférieure à la CLASSE V-1 (voir 1.2.12.1, Note 2) par au moins 13 mm d'air, ou par une barrière solide de CLASSE V-1.

NOTE 1 Voir aussi 4.7.3.5.

NOTE 2 Au Canada et aux USA, des exigences complémentaires à 4.7.3.2 et 4.7.3.3 s'appliquent aux ENVELOPPES et aux PARTIES DECORATIVES ayant une surface externe avec une zone d'exposition plus large que 0,9 m^2 ou avec une dimension plus grande que 1,8 m.

NOTE 3 En considérant comment réduire au minimum la propagation du feu et quelles sont les «petites parties», il convient de tenir compte de l'effet cumulatif des petites parties lorsqu'elles sont adjacentes et également de la possibilité de propagation du feu d'une partie à une autre.

NOTE 4 Les exigences d'inflammabilité du matériau en 4.7.3 sont résumées dans le Tableau 4E.

La vérification est effectuée par examen et par évaluation des données correspondantes fournies par le fabricant.

4.7.3.2 Matériaux pour les enveloppes contre le feu

Les exigences suivantes s'appliquent suivant ce qui est approprié.

Le critère de masse de 18 kg s'applique aux matériels individuels complets, même s'ils sont utilisés très près l'un de l'autre (par exemple l'un au-dessus de l'autre). Toutefois, si une partie de l'ENVELOPPE CONTRE LE FEU est enlevée dans une telle situation (dans le même exemple le fond du matériel placé au-dessus), la masse combinée du matériel s'applique. Pour la détermination de la masse totale d'un matériel les fournitures ou produits consommables et les supports d'information et d'enregistrement utilisés avec le matériel ne doivent pas être pris en compte.

Pour les MATERIELS MOBILES ayant une masse totale ne dépassant pas 18 kg, le matériau des ENVELOPPES CONTRE LE FEU, dans la plus petite épaisseur significative de paroi utilisée, doit être de CLASSE V-1 ou satisfaire à l'essai de l'Article A.2.

Pour les MATERIELS MOBILES ayant une masse totale dépassant 18 kg et pour tous les MATERIELS FIXES, le matériau des ENVELOPPES CONTRE LE FEU, dans la plus petite épaisseur significative de paroi utilisée, doit être de CLASSE 5 VB ou satisfaire à l'essai de l'Article A.1.

Le matériau des composants qui obturent une ouverture dans une ENVELOPPE CONTRE LE FEU et qui sont destinés à être montés de cette façon doit:

– être un MATERIAU DE CLASSE V-1; ou
– satisfaire aux essais de l'Article A.2; ou
– satisfaire aux exigences d'inflammabilité de la norme de composants correspondante de la CEI.

NOTE Les porte fusibles, les interrupteurs, les lampes témoins, les connecteurs et les socles de connecteurs sont des exemples de ces composants.

Les matériaux plastiques des ENVELOPPES CONTRE LE FEU doivent être situés à plus de 13 mm dans l'air des parties sur lesquelles se produisent des arcs, telles que les contacts des commutateurs non enfermés et des interrupteurs non enfermés.

Les matériaux plastiques des ENVELOPPES CONTRE LE FEU situées à moins de 13 mm dans l'air des parties sur lesquelles ne se produisent pas d'arcs qui, dans n'importe quelle condition de fonctionnement normal ou anormal, pourraient atteindre une température suffisante pour enflammer le matériau, doivent être capables de satisfaire à l'essai de la CEI 60695-2-20. Le temps moyen d'inflammation de l'échantillon ne doit pas être inférieur à 15 s. Si l'échantillon se ramollit sans s'enflammer, le temps pour lequel le phénomène se produit n'est pas considéré comme le temps d'inflammation.

La vérification est effectuée par examen des données du matériel et du matériau et, si nécessaire, par un ou des essais appropriés dans l'Annexe A ou de la CEI 60695-2-20.

4.7.3.3 Matériaux pour les composants et les autres parties à l'extérieur des enveloppes contre le feu

A l'exception de ce qui est spécifié dans la note ci-dessous, les composants et les autres parties (y compris les ENVELOPPES MECANIQUES, les ENVELOPPES ELECTRIQUES et les PARTIES DECORATIVES) situés à l'extérieur des ENVELOPPES CONTRE LE FEU, doivent être

– EN MATERIAU DE CLASSE HB75 si la plus petite épaisseur significative de ce matériau est < 3 mm, ou
– EN MATERIAU DE CLASSE HB40 si la plus petite épaisseur significative de ce matériau est ≥ 3 mm, ou
– en MATERIAU CELLULAIRE DE CLASSE HBF.

NOTE Lorsqu'une ENVELOPPE MECANIQUE ou une ENVELOPPE ELECTRIQUE sert aussi comme ENVELOPPE CONTRE LE FEU, les exigences pour les ENVELOPPES CONTRE LE FEU s'appliquent.

Les exigences pour les matériaux dans les assemblages de filtres à air sont données en 4.7.3.5 et les exigences pour les matériaux utilisés dans les composants à haute tension sont données en 4.7.3.6.

Les connecteurs doivent satisfaire à un des cas ci-dessous:

– être un MATERIAU DE CLASSE V-2; ou
– satisfaire aux essais de l'Article A.2; ou
– satisfaire aux exigences sur l'inflammabilité de la norme de composants correspondante de la CEI; ou
– être montés sur un matériau de classe v-1 et être de petite taille; ou
– être situés dans un circuit secondaire alimenté par une source d'énergie limitée au maximum à 15 VA (voir 1.4.11) dans des conditions de fonctionnement normales ou après un premier défaut dans le matériel (voir 1.4.14).

L'exigence applicable aux matériaux pour les composants et les autres parties spécifiant qu'ils doivent être de CLASSE D'INFLAMMABILITE HB40, de CLASSE D'INFLAMMABILITE HB75, ou de CLASSE D'INFLAMMABILITE CELLULAIRE HBF ne s'applique à aucun des cas suivants:

– composants électriques qui ne présentent pas de danger de feu dans des conditions de fonctionnement anormales, lorsqu'ils sont essayés suivant 5.3.7;
– matériaux et composants situés à l'intérieur d'une ENVELOPPE de volume inférieur ou égal à 0,06 m^3, réalisée entièrement en métal et sans ouvertures de ventilation, ou à l'intérieur d'une unité hermétique contenant un gaz inerte;
– boîtiers d'indicateurs (à condition qu'ils soient jugés par ailleurs propres à recevoir des parties sous TENSION DANGEREUSE), cadrans d'indicateurs et lampes ou leurs cabochons de signalisation;

– composants satisfaisant aux exigences d'inflammabilité d'une norme CEI de composants applicable qui comprend de telles exigences;

– composants électroniques, comme les circuits intégrés, les opto-coupleurs, les condensateurs et autres petites parties qui sont:

  - montés sur un MATERIAU DE CLASSE V-1; ou

  - alimentés par une source d'énergie ne dépassant pas 15 VA (voir 1.4.11) dans des conditions normales de fonctionnement ou après un premier défaut dans le matériel (voir 1.4.14), et montés sur un matériau de classe HB75 si la plus petite épaisseur significative de ce matériau est < 3 mm, ou de classe HB40 si la plus petite épaisseur significative de ce matériau est ≥ 3 mm;

– fils, câbles et connecteurs isolés par du PVC, TFE, PTFE, FEP, polychloroprène ou polyimide;

– colliers individuels (à l'exclusion des revêtements hélicoïdaux ou autres revêtements continus), rubans de laçage, attaches de câbles ou de torons, utilisés avec les faisceaux de câbles;

– engrenages, cames, courroies, paliers et autres petites parties qui ne constitueraient qu'un apport négligeable de combustible dans un incendie, y compris les PARTIES DECORATIVES, les étiquettes, les pieds de montage, les couvercles de serrure, les boutons et les organes analogues;

– fournitures, matières consommables, supports d'enregistrements et d'information;

– parties qui doivent avoir des caractéristiques particulières pour remplir leur fonction, telles que les rouleaux en caoutchouc pour la prise du papier et sa restitution et les tubes d'encre.

La vérification est effectuée par examen des données du matériel et du matériau et, si nécessaire, par le ou les essais appropriés dans l'Annexe A.

4.7.3.4 Matériaux pour les composants et les autres parties à l'intérieur des enveloppes contre le feu

Les exigences pour les matériaux dans les assemblages de filtres à air sont en 4.7.3.5 et les exigences pour les matériaux utilisés dans les composants à haute tension sont en 4.7.3.6. Les exigences relatives aux résistances sensibles à la tension (VDR) sont données à l'Annexe Q.

A l'intérieur des ENVELOPPES CONTRE LE FEU, les matériaux des composants et autres pièces, (y compris les ENVELOPPES MECANIQUES et ELECTRIQUES situées à l'intérieur des ENVELOPPES CONTRE LE FEU) doivent satisfaire à un des cas suivants:

– être en MATERIAU DE CLASSE V-2 ou CELLULAIRE HF-2; ou

– satisfaire à l'essai d'inflammabilité de l'Article A.2; ou

– satisfaire aux exigences sur l'inflammabilité de la norme de composants correspondante de la CEI, qui spécifie de telles exigences.

Les exigences ci-dessus ne s'appliquent à aucun des cas suivants:

– composants électriques qui ne présentent pas de danger de feu dans des conditions de fonctionnement anormales, lorsqu'ils sont essayés suivant 5.3.7;

– matériaux et composants situés à l'intérieur d'une ENVELOPPE de volume inférieur ou égal à 0,06 m^3, réalisée entièrement en métal et sans ouvertures de ventilation, ou à l'intérieur d'une unité hermétique contenant un gaz inerte;

– une ou plusieurs couches de matériaux d'isolation minces tels que du ruban adhésif, utilisé directement sur une surface quelconque à l'intérieur d'une ENVELOPPE CONTRE LE FEU, y compris la surface des parties transportant le courant, pourvu que la combinaison du matériau d'isolation mince et de la surface d'application satisfasse aux exigences d'une CLASSE V-2 ou CELLULAIRE HF-2;

NOTE Lorsque le matériau d'isolation mince auquel il est fait référence dans l'exemption ci-dessus est sur la surface interne d'une ENVELOPPE CONTRE LE FEU, les exigences de 4.6.2 continuent de s'appliquer à l'ENVELOPPE CONTRE LE FEU.

– boîtiers d'indicateurs (à condition qu'ils soient jugés par ailleurs propres à recevoir des parties sous TENSION DANGEREUSE), cadrans d'indicateurs et lampes ou leurs cabochons de signalisation;
– composants électroniques, comme les circuits intégrés, les opto-coupleurs, les condensateurs et autres petites parties qui sont montés sur un MATERIAU DE CLASSE V-1;
– fils, câbles et connecteurs isolés par du PVC, TFE, PTFE, FEP, polychloroprène ou polyimide;
– colliers individuels (à l'exclusion des revêtements hélicoïdaux ou autres revêtements continus), rubans de laçage, attaches de câbles ou de torons utilisés avec les faisceaux de câbles;
– parties ci-après pourvu qu'elles soient séparées par au moins 13 mm d'air ou par une barrière solide en MATERIAU DE CLASSE V-1, des parties électriques (autres que les fils et câbles isolés) qui, dans des conditions de défaut, sont susceptibles d'engendrer une température qui pourrait provoquer une inflammation:
  • les engrenages, cames, courroies, paliers et autres petites parties qui ne constituent qu'un apport négligeable de combustible dans un incendie, y compris les parties décoratives, les étiquettes, les pieds de montage, les couvercles de serrure, les boutons et les organes analogues;
  • les fournitures, matières consommables, supports d'enregistrements et d'information;
  • les parties qui doivent avoir des caractéristiques particulières pour remplir leur fonction, telles que les rouleaux en caoutchouc pour la prise du papier et sa restitution et les tubes d'encre;
  • les canalisations pour les circuits d'air ou de tout fluide, les réservoirs pour les poudres ou les liquides et les parties en plastique cellulaire, pourvu qu'ils soient en matériau de CLASSE HB75 si la plus petite épaisseur significative du matériau est < 3 mm ou de CLASSE HB40 si la plus petite épaisseur significative du matériau est ≥ 3 mm, ou de CLASSE CELLULAIRE HBF.

La vérification est effectuée par examen des données du matériel et du matériau et, si nécessaire, par le ou les essais appropriés de l'Annexe A.

4.7.3.5 Assemblages de filtres à air

Les assemblages de filtres à air doivent être construits en MATERIAU DE CLASSE V-2 ou HF-2 CELLULAIRE.

Cette exigence ne s'applique pas aux constructions suivantes:

– les assemblages de filtres à air dans les systèmes à circulation d'air, étanches à l'air ou non, qui ne sont pas destinés à avoir de communication avec l'extérieur de l'ENVELOPPE CONTRE LE FEU;
– les assemblages de filtres à air situés à l'intérieur ou à l'extérieur d'une ENVELOPPE CONTRE LE FEU, pourvu que les matériaux du filtre soient séparés par un écran métallique des parties qui pourraient provoquer l'inflammation. Cet écran peut être perforé et doit satisfaire aux exigences de 4.6.2 pour les fonds des ENVELOPPES CONTRE LE FEU;
– les assemblages de filtres à air construits
  • EN MATERIAU DE CLASSE HB75 si la plus petite épaisseur significative de ce matériau est < 3 mm, ou
  • EN MATERIAU DE CLASSE HB40 si la plus petite épaisseur significative de ce matériau est ≥ 3 mm, ou
  • en MATERIAU PLASTIQUE CELLULAIRE DE CLASSE HBF,

pourvu qu'elles soient séparées par au moins 13 mm d'air ou par une barrière solide en MATERIAU DE CLASSE V-1, des parties électriques (autres que les fils et câbles isolés) qui, dans des conditions de défaut, sont susceptibles d'engendrer une température qui pourrait provoquer une inflammation.

La vérification est effectuée par l'examen du matériel et des fiches techniques des matériaux et, si nécessaire, par des essais appropriés.

4.7.3.6 Matériaux utilisés dans les composants haute tension

Les composants haute tension fonctionnant à des tensions crête à crête supérieures à 4 kV doivent soit être de CLASSE V-2 soit de CLASSE CELLULAIRE HF-2, soit être conformes à 14.4 de la CEI 60065 soit satisfaire à l'essai au brûleur-aiguille de la CEI 60695-11-5.

La vérification est effectuée par l'examen du matériel et des fiches techniques des matériaux et, si nécessaire, par

- *les essais pour les MATERIAUX DE LA CLASSE V-2 ou CELLULAIRE HF-2; ou*
- *l'essai décrit en 14.4 de la CEI 60065; ou*
- *l'essai au brûleur-aiguille selon la CEI 60695-11-5.*

De plus les indications suivantes, qui se réfèrent à la CEI 60695-11-5, s'appliquent:

Article 7 – Degrés de sévérité

La flamme d'essai est appliquée pendant 10 s. Si une flamme auto-alimentée ne dure pas plus de 30 s, la flamme est appliquée à nouveau pendant 1 min au même point ou en tout autre point. Si à nouveau une flamme auto-alimentée ne dure pas plus de 30 s, la flamme d'essai est alors appliquée pendant 2 min au même point ou en tout autre point.

Article 8 – Préconditionnement

A l'exception des transformateurs haute tension et des multiplicateurs haute tension, les spécimens sont maintenus pendant 2 h dans une étuve à la température de 100 °C ± 2 °C.

Pour les transformateurs haute tension, une puissance de 10 W (en continu ou en alternatif à la fréquence du réseau) est appliquée initialement au bobinage haute tension. Cette puissance est maintenue pendant 2 min, puis augmentée par paliers successifs de 10 W toutes les 2 min jusqu'à 40 W.

L'épreuve dure 8 min ou se termine dès l'apparition d'une rupture du bobinage ou d'une séparation appréciable de l'enveloppe de protection.

NOTE 1 Certains transformateurs sont conçus de telle sorte que ce préconditionnement ne peut pas être appliqué. Dans ce cas, on applique le préconditionnement dans l'étuve.

Pour les multiplicateurs haute tension, une tension provenant d'un transformateur haute tension approprié est appliquée à chaque spécimen, le circuit de sortie étant court-circuité.

La tension d'entrée est réglée de sorte que le courant de court-circuit initial soit de 25 mA ± 5 mA. Ce courant est maintenu pendant 30 min ou l'épreuve se termine dès l'apparition d'une interruption du circuit ou d'une séparation appréciable de l'enveloppe de protection.

NOTE 2 Lorsque la conception du multiplicateur haute tension est telle qu'un courant de court-circuit de 25 mA ne peut être obtenu, on utilise un courant de préconditionnement représentant le courant maximal que l'on peut atteindre, déterminé soit par la conception du multiplicateur soit par ses conditions d'utilisation dans un appareil particulier.

Article 11 – Evaluation des résultats d'essai

Après la première application de la flamme d'essai, les spécimens ne doivent pas s'être consumés complètement.

Après toute application de la flamme d'essai, toute flamme auto-alimentée doit s'être éteinte en 30 s. Il ne doit y avoir ni inflammation du papier mousseline ni roussissement de la planche.

Tableau 4E – Résumé des exigences d'inflammabilité des matériaux

Partie		Exigence
ENVELOPPE CONTRE LE FEU 4.7.3.2	MATERIELS MOBILES >18 kg et MATERIELS FIXES	– 5VB – Essai A.1 – Essai au fil chauffant de la CEI 60695-2-20 (Si <13 mm d'air avec les parties à haute température qui pourraient causer une inflammation)
	MATERIELS MOBILES ≤18 kg	– V-1 – Essai A.2 – Essai au fil chauffant de la CEI 60695-2-20 (Si <13 mm d'air avec les parties à haute température qui pourraient causer une inflammation)
	Parties qui obturent une ouverture	– V-1 – Essai A.2 – Norme du composant
Composants et parties, y compris les ENVELOPPES MECANIQUES et les ENVELOPPES ELECTRIQUES, à l'extérieur des ENVELOPPES CONTRE LE FEU 4.7.3.1 et 4.7.3.3		– HB40 pour une épaisseur ≥3 mm – HB75 pour une épaisseur <3 mm – HBF – Essai au fil incandescent 550 °C de la CEI 60695-2-11 Pour les connecteurs et les exceptions voir 4.7.3.3
Composants et parties, y compris les ENVELOPPES MECANIQUES et les ENVELOPPES ELECTRIQUES, à l'intérieur des ENVELOPPES CONTRE LE FEU 4.7.3.4		– V-2 – HF-2 – Essai A.2 – Norme du composant Pour les exceptions voir 4.7.3.4
Assemblages de filtres 4.7.3.5		– V-2 – HF-2 – Essai A.2 Pour les exceptions voir 4.7.3.5
Composants haute tension (>4 kV) 4.7.3.6		– V-2 – HF-2 – Essai de 14.4 de la CEI 60065 – Essai au brûleur-aiguille de la CEI 60695-11-5

5 Exigences électriques et simulation de conditions de défauts

5.1 Courant de contact et courant dans le conducteur de protection

Dans ce paragraphe, les mesures de courant à travers des réseaux simulant l'impédance du corps humain sont désignées comme mesures de COURANT DE CONTACT.

A l'exception de l'application de 5.1.8.2, ces exigences ne s'appliquent pas aux matériels destinés à être alimentés uniquement par le RESEAU D'ALIMENTATION EN COURANT CONTINU.

5.1.1 Généralités

Le matériel doit être conçu et construit de façon que ni le COURANT DE CONTACT ni le COURANT DANS LE CONDUCTEUR DE PROTECTION ne puisse créer un danger de choc électrique.

La vérification est effectuée par des essais conformément aux exigences de 5.1.2 à 5.1.7 compris et, si c'est applicable, de 5.1.8 (voir aussi 1.4.4).

Toutefois, s'il est clair d'après l'étude du diagramme des circuits des MATÉRIELS FIXES RELIÉS À DEMEURE ou des MATÉRIELS DU TYPE B RACCORDÉS PAR PRISE DE COURANT, qui ont un CONDUCTEUR DE MISE À LA TERRE DE PROTECTION, que le COURANT DE CONTACT dépassera 3,5 mA efficaces, mais que le COURANT DANS LE CONDUCTEUR DE PROTECTION ne dépassera pas 5 % du courant de charge, les essais de 5.1.5, 5.1.6 et 5.1.7.1 a) ne sont pas effectués.

NOTE Dans le cas ci-dessus, l'exigence de 5.1.7.1 b) continue de s'appliquer.

5.1.2 Configuration du matériel en essai

5.1.2.1 Raccordement unique à une alimentation du réseau en courant alternatif

Les systèmes comprenant des matériels interconnectés avec des connexions individuelles au RÉSEAU D'ALIMENTATION EN COURANT ALTERNATIF doivent faire l'objet d'un essai individuel sur chaque élément du système. Les systèmes comprenant des matériels interconnectés avec une connexion commune au RÉSEAU D'ALIMENTATION EN COURANT ALTERNATIF doivent être traités comme un matériel unique. Voir aussi 1.4.10 au sujet des différentes configurations possibles.

NOTE Les systèmes comprenant des matériels interconnectés sont spécifiés avec plus de détails dans l'Annexe A de la CEI 60990.

5.1.2.2 Raccordements multiples redondants à une alimentation du réseau en courant alternatif

Les matériels qui sont prévus pour des connexions multiples au réseau à ALIMENTATION EN COURANT ALTERNATIF, dont une seule est nécessaire à la fois, doivent être essayés avec une seule connexion.

5.1.2.3 Raccordements multiples simultanés à une alimentation du réseau en courant alternatif

Les matériels qui nécessitent une alimentation venant simultanément de deux alimentations du RESEAU EN COURANT ALTERNATIF ou plus doivent être essayés avec toutes les sources d'alimentation connectées.

Le COURANT DE CONTACT total traversant tous les CONDUCTEURS DE MISE A LA TERRE DE PROTECTION qui sont connectés entre eux et à la terre est mesuré.

Un CONDUCTEUR DE MISE A LA TERRE DE PROTECTION qui n'est pas connecté à l'intérieur du matériel à d'autres parties reliées à la terre dans le matériel ne doit pas être inclus dans les essais ci-dessus. Si une source d'alimentation en courant alternatif possède un CONDUCTEUR DE MISE A LA TERRE DE PROTECTION, elle doit être soumise aux essais selon 5.1.2.1 (voir aussi 5.1.7.2).

5.1.3 Circuit d'essai

Le matériel est essayé à l'aide du circuit de la Figure 5A (pour les matériels monophasés à connecter uniquement sur des schémas d'alimentation TN étoile ou TT) ou de la Figure 5B (pour les matériels triphasés à connecter uniquement sur des schémas d'alimentation TN *étoile ou TT) ou, lorsque c'est approprié, un autre circuit d'essai figurant dans les Figures 7, 9, 10, 12, 13 ou 14 de la CEI 60990.*

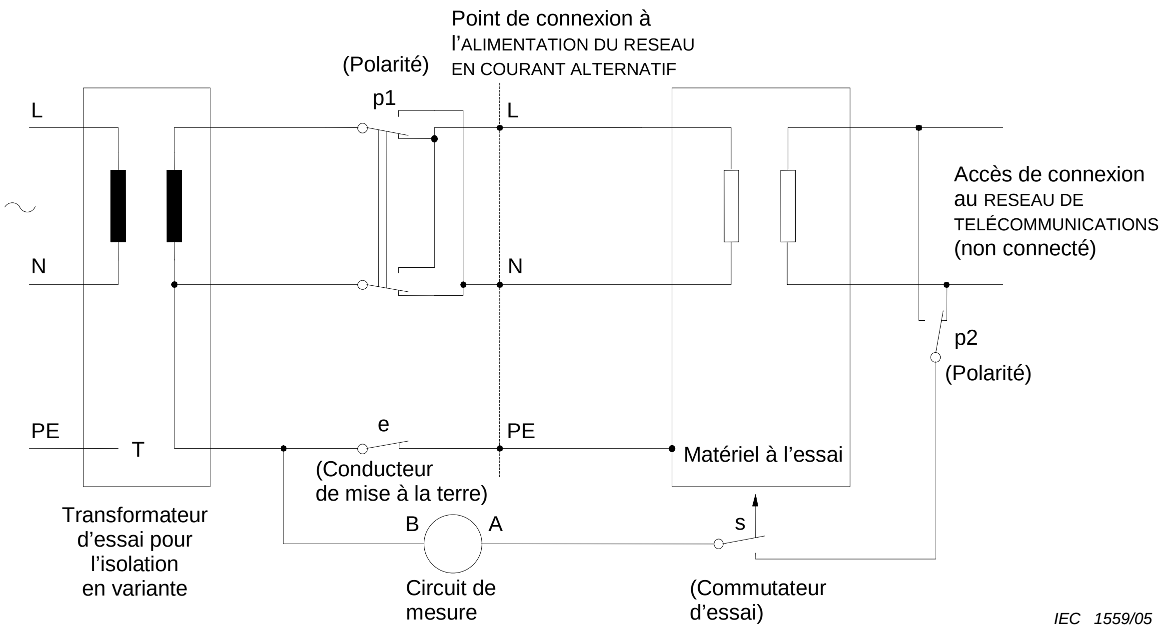
L'utilisation d'un transformateur d'essai pour l'isolation est optionnel. Pour la protection maximale, un transformateur d'essai pour l'isolation (T dans les Figures 5A et 5B) est utilisé et la borne principale de mise à la terre de protection du matériel à l'essai est mise à la terre. Toute fuite capacitive dans le transformateur doit être prise en compte. En variante à la mise à la terre du matériel à l'essai, le secondaire du transformateur d'essai et le matériel à l'essai sont laissés flottants (non mis à la terre), auquel cas il n'est pas nécessaire de tenir compte de la fuite capacitive dans le transformateur.

Si le transformateur T n'est pas utilisé, l'appareil en essai et les circuits d'essai ne doivent pas être mis à la terre. Le matériel en essai est placé sur un support isolant, et des précautions adéquates de sécurité sont prises dans l'éventualité de la mise sous TENSION DANGEREUSE de la MASSE du matériel.

Les matériels à connecter sur un schéma d'alimentation IT sont essayés en conséquence (voir les Figures 9, 10 et 12 de la CEI 60990). De tels matériels peuvent aussi être connectés sur des schémas d'alimentation TN ou TT sans autre essai.

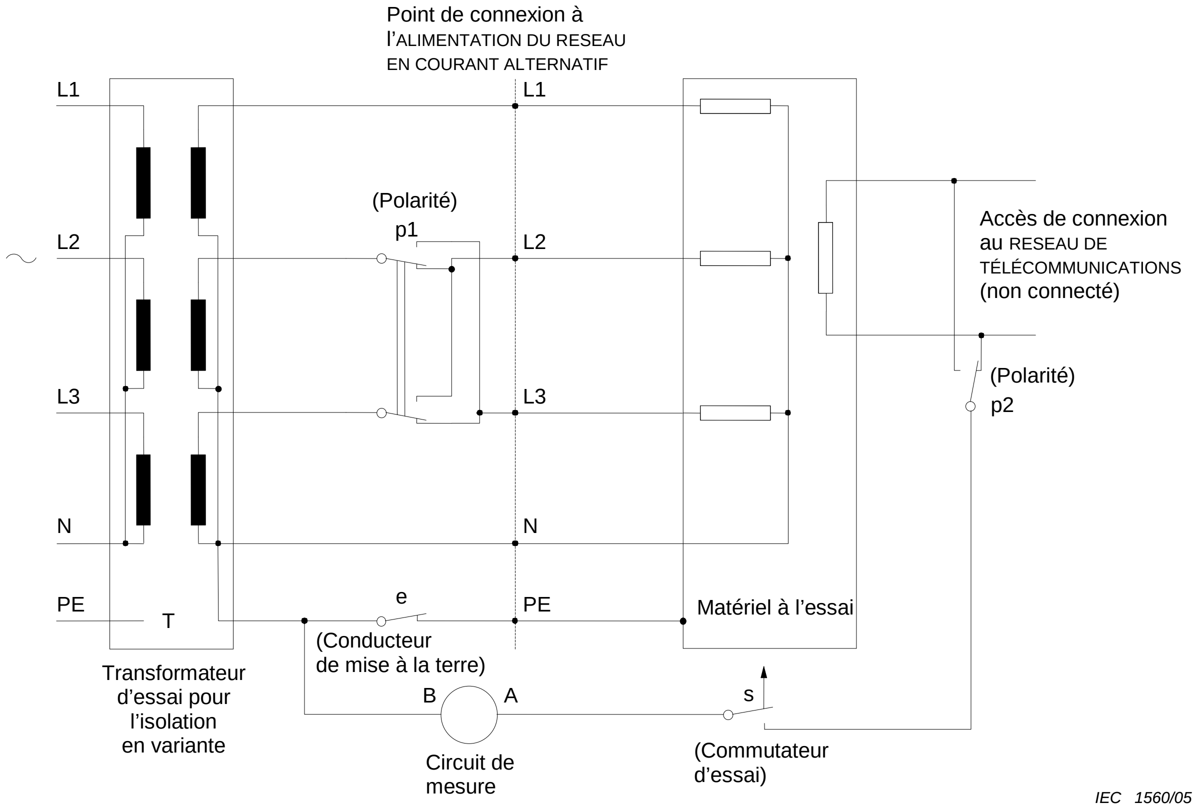
Un matériel monophasé destiné à fonctionner entre deux conducteurs de phase est essayé à l'aide d'un circuit d'essai triphasé tel que celui de la Figure 5B.

S'il y a un inconvénient à essayer le matériel à la tension d'alimentation la plus défavorable (voir 1.4.5), il est permis de faire l'essai à n'importe quelle tension disponible dans la PLAGE ASSIGNÉE DE TENSIONS ou dans la tolérance de la TENSION ASSIGNÉE, et de calculer ensuite les résultats.



NOTE Cette figure est tirée de la Figure 6 de la CEI 60990.

Figure 5A – Circuit d'essai pour le courant de contact d'un matériel monophasé sur des schémas d'alimentation TN étoile ou TT



NOTE Cette figure est tirée de la Figure 11 de la CEI 60990.

Figure 5B – Circuit d'essai pour le courant de contact d'un matériel triphasé sur des schémas d'alimentation TN étoile ou TT

5.1.4 Application de l'appareil de mesure

Les essais sont effectués à l'aide de l'un des appareils de mesure de l'Annexe D, ou de tout autre circuit donnant les mêmes résultats.

L'extrémité B de l'appareil de mesure est connectée au conducteur mis à la terre (neutre) de l'alimentation (voir Figure 5A ou 5B).

L'extrémité A de l'appareil de mesure est connectée comme spécifié en 5.1.5.

Pour une partie accessible non conductrice, l'essai est effectué vers une feuille métallique de dimensions 100 mm sur 200 mm en contact avec la partie. Si la surface de la feuille est plus petite que la surface en essai, la feuille est déplacée pour essayer toutes les parties de la surface. Lorsqu'une feuille métallique adhésive est utilisée, l'adhésif doit être conducteur. Des précautions sont prises pour empêcher que la feuille métallique n'affecte la dissipation de chaleur du matériel.

NOTE 1 L'essai utilisant la feuille simule le contact de la main.

Les parties conductrices qui sont connectées de manière fortuite à d'autres parties sont essayées à la fois comme parties connectées et comme parties déconnectées.

NOTE 2 Les parties connectées de manière fortuite sont décrites avec plus de détails dans l'Annexe C de la CEI 60990.

5.1.5 Procédure d'essai

Pour les matériels ayant une connexion de mise à la terre de protection ou une connexion de MISE A LA TERRE FONCTIONNELLE*, l'extrémité A de l'appareil de mesure est connectée par l'intermédiaire de l'interrupteur de mesure «s», à la borne principale de mise à la terre du matériel à l'essai, l'interrupteur «e» du conducteur de mise à la terre étant ouvert.*

L'essai est aussi effectué, sur tous les matériels, avec l'extrémité A du réseau de mesure connecté par l'intermédiaire de l'interrupteur de mesure «s», à chaque partie accessible non mise à la terre ou non conductrice et à chaque circuit accessible non mis à la terre, à tour de rôle, l'interrupteur «e» du conducteur de mise à la terre étant fermé.

De plus:

- *pour les matériels monophasés, les essais sont répétés en polarité inversée (interrupteur «p1»);*
- *pour les matériels triphasés, les essais sont répétés en polarité inversée (interrupteur «p1») à moins que le matériel ne soit sensible à la séquence de phases.*

Lors des essais des matériels triphasés, tous les composants utilisés pour des raisons de CEM et reliés entre phase et terre sont déconnectés un par un. A cet effet, les groupes de composants en parallèle reliés par une connexion unique sont traités comme des composants uniques. Chaque fois qu'on déconnecte une connexion à la terre du composant, la séquence de manœuvres des interrupteurs est répétée.

NOTE Si les filtres sont normalement enrobés, il peut être nécessaire de fournir un filtre non enrobé pour cet essai ou de simuler le réseau du filtre.

Pour chaque position de l'appareil de mesure, tous les interrupteurs dans le CIRCUIT PRIMAIRE *et susceptibles d'être manœuvrés en usage normal sont ouverts et fermés dans toutes les combinaisons possibles.*

Après application de chacune des conditions d'essai, le matériel est ramené à son état de fonctionnement d'origine, sans défaut ou dommage consécutif.

5.1.6 Mesures d'essai

Soit la valeur efficace de la tension, U_2, est mesurée à l'aide de l'appareil de mesure de la Figure D.1, soit la valeur efficace du courant est mesurée à l'aide de l'appareil de mesure de la Figure D.2.

L'appareil D.1 permet une mesure plus précise que l'appareil D.2 si la forme d'onde est non sinusoïdale et si la fréquence fondamentale dépasse 100 Hz.

En variante, la valeur de crête de la tension, U_2, est mesurée à l'aide de l'appareil de mesure décrit à l'Article D.1.

Si la tension, U_2, est mesurée à l'aide de l'appareil de mesure décrit à l'Article D.1, le calcul suivant est utilisé:

$$\text{COURANT DE CONTACT } (A) = U_2 / 500$$

NOTE Bien que les valeurs efficaces du COURANT DE CONTACT aient traditionnellement été mesurées, les valeurs de crête fournissent une meilleure corrélation avec la réponse du corps humain aux formes d'onde de courant non sinusoïdal.

Aucune des valeurs mesurées conformément à 5.1.6 ne doit dépasser les limites correspondantes du Tableau 5A, à l'exception de ce qui est permis en 2.4 (voir aussi 1.5.6 et 1.5.7) et 5.1.7.

Tableau 5A – Courant maximal

<table>
<tr><th>Type de matériel</th><th>Borne A de l'appareil de mesure reliée à:</th><th>COURANT DE CONTACT maximal mA efficace [a]</th><th>COURANT maximal DANS LE CONDUCTEUR DE PROTECTION</th></tr>
<tr><td>Tous les matériels</td><td>Parties accessibles et circuits non connectés à la terre de protection[b]</td><td>0,25</td><td>–</td></tr>
<tr><td>PORTATIFS</td><td rowspan="4">Borne principale de mise à la terre de protection
(si elle existe)</td><td>0,75</td><td>–</td></tr>
<tr><td>PORTABLES (autres que PORTATIFS mais y compris les TRANSPORTABLES)</td><td>3,5</td><td>–</td></tr>
<tr><td>FIXES, TYPE A RELIES PAR PRISE DE COURANT</td><td>3,5</td><td>–</td></tr>
<tr><td>Tous les autres MATERIELS FIXES
– non soumis aux conditions de 5.1.7
– soumis aux conditions de 5.1.7</td><td>
3,5
–</td><td>
–
5 % du courant d'entrée</td></tr>
<tr><td colspan="4">[a] Si des valeurs de crête du COURANT DE CONTACT sont mesurées, les valeurs maximales sont obtenues en multipliant les valeurs efficaces dans le tableau par 1,414.
[b] Certaines parties accessibles non reliées à la terre sont couvertes par 1.5.6 et 1.5.7 et les exigences de 2.4 s'appliquent. Elles peuvent différer de celles de 5.1.6.</td></tr>
</table>

5.1.7 Matériel avec un courant de contact dépassant 3,5 mA

5.1.7.1 Généralités

Les résultats de mesure du COURANT DE CONTACT dépassant 3,5 mA en valeur efficace sont autorisés pour les matériels suivants qui possèdent une borne de mise à la terre de protection:

– MATERIEL FIXE RELIE A DEMEURE;

– MATERIEL FIXE DU TYPE B RACCORDE PAR PRISE DE COURANT;

– MATERIEL FIXE DU TYPE A RACCORDE PAR PRISE DE COURANT avec une connexion unique au RESEAU D'ALIMENTATION EN COURANT ALTERNATIF et équipé d'une borne de mise à la terre de protection en plus de la borne principale de mise à la terre de protection, le cas échéant (voir 2.6.4.1). Les instructions d'installation doivent spécifier que cette borne séparée de mise à la terre de protection est reliée à la terre de façon permanente;

NOTE 1 Le matériel ci-dessus ne doit pas être installé à un EMPLACEMENT A ACCES RESTREINT. Toutefois, l'exigence pour le MATERIEL FIXE est plus sévère que les exigences similaires de 2.3.2.3 a) parce que le risque potentiel est plus important.

– MATERIEL MOBILE ou le MATERIEL DU TYPE A RACCORDE PAR PRISE DE COURANT destiné à être utilisé dans UN EMPLACEMENT A ACCES RESTREINT avec une connexion unique au RESEAU D'ALIMENTATION EN COURANT ALTERNATIF et équipé d'une borne de mise à la terre de protection séparée en plus de la borne principale de mise à la terre de protection, le cas échéant (voir 2.6.4.1). Les instructions d'installation doivent spécifier que cette borne séparée de mise à la terre de protection est reliée à la terre de façon permanente;

NOTE 2 La limitation d'utilisation à un EMPLACEMENT A ACCES RESTREINT est plus sévère que les exigences similaires de 2.3.2.3 a) parce que le risque potentiel est plus important.

– MATERIEL FIXE DU TYPE A RACCORDE PAR PRISE DE COURANT avec connexions multiples simultanées au RESEAU D'ALIMENTATION EN COURANT ALTERNATIF, destiné à être utilisé à un emplacement disposant d'une liaison équipotentielle (par exemple un centre de télécommunications, une salle informatique dédiée ou un EMPLACEMENT A ACCES RESTREINT). Une borne de mise à la terre de protection supplémentaire séparée doit être prévue sur le matériel. Les instructions d'installation doivent exiger tous les éléments suivants:

- l'installation du bâtiment doit fournir un moyen de connexion à la terre de protection; et
- le matériel doit être connecté à ce moyen; et
- une personne du PERSONNEL DE MAINTENANCE doit vérifier si le socle de prise qui doit alimenter le matériel possède ou non une connexion à la terre de protection du bâtiment. Si tel n'est pas le cas, la personne membre du PERSONNEL DE MAINTENANCE doit pourvoir à l'installation d'un CONDUCTEUR DE MISE A LA TERRE DE PROTECTION entre la borne de mise à la terre de protection séparée et le fil de terre de protection dans le bâtiment.

NOTE 3 En Finlande, en Norvège et en Suède, les résultats de mesure du COURANT DE CONTACT qui dépassent 3,5 mA en valeur efficace sont autorisés uniquement pour le matériel suivant:

- MATERIEL FIXE DU TYPE A RACCORDE PAR PRISE DE COURANT qui
  - est destiné à être utilisé dans un EMPLACEMENT A ACCES RESTREINT où la liaison équipotentielle a été appliquée, par exemple dans un centre de télécommunications; et
  - est équipé pour un CONDUCTEUR DE MISE A LA TERRE DE PROTECTION relié à demeure; et
  - est fourni avec des instructions pour l'installation de ce conducteur par une personne du PERSONNEL DE MAINTENANCE;
- MATERIEL FIXE DU TYPE B RACCORDE PAR PRISE DE COURANT;
- MATERIEL FIXE RELIE A DEMEURE.

NOTE 4 Au Danemark, les résultats des mesures du COURANT DE CONTACT dépassant 3,5 mA en valeur efficace sont autorisés uniquement pour les MATERIELS RELIES A DEMEURE et les MATERIELS DE TYPE B RACCORDES PAR PRISE DE COURANT.

Si le résultat de la mesure du COURANT DE CONTACT sur l'un des matériels indiqués ci-dessus dépasse 3,5 mA en valeur efficace, les exigences suivantes a) et b) s'appliquent ainsi que celles de 5.1.7.2, le cas échéant.

a) Le COURANT efficace DANS LE CONDUCTEUR DE PROTECTION ne doit pas dépasser 5 % du courant de charge par phase dans les conditions normales de fonctionnement. Si la charge n'est pas équilibrée, on doit utiliser pour ce calcul le plus élevé des courants sur les trois phases.

   Pour mesurer le COURANT DU CONDUCTEUR DE PROTECTION, la procédure pour mesurer le COURANT DE CONTACT est utilisée, mais l'appareil de mesure est remplacé par un ampèremètre à impédance négligeable; et

b) une des étiquettes suivantes, ou une étiquette portant une phrase analogue, doit être fixée au voisinage de la connexion du RESEAU D'ALIMENTATION EN COURANT ALTERNATIF:

AVERTISSEMENT	**AVERTISSEMENT**
COURANT DE FUITE ÉLEVÉ RACCORDEMENT À LA TERRE INDISPENSABLE AVANT LE RACCORDEMENT À L'ALIMENTATION	**COURANT DE CONTACT ÉLEVÉ RACCORDEMENT À LA TERRE INDISPENSABLE AVANT LE RACCORDEMENT À L'ALIMENTATION**

La vérification est effectuée par examen et par des mesures.

5.1.7.2 Connexions multiples simultanées à l'alimentation

Ce qui suit s'applique au matériel essayé selon 5.1.2.3. Si le résultat de la mesure du COURANT DE CONTACT total dépasse 3,5 mA en valeur efficace, l'essai est répété avec chaque RESEAU D'ALIMENTATION EN COURANT ALTERNATIF et son CONDUCTEUR DE TERRE DE PROTECTION connecté un à la fois, l'autre RESEAU D'ALIMENTATION EN COURANT ALTERNATIF, y compris ses CONDUCTEURS DE TERRE DE PROTECTION, étant déconnecté. Toutefois, si deux connexions au RESEAU D'ALIMENTATION EN COURANT ALTERNATIF sont inséparables, par exemple des *connexions pour un moteur et ses circuits de commande, elles doivent être toutes les deux sous tension pour un essai répété.*

NOTE Il n'est pas attendu que le matériel en essai fonctionne normalement au cours de cet essai.

Si le résultat de la mesure du COURANT DE CONTACT pour un des essais répétés dépasse 3,5 mA en valeur efficace, les exigences de 5.1.7.1 a) s'appliquent à la connexion concernée avec le RESEAU D'ALIMENTATION EN COURANT ALTERNATIF. Pour calculer 5 % du courant d'entrée par phase, on utilise le courant d'entrée provenant du RESEAU D'ALIMENTATION EN COURANT ALTERNATIF mesuré au cours de l'essai répété.

5.1.8 Courants de contact transmis vers des réseaux de télécommunications et des systèmes de distribution par câbles et reçus des réseaux de télécommunications

NOTE Dans le présent paragraphe, les références aux «accès de connexion du RESEAU DE TELECOMMUNICATIONS» (ou accès de télécommunications) sont destinées à couvrir les points de connexion auxquels un RESEAU DE TELECOMMUNICATIONS est destiné à être raccordé. De telles références ne sont pas destinées à inclure d'autres accès de données, tels que ceux qui sont communément identifiés comme série, parallèles, clavier, jeu, manette, etc.

5.1.8.1 Limitation du courant de contact transmis à un réseau de télécommunications et à un système de distribution par câbles

Le COURANT DE CONTACT d'un matériel alimenté par un RESEAU D'ALIMENTATION EN COURANT ALTERNATIF vers un RESEAU DE TELECOMMUNICATIONS ou un SYSTEME DE DISTRIBUTION PAR CABLES doit être limité.

La vérification est effectuée à l'aide du circuit d'essai détaillé en 5.1.3.

Les essais ne sont pas effectués sur les matériels dans lesquels le circuit à relier à un RÉSEAU DE TÉLECOMMUNICATIONS OU À UN SYSTEME DE DISTRIBUTION PAR CABLES est connecté à la borne de mise à la terre de protection ou à la borne de MISE À LA TERRE FONCTIONNELLE dans le matériel. Le courant du matériel à l'essai vers le RÉSEAU DE TÉLÉCOMMUNICATIONS ou le SYSTEME DE DISTRIBUTION PAR CABLES est considéré comme étant égal à zéro.

Pour les matériels ayant plus d'un circuit à connecter au RÉSEAU DE TÉLÉCOMMUNICATIONS ou au SYSTEME DE DISTRIBUTION PAR CABLES, l'essai est effectué sur un seul exemple de chaque type de circuit.

Pour les matériels qui n'ont pas de borne principale de mise à la terre de protection, l'interrupteur du conducteur de protection "e", s'il est connecté à une borne de MISE À LA TERRE FONCTIONNELLE sur le matériel à l'essai, est laissé ouvert. Sinon il est fermé.

La borne B de l'appareil de mesure est connectée au conducteur mis à la terre (neutre) de l'alimentation. La borne A est connectée par l'intermédiaire de l'interrupteur de mesure «s» et l'interrupteur de polarité «p2» à l'accès de connexion du RÉSEAU DE TÉLÉCOMMUNICATIONS ou du SYSTEME DE DISTRIBUTION PAR CABLES.

Pour les matériels monophasés l'essai est effectué dans toutes les combinaisons des interrupteurs de polarité "p1" et "p2".

Pour les matériels triphasés, l'essai est effectué dans les deux positions de l'interrupteur de polarité "p2".

Après application de chacune des conditions d'essai, le matériel est ramené à son état de fonctionnement d'origine.

Les mesures d'essai sont effectuées à l'aide de l'un des appareils de mesure de l'Annexe D comme décrit en 5.1.6.

Aucune des valeurs mesurées conformément à 5.1.8.1 ne doit dépasser 0,25 mA en valeur efficace.

5.1.8.2 Sommation des courants de contact reçus des réseaux de télécommunications

NOTE L'Annexe W explique la base de 5.1.8.2.

Un matériel à l'essai qui fournit des accès de connexion du RESEAU DE TELECOMMUNICATIONS pour la connexion de multiples éléments d'autres matériels de télécommunications ne doit pas créer un danger pour les UTILISATEURS et le PERSONNEL DE MAINTENANCE du RESEAU DE TELECOMMUNICATIONS du fait de la sommation des courants de contacts.

Dans ces exigences, les abréviations ont la signification suivante:

– I_1 est le COURANT DE CONTACT reçu d'autres matériels par l'intermédiaire d'un RESEAU DE TELECOMMUNICATIONS à l'accès de télécommunication du matériel à l'essai;
– $\sum I_1$ est la somme des COURANTS DE CONTACT reçus d'autres matériels à tous les accès de télécommunications du matériel à l'essai;
– I_2 est le COURANT DE CONTACT dû au RESEAU D'ALIMENTATION EN COURANT ALTERNATIF du matériel à l'essai.

Il doit être supposé que chaque accès de télécommunications reçoit 0,25 mA ($I_{1)}$ de l'autre matériel, à moins que l'on sache que le courant réel venant de l'autre matériel est inférieur.

Les exigences suivantes, a) ou b) suivant celle qui s'applique, doivent être respectées:

a) Matériel à l'essai avec des accès de télécommunications mis à la terre

Pour un matériel à l'essai dans lequel chaque accès de télécommunications est relié à la borne de mise à la terre de protection du matériel à l'essai, les points suivants 1), 2) et 3) doivent être pris en considération:

1) si $\sum I_1$ (non compris I_2) dépasse 3,5 mA:
   – le matériel doit être équipé d'une possibilité de connexion permanente à la terre de protection en plus du CONDUCTEUR DE MISE A LA TERRE DE PROTECTION dans le câble d'alimentation des MATERIELS DE TYPE A ou B RACCORDES PAR PRISE DE COURANT; et
   – les instructions d'installation doivent spécifier la fourniture d'une connexion permanente à la terre de protection, avec une section au moins égale à 2,5 mm^2, si elle a une protection mécanique, sinon de 4,0 mm$^{2;}$ et
   – une des étiquettes suivantes, ou une étiquette portant une phrase analogue, doit être fixée au voisinage de la connexion permanente à la terre. Il est permis de combiner cette étiquette avec l'étiquette de 5.1.7.1 b).

AVERTISSEMENT	AVERTISSEMENT
COURANT DE FUITE ÉLEVÉ RACCORDEMENT À LA TERRE INDISPENSABLE AVANT LE RACCORDEMENT AU RÉSEAU DE TÉLÉCOMMUNICATIONS	**COURANT DE CONTACT ÉLEVÉ RACCORDEMENT À LA TERRE INDISPENSABLE AVANT LE RACCORDEMENT AU RÉSEAU DE TÉLÉCOMMUNICATIONS**

2) $\sum I_1$ plus I_2 doit satisfaire aux limites du Tableau 5A (voir 5.1.6).
3) Si c'est applicable, un tel matériel doit satisfaire à 5.1.7. La valeur de I_2 doit être utilisée pour calculer la limite de 5 % du courant d'entrée par phase spécifiée en 5.1.7.

La vérification de la conformité au point a) est effectuée par examen et, si nécessaire, par un essai.

Si le matériel est équipé d'une possibilité de connexion permanente à la terre de protection conformément au point 1) ci-dessus, il n'est pas nécessaire de faire des mesures, excepté que I_2 doit satisfaire aux exigences applicables de 5.1.

Les essais de COURANT DE CONTACT, s'ils sont nécessaires, sont effectués à l'aide de l'appareil de mesure convenable décrit à l'Annexe D ou de tout autre appareil donnant les mêmes résultats. Une source en courant alternatif à couplage capacitif de la même fréquence de ligne et phase que le RÉSEAU D'ALIMENTATION EN COURANT ALTERNATIF est appliquée à chaque accès de télécommunications de façon que 0,25 mA, ou le courant réel venant du matériel si on sait qu'il est inférieur, soit disponible pour traverser cet accès de télécommunications. Le courant circulant dans le conducteur de protection est alors mesuré.

b) Matériel à l'essai dont les accès de télécommunications n'ont pas de référence par rapport à la terre de protection

Si les accès de télécommunications sur le matériel n'ont pas de connexion commune, chaque accès de télécommunications doit satisfaire à 5.1.8.1.

Si tous les accès de télécommunications ou si un groupe de tels accès ont une connexion commune, le COURANT DE CONTACT total de chaque connexion commune ne doit pas dépasser 3,5 mA.

La vérification de la conformité au point b) est effectuée par examen et, si nécessaire, par les essais de 5.1.8.1 ou, s'il y a des points de connexion commune, par l'essai suivant.

Une source en courant alternatif à couplage capacitif de même fréquence de ligne et de même phase que le RÉSEAU D'ALIMENTATION EN COURANT ALTERNATIF est appliquée à chaque accès de télécommunications de façon que 0,25 mA, ou le courant réel venant du matériel si l'on sait qu'il est inférieur, soit disponible pour traverser cet accès de télécommunications. Les points de connexion communs sont essayés conformément à 5.1, que ces points soient accessibles ou non.

5.2 Rigidité diélectrique

NOTE Lorsque l'on fait référence à l'essai de rigidité diélectrique de 5.2 dans d'autres parties de cette norme, on considère que l'essai de rigidité diélectrique est effectué à chaud conformément à 5.2.1.

Lorsque l'on fait une référence spécifique à l'essai de rigidité diélectrique à 5.2.2 dans d'autres parties de cette norme, on considère que l'essai de rigidité diélectrique est effectué sans le chauffage préalable donné en 5.2.1.

5.2.1 Généralités

La rigidité diélectrique de l'ISOLATION SOLIDE utilisée dans le matériel doit être appropriée.

La vérification est effectuée conformément à 5.2.2 alors que le matériel est encore en bonne condition de température immédiatement après l'essai d'échauffement de 4.5.2.

Si un composant ou un sous-ensemble est essayé séparément à l'extérieur du matériel, il est porté à la température atteinte par cette partie pendant l'essai d'échauffement de 4.5.2 (par exemple en le plaçant dans une étuve) avant l'essai de rigidité diélectrique. Toutefois, il est permis que les essais de rigidité diélectrique des matériaux en couches minces pour l'ISOLATION SUPPLÉMENTAIRE ou l'ISOLATION RENFORCÉE selon 2.10.5.9 ou 2.10.5.10 soient effectués à la température ambiante.

Aucun essai de rigidité diélectrique ne s'applique à l'isolation d'un transformateur entre un enroulement quelconque et le noyau ou l'écran, pourvu que le noyau ou l'écran soit totalement enfermé ou mis sous boîtier rempli et qu'il n'y ait aucune connexion électrique au noyau ou à l'écran. Toutefois, les essais entre les parties qui ont des sorties continuent de s'appliquer.

5.2.2 Procédure d'essai

Sauf spécification contraire dans la présente norme, l'isolation est soumise soit à une tension pratiquement sinusoïdale, de 50 Hz ou 60 Hz soit à une TENSION CONTINUE de valeur égale à la valeur de crête de la tension d'essai alternative prescrite.

Les tensions d'essai pour la rigidité diélectrique pour la qualité appropriée d'isolation (ISOLATION FONCTIONNELLE si prescrite en 5.3.4 b), ISOLATION PRINCIPALE, ISOLATION SUPPLEMENTAIRE OU ISOLATION RENFORCEE) sont telles que spécifiées soit:

- *au Tableau 5B en utilisant la VALEUR DE CRETE DE LA TENSION DE SERVICE (U) en 2.10.2; soit*
- *au Tableau 5C en utilisant la TENSION DE TENUE PRESCRITE, telle que déterminée à l'Article G.4.*

NOTE 1 A différents endroits dans la présente norme, des essais spéciaux de rigidité diélectrique ou des tensions d'essai spéciales sont spécifiés pour certaines situations. Les tensions d'essai de 5.2.2 ne s'appliquent pas à de telles situations.

NOTE 2 Pour la prise en compte des surtensions temporaires, voir la CEI 60664-1.

Pour les matériels des catégories de surtension I et II, il est permis d'utiliser soit le Tableau 5B soit le Tableau 5C. Toutefois, pour un CIRCUIT SECONDAIRE qui n'est ni connecté à une terre de protection ni équipé d'une grille de protection conforme à 2.6.1 e), c'est le Tableau 5C qui doit être utilisé.

Pour les matériels des catégories de surtensions III et IV, le Tableau 5C doit être utilisé.

La tension appliquée à l'isolation en essai est amenée progressivement de zéro à la tension prescrite, et maintenue à cette valeur pendant 60 s.

Si, ailleurs dans la présente norme, des ESSAIS INDIVIDUELS DE SERIE sont prescrits conformément à 5.2.2, il est permis de réduire la durée de l'essai de rigidité diélectrique à 1 s pour réduire de 10 % la tension d'essai autorisée au Tableau 5C.

Il ne doit pas se produire de rupture de l'isolation pendant l'essai.

On considère qu'il s'est produit une rupture de l'isolation lorsque le courant qui circule par l'effet de l'application de la tension d'essai augmente rapidement d'une façon incontrôlée, c'est-à-dire que l'isolation n'empêche plus la circulation du courant. L'effet de couronne ou un simple contournement momentané n'est pas considéré comme une perforation de l'isolation.

Les revêtements isolants sont essayés avec une feuille métallique en contact avec la surface isolante. Cette procédure est limitée aux endroits où l'isolation est présumée faible, par exemple aux endroits où des arêtes vives métalliques se trouvent sous l'isolation. Lorsque c'est possible, les revêtements d'isolation sont essayés séparément. On veille à ce que la feuille métallique soit placée de telle façon qu'il ne se produise pas de contournement aux bords de l'isolation. Lorsqu'une feuille métallique adhésive est utilisée, l'adhésif doit être conducteur.

Pour éviter les dommages aux composants ou aux isolations qui ne sont pas concernés par l'essai, il est permis de déconnecter les circuits intégrés ou analogues ainsi que d'utiliser une liaison équipotentielle.

Pour le matériel comportant à la fois une ISOLATION RENFORCEE et des natures d'isolation plus faibles, on veille à ce que la tension appliquée à l'ISOLATION RENFORCEE ne produise pas de contraintes trop élevées sur l'ISOLATION PRINCIPALE ou sur l'ISOLATION SUPPLÉMENTAIRE.

NOTE 3 Lorsqu'il y a des condensateurs sur l'isolation à l'essai (par exemple condensateurs d'antiparasitage), il est recommandé d'utiliser des tensions d'essai continues.

NOTE 4 Il y a lieu de déconnecter les composants qui fournissent un chemin en courant continu en parallèle avec l'isolation à essayer, tels que les résistances de décharge des condensateurs de filtre et les dispositifs de limitation de tension.

Lorsque l'isolation d'un enroulement de transformateur varie le long de la longueur de l'enroulement conformément à 2.10.1.5, une méthode d'essai de rigidité diélectrique qui en tient compte est utilisée.

NOTE 5 Un exemple d'une telle méthode d'essai est une méthode dans laquelle une tension d'essai induite est appliquée à une fréquence suffisamment élevée pour éviter la saturation du transformateur. On augmente la tension d'entrée jusqu'à une valeur qui induit une tension de sortie égale à la tension d'essai requise.

Aucun essai n'est appliqué à l'ISOLATION FONCTIONNELLE à moins que 5.3.4 b) n'ait été choisi.

Tableau 5B – Tensions d'essai pour les essais de rigidité diélectrique fondés sur les valeurs de crête des tensions de service

Partie 1

Nature de l'isolation	Points d'application (suivant ce qui est approprié)						
	CIRCUIT PRIMAIRE et MASSE CIRCUIT PRIMAIRE et CIRCUIT SECONDAIRE entre parties de CIRCUITS PRIMAIRES					CIRCUIT SECONDAIRE et MASSE entre CIRCUITS SECONDAIRES indépendants	
	TENSION DE SERVICE *U*, de crête ou continue					TENSION DE SERVICE *U*	
	jusqu'à 210 V inclus [a]	Supé-rieure à 210 V jusqu'à 420 V inclus [b]	Supérieure à 420 V jusqu'à 1,41 kV inclus	Supérieure à 1,41 kV jusqu'à 10 kV inclus [c]	Supérieure à 10 kV jusqu'à 50 kV inclus	Jusqu'à 42,4 V inclus crête ou 60 V continue [d]	Supérieure à 42,4 V crête ou 60 V continue jusqu'à 10 kV inclus crête ou continue [d]
	Tension d'essai, volts efficaces en courant alternatif						
FONCTIONNELLE	1 000	1 500	voir V_a dans le Tableau 5B, partie 2	voir V_a dans le Tableau 5B, partie 2	1,06 *U*	500	voir V_a dans le Tableau 5B, partie 2
PRINCIPALE, SUPPLEMENTAIRE	1 000	1 500	voir V_a dans le Tableau 5B, partie 2	voir V_a dans le Tableau 5B, partie 2	1,06 *U*	Pas d'essai	voir V_a dans le Tableau 5B, partie 2
RENFORCEE	2 000	3 000	3 000	voir V_b dans le Tableau 5B, partie 2	1,06 *U*	Pas d'essai	voir V_b dans le Tableau 5B, partie 2

Pour des VALEURS DE CRETE DE LA TENSION DE SERVICE supérieures à 10 kV, valeur de crête ou continue dans les CIRCUITS SECONDAIRES, des tensions d'essai identiques à celles pour les CIRCUITS PRIMAIRES s'appliquent.

[a] Utiliser cette colonne pour les RESEAUX D'ALIMENTATION EN COURANT CONTINU non reliés à la terre jusqu'à 210 V inclus [voir 2.10.3.2 c)].

[b] Utiliser cette colonne pour les RESEAUX D'ALIMENTATION EN COURANT CONTINU non reliés à la terre au-delà de 210 V, jusqu'à 420 V inclus [voir 2.10.3.2 c)].

[c] Utiliser cette colonne pour les RESEAUX D'ALIMENTATION EN COURANT CONTINU au-delà de 420 V [voir 2.10.3.2 c)].

[d] Utiliser ces colonnes pour le courant continu dérivé dans le matériel provenant d'un RESEAU D'ALIMENTATION EN COURANT ALTERNATIF ou pour les RESEAUX D'ALIMENTATION EN COURANT CONTINU qui sont reliés à la terre dans le même bâtiment.

Tableau 5B – Tensions d'essai pour les essais de rigidité diélectrique fondés sur les valeurs de crête des tensions de service

Partie 2

U valeur de crête ou tension continue	V_a c.a efficace	V_b c.a efficace	***U*** valeur de crête ou tension continue	V_a c.a efficace	V_b c.a efficace	***U*** valeur de crête ou tension continue	V_a c.a efficace	V_b c.a efficace
34	500	800	250	1 261	2 018	1 750	3 257	3 257
35	507	811	260	1 285	2 055	1 800	3 320	3 320
36	513	821	270	1 307	2 092	1 900	3 444	3 444
38	526	842	280	1 330	2 127	2 000	3 566	3 566
40	539	863	290	1 351	2 162	2 100	3 685	3 685
42	551	882	300	1 373	2 196	2 200	3 803	3 803
44	564	902	310	1 394	2 230	2 300	3 920	3 920
46	575	920	320	1 414	2 263	2 400	4 034	4 034
48	587	939	330	1 435	2 296	2 500	4 147	4 147
50	598	957	340	1 455	2 328	2 600	4 259	4 259
52	609	974	350	1 474	2 359	2 700	4 369	4 369
54	620	991	360	1 494	2 390	2 800	4 478	4 478
56	630	1 008	380	1 532	2 451	2 900	4 586	4 586
58	641	1 025	400	1 569	2 510	3 000	4 693	4 693
60	651	1 041	420	1 605	2 567	3 100	4 798	4 798
62	661	1 057	440	1 640	2 623	3 200	4 902	4 902
64	670	1 073	460	1 674	2 678	3 300	5 006	5 006
66	680	1 088	480	1 707	2 731	3 400	5 108	5 108
68	690	1 103	500	1 740	2 784	3 500	5 209	5 209
70	699	1 118	520	1 772	2 835	3 600	5 309	5 309
72	708	1 133	540	1 803	2 885	3 800	5 507	5 507
74	717	1 147	560	1 834	2 934	4 000	5 702	5 702
76	726	1 162	580	1 864	2 982	4 200	5 894	5 894
78	735	1 176	588	1 875	3 000	4 400	6 082	6 082
80	744	1 190	600	1 893	3 000	4 600	6 268	6 268
85	765	1 224	620	1 922	3 000	4 800	6 452	6 452
90	785	1 257	640	1 951	3 000	5 000	6 633	6 633
95	805	1 288	660	1 979	3 000	5 200	6 811	6 811
100	825	1 319	680	2 006	3 000	5 400	6 987	6 987
105	844	1 350	700	2 034	3 000	5 600	7 162	7 162
110	862	1 379	720	2 060	3 000	5 800	7 334	7 334
115	880	1 408	740	2 087	3 000	6 000	7 504	7 504
120	897	1 436	760	2 113	3 000	6 200	7 673	7 673
125	915	1 463	780	2 138	3 000	6 400	7 840	7 840
130	931	1 490	800	2 164	3 000	6 600	8 005	8 005
135	948	1 517	850	2 225	3 000	6 800	8 168	8 168
140	964	1 542	900	2 285	3 000	7 000	8 330	8 330
145	980	1 568	950	2 343	3 000	7 200	8 491	8 491
150	995	1 593	1 000	2 399	3 000	7 400	8 650	8 650
152	1 000	1 600	1 050	2 454	3 000	7 600	8 807	8 807
[a] 155	1 000	1 617	1 100	2 508	3 000	7 800	8 964	8 964
[a] 160	1 000	1 641	1 150	2 560	3 000	8 000	9 119	9 119
[a] 165	1 000	1 664	1 200	2 611	3 000	8 200	9 273	9 273
[a] 170	1 000	1 688	1 250	2 661	3 000	8 400	9 425	9 425
[a] 175	1 000	1 711	1 300	2 710	3 000	8 600	9 577	9 577
[a] 180	1 000	1 733	1 350	2 758	3 000	8 800	9 727	9 727
[a] 184	1 000	1 751	1 400	2 805	3 000	9 000	9 876	9 876
185	1 097	1 755	1 410	2 814	3 000	9 200	10 024	10 024
190	1 111	1 777	1 450	2 868	3 000	9 400	10 171	10 171
200	1 137	1 820	1 500	2 934	3 000	9 600	10 317	10 317
210	1 163	1 861	1 550	3 000	3 000	9 800	10 463	10 463
220	1 189	1 902	1 600	3 065	3 065	10 000	10 607	10 607
230	1 214	1 942	1 650	3 130	3 130			
240	1 238	1 980	1 700	3 194	3 194			

L'interpolation linéaire est autorisée entre les deux points les plus proches.

[a] Pour ces tensions, les valeurs de V_b sont déterminées par la courbe générale $V_b = 155{,}86\ U^{0{,}4638}$ et ne sont pas 1,6 V_a.

Tableau 5C – Tensions d'essai pour les essais de rigidité diélectrique fondées sur les tensions de tenue prescrite

TENSION DE TENUE PRESCRITE jusqu'à, inclus	Tension d'essai pour ISOLATION ~~FONCTIONNELLE,~~ PRINCIPALE ou ISOLATION SUPPLEMENTAIRE	Tension d'essai pour ISOLATION RENFORCEE
kV crête	kV crête ou continue	
0,33	~~0,35~~ 0,33	~~0,7~~ 0,5
0,5	~~0,55~~ 0,5	~~1,1~~ 0,8
0,8	~~0,9~~ 0,8	~~1,8~~ 1,5
1,5	1,5	~~3~~ 2,5
2,5	2,5	~~5~~ 4
4,0	4~~,0~~	~~8~~ 6
6,0	6~~,0~~	~~10~~ 8
8,0	8~~,0~~	~~13~~ 12
12	12	~~19~~ 18
U [a]	~~1,0 x~~ *U*	~~1,6~~ 1,5 x *U*

L'interpolation linéaire est autorisée entre les deux points les plus proches.

Si l'ISOLATION FONCTIONNELLE est soumise à l'essai (comme cela est prescrit en 5.3.4 b), la tension d'essai pour une TENSION DE SERVICE jusqu'à 42,4 V valeur de crête ou 60 V courant continu inclus ne doit pas dépasser 707 V en valeur de crête ou en courant continu. Pour une TENSION DE SERVICE supérieure, la tension d'essai donnée au Tableau 5B ou 5C est utilisée.

[a] *U* est toute TENSION DE TENUE PRESCRITE supérieure à 12,0 kV.

5.3 Fonctionnement anormal et conditions de défaut

5.3.1 Protection contre les surcharges et fonctionnement anormal

Le matériel doit être conçu de façon que les risques d'incendie ou de choc électrique, dus à une surcharge mécanique ou électrique ou à une défaillance, ou dus à un fonctionnement anormal ou à une utilisation négligente, soient limités autant que possible.

Après un fonctionnement anormal ou un premier défaut (voir 1.4.14), le matériel doit rester sûr pour l'OPERATEUR au sens de la présente norme, mais il n'est pas prescrit que le matériel soit encore en bon état de marche. Il est permis d'utiliser des coupe-circuit à fusibles, des COUPE-CIRCUIT THERMIQUES, des dispositifs de protection contre les surtensions ou des dispositifs analogues, pour assurer une protection appropriée.

La vérification est effectuée par examen et par les essais de 5.3. Avant le début de chaque essai, il est vérifié que le matériel fonctionne normalement.

Lorsqu'un composant ou un sous-ensemble est enfermé de telle sorte que la mise en court-circuit ou la déconnexion comme spécifié en 5.3 n'est pas possible ou est difficile à réaliser sans endommager le matériel, les essais peuvent être effectués sur des parties échantillons pourvues de câbles de connexion spéciaux. Si cela n'est pas possible ou pratique, le composant ou le sous-ensemble doit satisfaire aux essais comme un tout.

Les matériels sont essayés par application de toute condition qui peut survenir en usage normal et en mauvais usage prévisible.

De plus, les matériels qui sont munis d'un couvercle de protection doivent être essayés avec le couvercle en place dans les conditions normales de repos jusqu'à ce que l'état d'équilibre soit atteint.

5.3.2 Moteurs

Dans les conditions de surcharge, de rotor bloqué et dans les autres conditions anormales, les moteurs ne doivent pas créer de danger à cause de températures excessives.

NOTE Parmi les méthodes à utiliser, on peut citer les suivantes:

– utilisation de moteurs qui ne s'échauffent pas de façon excessive dans les conditions à rotor bloqué (protection par impédance propre ou externe);
– utilisation, dans les CIRCUITS SECONDAIRES, de moteurs qui peuvent dépasser les limites de température autorisées mais qui ne créent pas de danger;
– utilisation d'un dispositif sensible au courant du moteur;
– utilisation d'un COUPE-CIRCUIT THERMIQUE intégré;
– utilisation d'un circuit détecteur qui coupe l'alimentation du moteur en un temps suffisamment court pour le protéger contre un échauffement excessif si, par exemple, le moteur ne remplit pas la fonction à laquelle il est destiné.

La vérification est effectuée par l'essai applicable de l'Annexe B.

5.3.3 Transformateurs

Les transformateurs doivent être protégés contre les surcharges, par exemple par

– une protection contre les surintensités,
– des coupe-circuit thermiques internes, ou
– l'utilisation de transformateurs limiteurs de courant.

La vérification est effectuée par les essais de l'Article C.1 qui s'appliquent.

5.3.4 Isolation fonctionnelle

Pour l'ISOLATION FONCTIONNELLE, les LIGNES DE FUITE et les DISTANCES DANS L'AIR doivent satisfaire à l'une des exigences suivantes a), b) ou c).

Pour l'isolation entre un CIRCUIT SECONDAIRE et une partie conductrice inaccessible qui est mise à la terre pour des raisons fonctionnelles, les DISTANCES DANS L'AIR et les LIGNES DE FUITE doivent satisfaire à a), b) ou c).

a) Elles satisfont aux exigences de 2.10 (ou de l'Annexe G) pour les LIGNES DE FUITE et DISTANCES DANS L'AIR pour l'ISOLATION FONCTIONNELLE.
b) Elles supportent les essais de rigidité diélectrique de 5.2.2 pour l'ISOLATION FONCTIONNELLE.
c) Elles sont court-circuitées lorsque le court-circuit pourrait provoquer
   - un échauffement excessif d'un matériau quelconque, créant de ce fait un risque de feu, à moins que le matériau qui pourrait être surchauffé ne soit de CLASSE V-1, ou
   - un risque de dommage thermique sur l'ISOLATION PRINCIPALE, l'ISOLATION SUPPLEMENTAIRE ou l'ISOLATION RENFORCEE, créant de ce fait un risque de choc électrique.

Les critères de conformité pour 5.3.4 c) sont donnés en 5.3.9.

5.3.5 Composants électromécaniques

Lorsqu'un danger risque de survenir, la vérification de la conformité à 5.3.1 des composants électromécaniques autres que les moteurs est effectuée par application des conditions suivantes:

– *les mouvements mécaniques doivent être bloqués dans la position la plus défavorable, alors que le composant est normalement alimenté; et*

– *dans le cas d'un composant normalement mis sous tension par intermittence, un défaut doit être simulé dans le circuit de commande pour entraîner la mise sous tension permanente du composant.*

La durée de chaque essai doit être la suivante:

– *pour les matériels et pour les composants dont le défaut de fonctionnement n'est pas évident pour l'OPERATEUR: aussi longtemps que nécessaire pour obtenir l'état d'équilibre ou jusqu'à l'interruption du circuit par suite d'autres conséquences des conditions de défaut simulées, selon ce qui se produit en premier lieu;*

– *pour les autres matériels et composants: 5 min ou jusqu'à l'interruption du circuit par suite de défaillance du composant (destruction thermique par exemple) ou d'autres conséquences des conditions de défaut simulé, suivant ce qui est le plus court.*

Pour les critères de conformité, voir 5.3.9.

5.3.6 Amplificateurs audio dans les matériels de traitement de l'information

Les matériels qui possèdent des amplificateurs audio doivent être soumis aux essais conformément aux Paragraphes 4.3.4 et 4.3.5 de la CEI 60065. Le matériel doit fonctionner normalement avant la réalisation des essais.

5.3.7 Simulation de défauts

Pour les composants et les circuits autres que ceux qui sont couverts par les exigences de 5.3.2, 5.3.3, 5.3.5 et 5.3.6, la vérification est effectuée par simulation des conditions de premier défaut (voir 1.4.14).

NOTE 1 Au Canada et aux Etats-Unis, des exigences supplémentaires s'appliquent pour la simulation des surcharges et d'autres défauts des connexions des circuits internes.

Les conditions de défaut suivantes sont simulées.

a) Court-circuit ou déconnexion des composants dans les CIRCUITS PRIMAIRES.

b) Court-circuit ou déconnexion dans un composant quelconque dans lequel une défaillance risquerait d'affecter défavorablement l'ISOLATION SUPPLEMENTAIRE ou l'ISOLATION RENFORCEE.

c) Court-circuit, déconnexion ou surcharge dans tous les composants et les parties concernés sauf s'ils satisfont aux exigences de 4.7.3.

NOTE 2 Une condition de surcharge est une condition quelconque entre la CHARGE NORMALE et la condition de courant maximal, jusqu'au court-circuit.

d) Défauts provenant de la connexion de l'impédance de charge la plus défavorable aux bornes et aux connecteurs qui délivrent l'énergie du matériel, autres que les socles d'alimentation du réseau.

e) Autres défauts individuels spécifiés en 1.4.14.

Lorsqu'il existe des socles multiples ayant un même câblage interne, l'essai est effectué sur un seul socle.

Pour les composants dans les CIRCUITS PRIMAIRES associés avec l'entrée du réseau, tels que les câbles d'alimentation, les connecteurs, les filtres d'antiparasitage, les interrupteurs et leur câblage d'interconnexion, aucun défaut n'est simulé pourvu que le composant satisfasse à 5.3.4 a) ou 5.3.4 b).

NOTE 3 De tels composants sont aussi concernés par d'autres exigences de la présente norme lorsqu'elles sont applicables, y compris celles de 1.5.1, 2.10.5, 4.7.3 et 5.2.2.

En plus des critères de conformité donnés en 5.3.9, les températures dans le transformateur alimentant le composant à l'essai ne doivent pas dépasser les températures spécifiées à *l'Article C.1, et l'exception décrite en détail dans l'Article C.1 concernant les transformateurs qui nécessiteraient un remplacement doit être prise en compte.*

5.3.8 Matériels utilisés sans surveillance

Les matériels destinés à être utilisés sans surveillance et comportant des THERMOSTATS, des LIMITEURS DE TEMPERATURE ou des COUPE-CIRCUIT THERMIQUES, ou comportant un condensateur non protégé par un coupe-circuit à fusibles ou un autre dispositif similaire connecté en parallèle avec les contacts, sont soumis aux essais suivants.

La conformité des THERMOSTATS, LIMITEURS DE TEMPERATURE et COUPE-CIRCUIT THERMIQUES aux exigences de l'Article K.6 est également vérifiée.

Les matériels sont mis en fonctionnement dans les conditions spécifiées en 4.5.2 et tout dispositif servant à limiter la température est court-circuité. Si le matériel est muni de plusieurs THERMOSTATS, LIMITEURS DE TEMPERATURE ou COUPE-CIRCUIT THERMIQUES, ceux-ci doivent être court-circuités l'un après l'autre.

S'il ne se produit pas d'interruption de courant, l'alimentation du matériel est coupée dès l'obtention de l'état d'équilibre et on doit laisser le matériel se refroidir jusqu'à environ la température ambiante.

Pour les matériels qui ne sont pas destiné à fonctionner de manière continue, l'essai est répété jusqu'à la stabilisation de la température, quel que soit le marquage DUREE ASSIGNEE DE FONCTIONNEMENT ou de DUREE ASSIGNEE DE REPOS. Pour cet essai, les THERMOSTATS, LIMITEURS DE TEMPERATURE et COUPE-CIRCUIT THERMIQUES ne doivent pas être court-circuités.

Si, pour l'un quelconque des essais, un COUPE-CIRCUIT THERMIQUE À RÉENCLENCHEMENT MANUEL fonctionne, ou si le courant est coupé d'une autre façon avant stabilisation de la température, la période de chauffage est considérée comme terminée. Mais si l'interruption est due à la rupture d'une partie intentionnellement faible, l'essai est répété sur un deuxième échantillon. Les deux échantillons doivent satisfaire aux conditions spécifiées en 5.3.9.

5.3.9 Critères de conformité pour fonctionnement anormal et condition de défaut

5.3.9.1 Pendant les essais

Pendant les essais de 5.3.4 c), 5.3.5, 5.3.7, 5.3.8 et de l'Article C.1:

- *si un feu survient, il ne doit pas se propager en dehors du matériel; et*
- *le matériel ne doit pas émettre de métal fondu; et*
- *les ENVELOPPES ne doivent pas se déformer au point d'entraîner la non-conformité avec 2.1.1, 2.6.1, 2.10.3 (ou l'Annexe G) et 4.4.1.*

En outre, au cours des essais de 5.3.7 c), sauf spécification contraire, les températures des matériaux isolants autres que les matériaux thermoplastiques ne doivent pas dépasser celles du Tableau 5D.

Tableau 5D – Limites de température pour les conditions de surcharge

Température maximale °C

Classe thermique							
105 (A)	**120 (E)**	**130 (B)**	**155 (F)**	**180 (H)**	**200**	**220**	**250**
150	165	175	200	225	245	265	295
Les désignations A à H, attribuées précédemment dans la CEI 60085 aux classes thermiques 105 à 180, sont données entre parenthèses.							

Si la défaillance de l'isolation ne risque pas de conduire à des TENSIONS DANGEREUSES *ou des* NIVEAUX D'ÉNERGIE DANGEREUX*, une température maximale de 300 °C est permise. Des températures plus élevées sont permises pour des isolations faites de verre ou de matériau céramique.*

5.3.9.2 Après les essais

Après les essais de 5.3.4 c), 5.3.5, 5.3.7, 5.3.8 et de l'Article C.1, un essai de rigidité diélectrique conformément à 5.2.2 est effectué sur:

– *l'*ISOLATION RENFORCEE*; et*

– *l'*ISOLATION PRINCIPALE *ou l'*ISOLATION SUPPLEMENTAIRE *faisant partie d'une* DOUBLE ISOLATION*; et*

– *l'*ISOLATION PRINCIPALE *entre le* CIRCUIT PRIMAIRE *et la borne principale de terre de protection;*

si l'une des conditions suivantes s'applique:

– *les* LIGNES DE FUITE *ou les* DISTANCES DANS L'AIR *ont été réduites en dessous des valeurs spécifiées en 2.10 (ou à l'Annexe G); ou*

– *l'isolation présente des signes visibles d'endommagement; ou*

– *l'isolation ne peut être examinée.*

6 Connexion à des réseaux de télécommunications

Si le matériel est à connecter sur un RESEAU DE TELECOMMUNICATIONS, les exigences de l'Article 6 s'appliquent en plus des exigences des Articles 1 à 5 de la présente norme.

NOTE 1 On suppose que des mesures adéquates, conformément à la recommandation K.11 de l'UIT-T, ont été prises de façon à réduire la possibilité que les surtensions appliquées au matériel excèdent 1,5 kV valeur de crête. Dans les installations dans lesquelles les matériels risquent d'être soumis à des surtensions supérieures à 1,5 kV crête, il peut être nécessaire de prendre des dispositions supplémentaires telles que la limitation des surtensions.

NOTE 2 Il peut exister des exigences légales concernant la connexion des matériels de traitement de l'information à un RESEAU de TELECOMMUNICATIONS géré par un opérateur de réseau public.

NOTE 3 Les exigences de 2.3.2, 6.1.2 et 6.2 peuvent s'appliquer à la même isolation physique ou à la même DISTANCE DANS L'AIR.

NOTE 4 Le RESEAU D'ALIMENTATION EN COURANT ALTERNATIF, s'il est utilisé comme un moyen de transmission de communication, n'est pas un RESEAU DE TELECOMMUNICATIONS (voir 1.2.13.8) et l'Article 6 ne s'applique pas. Les autres articles de la présente norme s'appliqueront aux composants de couplage comme les transformateurs de signaux, connectés entre le secteur et les autres circuits. Les exigences pour la DOUBLE ISOLATION ou ISOLATION RENFORCEE s'appliquent généralement. Voir aussi la CEI 60664-1 et l'Annexe Z de la présente norme pour les surtensions attendues en divers points du système d'ALIMENTATION DU RESEAU EN COURANT ALTERNATIF.

NOTE 5 Au Canada et aux Etats-Unis, des exigences supplémentaires s'appliquent aux CIRCUITS TRT pour la protection contre les surtensions dues au contact avec une ligne d'énergie (contact entre une ligne de télécommunications et une ligne d'énergie), à l'induction et à l'élévation du potentiel de terre provenant du courant de défaut de la ligne d'énergie.

6.1 Protection du personnel de maintenance du réseau de télécommunications et des utilisateurs d'autres matériels connectés au réseau contre les risques provenant du matériel

6.1.1 Protection contre les tensions dangereuses

Les circuits destinés à être connectés directement sur un RESEAU DE TELECOMMUNICATIONS doivent être conformes aux exigences pour un CIRCUIT TBTS ou un CIRCUIT TRT.

Lorsque la protection d'un RESEAU DE TELECOMMUNICATIONS dépend de la mise à la terre de protection, les instructions d'installation du fabricant et les autres documents concernés doivent spécifier que l'intégrité de la terre de protection doit être assurée, voir aussi 1.7.2.1.

La vérification est effectuée par examen et par des mesures.

6.1.2 Séparation entre les réseaux de télécommunications et la terre

6.1.2.1 Exigences

Sauf spécification contraire en 6.1.2.2, il doit y avoir une isolation entre les circuits destinés à être connectés sur un RESEAU DE TELECOMMUNICATIONS et toutes les parties ou circuits qui seront mis à la terre soit à l'intérieur du matériel à l'essai soit par l'intermédiaire d'un autre matériel.

Les parasurtenseurs qui pontent l'isolation doivent avoir une tension de service nominale minimale U_{op} (par exemple la tension d'amorçage d'un tube à décharge dans un gaz) de

$$U_{op} = U_{peak} + \Delta U_{sp} + \Delta U_{sa}$$

où

U_{peak} a l'une des valeurs suivantes

pour les matériels destinés à être installés dans une zone où la tension nominale du RESEAU D'ALIMENTATION EN COURANT ALTERNATIF dépasse 130 V: 360 V

pour les autres appareils: 180 V

ΔU_{sp} est l'augmentation maximale de la tension assignée de fonctionnement due aux variations dans la production des composants. Si cela n'est pas spécifié par le fabricant du composant, ΔU_{sp} doit être pris comme étant égale à 10 % de la tension assignée de service du composant.

ΔU_{sa} est l'augmentation maximale de la tension assignée de fonctionnement due au vieillissement du composant pendant la durée de vie prévisible du matériel. Si cela n'est pas spécifié par le fabricant du composant, ΔU_{sa} doit être pris comme étant égale à 10 % de la tension assignée de fonctionnement du composant.

NOTE 1 ($\Delta U_{sp} + \Delta U_{sa}$) peut être une valeur unique fournie par le fabricant du composant.

La vérification est effectuée par examen et par les essais suivants. Les exigences de dimension et de construction de 2.10 et de l'Annexe G ne s'appliquent pas pour la conformité à 6.1.2.

NOTE 2 En Finlande, en Norvège et en Suède, il y a des exigences supplémentaires pour les isolations. Pour le texte complet, voir l'EN 60950-1:~~200X~~2006.

L'isolation est soumise à un essai de rigidité diélectrique conformément à 5.2.2. La tension d'essai en courant alternatif est la suivante:

– pour les matériels destinés à être installés dans une zone où la tension nominale du RESEAU D'ALIMENTATION EN COURANT ALTERNATIF dépasse 130 V: 1,5 kV

– pour les autres appareils: 1,0 kV.

Les tensions d'essai s'appliquent que le matériel soit ou non alimenté par le RÉSEAU D'ALIMENTATION EN COURANT ALTERNATIF.

Les composants en parallèle sur l'isolation qui sont laissés en place pendant l'essai de rigidité diélectrique ne doivent pas être endommagés. Il ne doit pas y avoir de rupture de l'isolation pendant l'essai de rigidité diélectrique.

Il est permis de retirer les composants, autres que les condensateurs, qui pontent l'isolation pendant l'essai de rigidité diélectrique.

Si cette option est choisie, un essai supplémentaire utilisant le circuit d'essai de la Figure 6A est effectué avec tous les composants en place.

Pour les matériels qui sont alimentés par un RESEAU D'ALIMENTATION EN COURANT ALTERNATIF, l'essai est effectué sous une tension égale à la TENSION ASSIGNEE du matériel ou à la tension la plus élevée de la PLAGE ASSIGNEE DE TENSIONS. Pour les matériels alimentés par un RESEAU D'ALIMENTATION EN COURANT CONTINU, l'essai est effectué avec une tension égale à la tension nominale la plus élevée du RESEAU D'ALIMENTATION EN COURANT ALTERNATIF dans la région où le matériel est utilisé, par exemple 230 V en Europe et 120 V en Amérique du Nord.

Le courant circulant dans le circuit d'essai de la Figure 6A ne doit pas dépasser 10 mA.

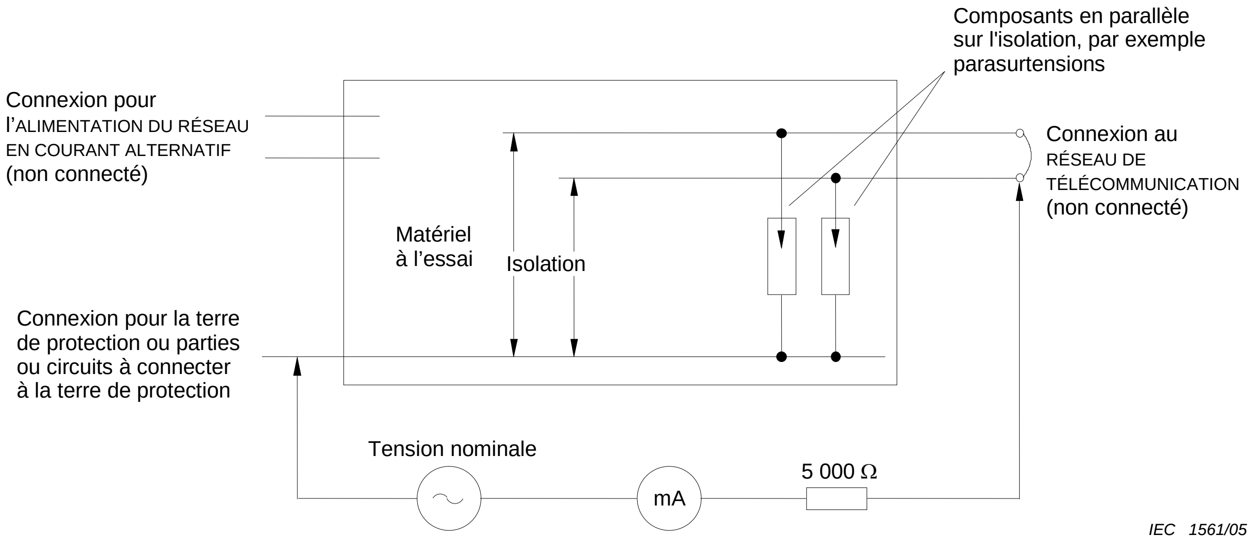


Figure 6A – Essai de la séparation entre le réseau de télécommunications et la terre

6.1.2.2 Exclusions

Les exigences de 6.1.2.1 ne s'appliquent à aucun des matériels suivants:

- aux MATERIELS RELIES A DEMEURE ou aux MATERIELS DE TYPE B RACCORDES PAR PRISE DE COURANT;
- aux matériels destinés à être installés par le PERSONNEL DE MAINTENANCE et qui ont des instructions d'installation qui prescrivent que le matériel soit connecté à un socle de prise de courant avec une connexion de mise à la terre de protection (voir 6.1.1);
- aux matériels équipés d'un CONDUCTEUR DE MISE A LA TERRE DE PROTECTION fixé à demeure et munis d'instructions pour l'installation de ce conducteur.

NOTE En Finlande, en Norvège et en Suède, les exclusions ne sont applicables qu'aux MATERIELS RELIES A DEMEURE et aux MATERIELS DE TYPE B RACCORDES PAR PRISE DE COURANT ainsi qu'aux matériels destinés à être utilisés dans un EMPLACEMENT A ACCES RESTREINT où une liaison équipotentielle a été appliquée, par exemple dans un centre de télécommunication ayant une connexion permanente du CONDUCTEUR DE MISE A LA TERRE DE PROTECTION avec instructions d'installation de ce conducteur par le PERSONNEL DE MAINTENANCE.

6.2 Protection des utilisateurs du matériel contre les surtensions sur les réseaux de télécommunications

6.2.1 Exigences de séparation

Les matériels doivent fournir une séparation électrique appropriée entre un CIRCUIT TRT-1 ou un CIRCUIT TRT-3 et les parties suivantes du matériel.

a) Les parties conductrices non mises à la terre et les parties non conductrices du matériel susceptibles d'être tenues ou ~~touchées~~ bien maintenues en contact continu avec le corps en usage normal (par exemple un combiné ou casque téléphonique, ~~un clavier ou la totalité de la surface extérieure~~ la surface repose-paume d'un ordinateur personnel portable).

b) Les parties et circuits qui peuvent être touchés à l'aide du doigt d'épreuve de la Figure 2A (voir 2.1.1.1), à l'exception des contacts des connecteurs qui ne peuvent pas être touchés par le calibre d'essai de la Figure 2C (voir 2.1.1.1).

c) Un CIRCUIT TBTS, UN CIRCUIT TRT-2 ou un CIRCUIT A LIMITATION DE COURANT prévu pour la connexion à d'autres matériels. L'exigence pour la séparation s'applique que les circuits soient accessibles ou non.

Ces exigences ne s'appliquent pas lorsque l'analyse des circuits et l'étude du matériel indiquent que la protection adéquate est assurée par d'autres moyens, par exemple entre deux circuits ayant chacun une connexion permanente à la terre de protection.

La vérification est effectuée par examen et par les essais de 6.2.2. Les exigences de dimension et de construction de 2.10 et de l'Annexe G ne s'appliquent pas pour la conformité à 6.2.1.

NOTE Les exigences de 2.10 et l'Annexe G peuvent s'appliquer pour la conformité à 2.2 et 2.3. Voir note e et note f du Tableau 2H.

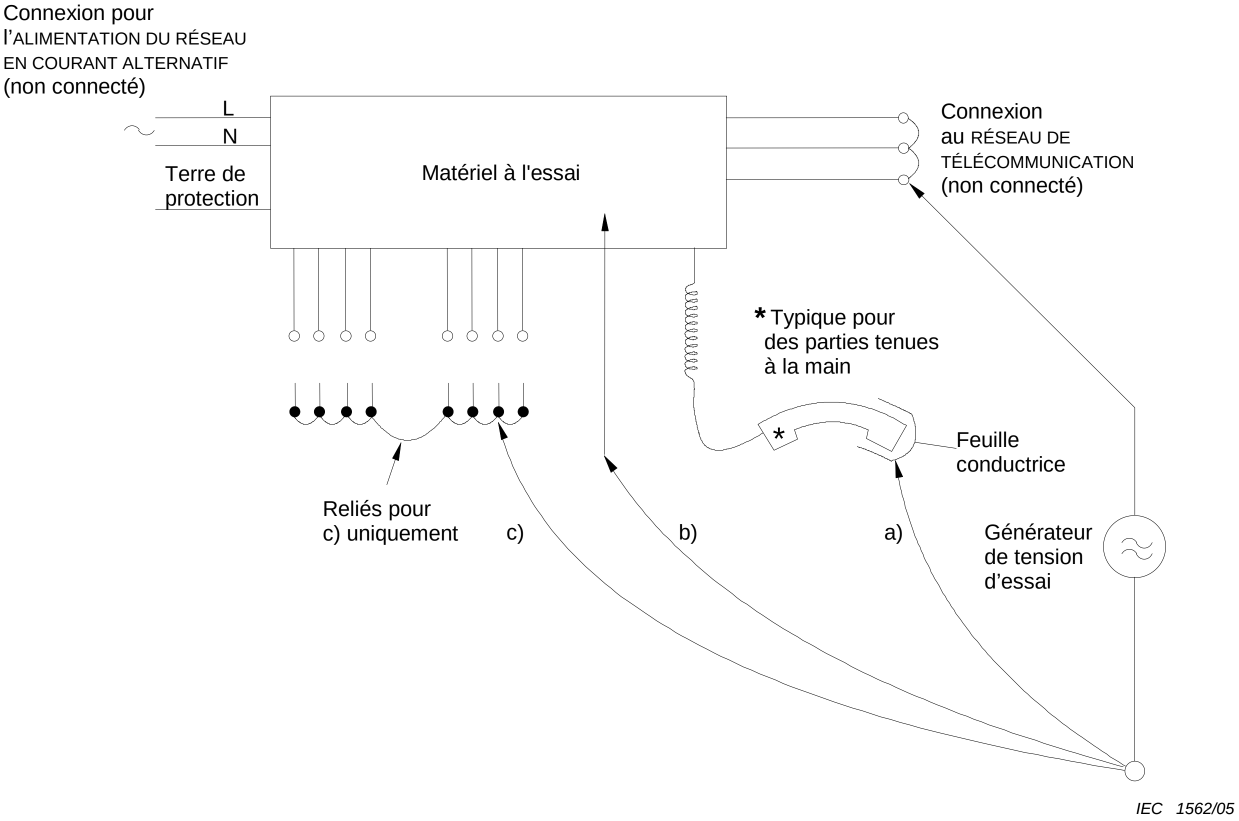


Figure 6B – Points d'application des tensions d'essai

6.2.2 Procédure de l'essai de rigidité diélectrique

La conformité à 6.2.1 est vérifiée par les essais de 6.2.2.1 ou de 6.2.2.2.

NOTE En Australie, ~~les essais à la fois de 6.2.2.1 et de 6.2.2.2 s'appliquent.~~ une valeur de 3,0 kV est utilisée pour les matériels en 6.2.1 a) et une valeur de 1,5 kV pour les matériels en 6.2.1 b) et 6.2.1 c). Ces valeurs ont été déterminées en considérant les tensions induites par basse fréquence à partir du système de distribution de l'alimentation électrique.

Si un essai est effectué sur un composant (voir 1.4.3), par exemple un transformateur de signal, qui est manifestement prévu pour assurer la séparation demandée, le composant ne doit pas être court-circuité par d'autres composants, des dispositifs de montage ou par un câblage, à moins que ces composants ou ce câblage ne respectent également les exigences de séparation de 6.2.

Pour les essais, tous les conducteurs destinés à être reliés au RÉSEAU DE TÉLÉCOMMUNICATIONS sont connectés ensemble (voir Figure 6B), y compris tout conducteur pour lequel l'exploitant du RÉSEAU DE TÉLÉCOMMUNICATIONS demande la mise à la terre. De même, tous les conducteurs destinés à être connectés à d'autres matériels sont connectés ensemble pour les essais relatifs à 6.2.1 c).

Les parties non conductrices sont essayées avec une feuille métallique en contact avec la surface. Lorsqu'une feuille métallique adhésive est utilisée, l'adhésif doit être conducteur.

6.2.2.1 Essai d'impulsion

La séparation électrique est soumise à dix impulsions de polarité alternée, en utilisant la référence 1 de générateur d'impulsions d'essai du Tableau N.1 L'intervalle entre impulsions successives est de 60 s et U_c est égale à

- pour 6.2.1 a): 2,5 kV; et
- pour 6.2.1 b) et 6.2.1 c): 1,5 kV.

NOTE 1 La valeur de 2,5 kV pour 6.2.1 a) a été choisie principalement pour s'assurer de la qualité de l'isolation concernée mais pas nécessairement pour la simulation de possibles surtensions.

NOTE 2 En Australie une valeur de U_c = 7,0 kV est utilisée en 6.2.1 a) pour les téléphones à main et pour les casques.

6.2.2.2 Essai de rigidité diélectrique

La séparation électrique est soumise à un essai de rigidité diélectrique conformément à 5.2.2.

La tension d'essai alternative est:

- pour 6.2.1 a): 1,5 kV; et
- pour 6.2.1 b) et 6.2.1 c): 1,0 kV.

NOTE En Australie, une valeur de 3,0 kV est utilisée en 6.2.1 a) pour les téléphones tenus à la main et les combinés téléphoniques et 2,5 kV pour les autres matériels, pour simuler les chocs de foudre sur les lignes de réseau typique en zone rurale ou semi-rurale. Une valeur de 1,5 kV est utilisée en 6.2.1 b) et c).

Pour 6.2.1 b) et 6.2.1 c), il est permis d'enlever les parasurtenseurs pourvu que de tels dispositifs satisfassent à l'essai en impulsion de 6.2.2.1 pour 6.2.1 b) et 6.2.1 c) lorsqu'ils sont essayés comme composants à l'extérieur du matériel. Pour 6.2.1 a), les parasurtenseurs ne doivent pas être enlevés.

6.2.2.3 Critères de conformité

Pendant les essais de 6.2.2.1 et de 6.2.2.2, il ne doit pas y avoir de rupture de l'isolation.

On considère qu'il s'est produit une rupture de l'isolation lorsque le courant qui circule par l'effet de l'application de la tension d'essai augmente rapidement d'une façon incontrôlée, c'est-à-dire que l'isolation n'empêche plus la circulation du courant.

Si un parasurtenseur fonctionne (ou si un amorçage survient dans un tube à décharge) pendant l'essai:

– *pour 6.2.1 a), ce fonctionnement représente un défaut;*
– *pour 6.2.1 b) et 6.2.1 c), un tel fonctionnement est permis pendant l'essai en impulsion; et*
– *pour 6.2.1 b) et 6.2.1 c), un tel fonctionnement pendant l'essai de rigidité diélectrique (par tout parasurtenseur laissé en place) représente un défaut.*

Pour les essais en impulsion, les dommages à l'isolation doivent être vérifiés par l'une des deux méthodes suivantes:

– *pendant l'application des impulsions, par l'observation des oscillogrammes. On apprécie le fonctionnement d'un parasurtenseur ou une rupture de l'isolation d'après la forme d'un oscillogramme.*
– *après l'application des impulsions, par un essai de résistance d'isolement. Il est permis de déconnecter les parasurtenseurs pendant la mesure de la résistance d'isolement. La tension d'essai est de 500 V continu ou, en présence de parasurtenseurs, une tension continue inférieure de 10 % à la tension de fonctionnement ou d'amorçage du parasurtenseur. La résistance d'isolement ne doit pas être inférieure à 2 MΩ.*

NOTE Une description des procédures pour apprécier s'il y a eu rupture de l'isolation ou fonctionnement d'un parasurtenseur, en utilisant les oscillogrammes, est donnée à l'Annexe S.

6.3 Protection du système de câblage de télécommunication contre les surchauffes

Le matériel destiné à fournir la puissance à travers le système de câblage de télécommunication à des matériels déportés doit limiter le courant de sortie à une valeur qui ne provoque pas de dommages au système de câblage de télécommunication, à cause d'une surchauffe, dans toutes les conditions de charge externe. Le courant continu maximal venant du matériel ne doit pas dépasser une limite de courant qui est appropriée pour le diamètre minimal de conducteur spécifié dans les instructions d'installation du matériel. Le courant continu maximal est de 1,3 A si un tel câblage n'est pas spécifié.

NOTE 1 Le dispositif de protection contre les surintensités peut être un dispositif discret tel qu'un fusible ou un circuit qui assure cette fonction.

NOTE 2 Le diamètre minimal de conducteur normalement utilisé dans les câblages de télécommunications est de 0,4 mm, pour lequel le courant continu maximal pour un câble multipaire est 1,3 A. Ce câblage n'est pas en général couvert par les instructions d'installation du matériel car l'installation du câblage est souvent indépendante de l'installation du matériel.

NOTE 3 Une limitation de courant supplémentaire peut être nécessaire pour les matériels destinés à être connectés à des réseaux qui sont soumis à des surtensions à cause des paramètres de fonctionnement des dispositifs de protection.

La vérification est effectuée comme suit.

Si la limitation du courant est due à l'impédance propre de la source de courant, la vérification est effectuée par mesurage du courant de sortie circulant dans toute charge résistive, y compris un court-circuit. La limite de courant ne doit pas être dépassée après 60 s d'essai.

Si la limitation de courant est assurée par un dispositif de protection contre les surintensités ayant une caractéristique temps/courant spécifiée:

– *la caractéristique temps/courant doit montrer qu'un courant égal à 110 % de la limite de courant sera interrompu dans les 60 min; et*

NOTE 4 Les caractéristiques temps/courant des fusibles du type gD et du type gN spécifiés dans la CEI 60269-2-1 sont conformes aux limites ci-dessus. Les fusibles de type gD ou de type gN de 1 A satisferaient à la limite de courant de 1,3 A.

– *le courant de sortie circulant dans toute charge résistive, y compris un court-circuit, avec le dispositif de protection contre les surintensités court-circuité, mesuré après 60 s* *d'essai, ne doit pas dépasser 1 000/U, où U est la tension de sortie mesurée conformément à 1.4.5 avec tous les circuits de charge déconnectés.*

Si la limitation de courant est assurée par un dispositif de protection contre les surintensités n'ayant pas une caractéristique temps/courant spécifiée:

– *le courant de sortie circulant dans toute charge résistive, y compris un court-circuit, ne doit pas dépasser la limite de courant après 60 s d'essai; et*
– *le courant de sortie circulant dans toute charge résistive, y compris un court-circuit, avec le dispositif de protection contre les surintensités court-circuité, mesuré après 60 s d'essai, ne doit pas dépasser 1 000/U, où U est la tension de sortie mesurée conformément à 1.4.5 avec tous les circuits de charge déconnectés.*

7 Connexion aux systèmes de distribution par câbles

7.1 Généralités

Si un matériel est destiné à être connecté à un SYSTEME DE DISTRIBUTION PAR CABLES, les exigences de l'Article 7 s'appliquent en plus des exigences des Articles 1 à 5 de cette norme.

NOTE 1 Sauf si la connexion utilise un câble coaxial, le circuit n'est pas un SYSTÈME DE DISTRIBUTION PAR CABLES et l'Article 6 s'applique.

NOTE 2 On suppose que des mesures adéquates ont été prises pour réduire la probabilité que des surtensions transitoires se présentant au matériel dépassent les valeurs suivantes:

– 10 kV pour les matériels connectables seulement à une antenne extérieure ;
– 4 kV aux autres matériels, voir les recommandations UIT-T K.20, K.21 et K.45.

Dans les installations où des surtensions se présentant au matériel peuvent dépasser ces valeurs, des mesures supplémentaires, telles que la suppression des pointes de tension, peuvent être nécessaires.

NOTE 3 Des exigences légales peuvent exister concernant la connexion des matériels de traitement de l'information à un SYSTEME DE DISTRIBUTION PAR CABLES exploité par un opérateur de réseau public.

NOTE 4 Le système d'alimentation du RESEAU EN COURANT ALTERNATIF, s'il est utilisé comme moyen de communication, n'est pas un SYSTEME DE DISTRIBUTION PAR CABLES (voir 1.2.13.14) et l'Article 7 ne s'applique pas. Pour les matériels destinés à être connectés à de tels systèmes, les autres articles de cette norme s'appliquent aux composants de couplage, tels que les transformateurs de signaux et les condensateurs, connectés entre le réseau d'alimentation et d'autres circuits. Les exigences pour la DOUBLE ISOLATION ou ISOLATION RENFORCEE s'appliquent généralement. Voir aussi la CEI 60664-1 et l'Annexe Z de la présente norme pour les surtensions attendues en divers points du système d'ALIMENTATION DU RESEAU EN COURANT ALTERNATIF.

NOTE 5 On suppose que le blindage du câble sera mis à la terre conformément aux exigences d'installation de la CEI 60728-11.

7.2 Protection du personnel de maintenance d'un système de distribution par câbles et des utilisateurs d'autres matériels connectés au système, contre les dangers des matériels

Un circuit prévu pour être connecté directement à un SYSTEME DE DISTRIBUTION PAR CABLES doit satisfaire aux exigences pour un CIRCUIT TRT-1, un CIRCUIT TRT-3 ou un CIRCUIT SECONDAIRE à TENSION DANGEREUSE, selon la tension normale de fonctionnement.

Lorsque la protection du SYSTEME DE DISTRIBUTION PAR CABLES repose sur la mise à la terre de protection du matériel, les instructions d'installation et toute autre documentation applicable doivent indiquer que l'intégrité de la terre de protection doit être assurée, voir aussi 1.7.2.1.

La conformité est vérifiée par examen et par des mesures.

NOTE Pour les exigences en Finlande, en Norvège et en Suède voir 6.1.2.1 note 2 et 6.1.2.2 note. Le TERME RESEAU DE TELECOMMUNICATIONS est remplacé par SYSTEMES DE DISTRIBUTION PAR CABLES.

7.3 Protection des utilisateurs de matériels contre les surtensions sur le système de distribution par câbles

Les exigences et les essais de 6.2 s'appliquent, excepté que le terme «RESEAU DE TELECOMMUNICATIONS» est remplacé par «SYSTEME DE DISTRIBUTION PAR CABLES» dans tout le Paragraphe 6.2. Lors de l'application de 6.2 au SYSTEME DE DISTRIBUTION PAR CABLES, les exigences de séparation s'appliquent uniquement aux parties des circuits qui sont directement connectées au(x) conducteur(s) intérieur(s) du câble coaxial; les exigences de séparation ne s'appliquent pas aux parties des circuits qui sont directement connectées au(x) conducteur(s) extérieur(s) du câble coaxial ou écran(s).

Toutefois, les exigences de séparation et les essais de 6.2.1 a), b) et c) ne s'appliquent pas à un SYSTEME DE DISTRIBUTION PAR CABLES si tout ce qui suit s'applique:

– le circuit considéré est un CIRCUIT TRT-1; et
– sa face commune ou reliée à la terre est connectée à l'écran du câble coaxial, à toutes les parties accessibles et à tous les circuits (TNTS, parties métalliques accessibles et CIRCUITS A LIMITATION DE COURANT, le cas échéant); et
– l'écran du câble coaxial est destiné à être connecté à la terre dans l'installation du bâtiment.

NOTE 1 En Suède, dans de nombreux bâtiments, l'écran du câble coaxial n'est normalement pas raccordé à la terre dans l'installation des bâtiments.

NOTE 2 Pour les conditions d'installation en Norvège, voir la CEI 60728-11:2005.

La vérification est effectuée par examen et par l'application des exigences applicables et des essais de 6.2.

7.4 Isolation entre circuits primaires et systèmes de distribution par câbles

7.4.1 Généralités

A l'exception de ce qui est spécifié ci-dessous, l'isolation entre les CIRCUITS PRIMAIRES et la borne ou le branchement fournis pour la connexion d'un SYSTEME DE DISTRIBUTION PAR CABLES doit satisfaire à:

– l'essai de surtension de 7.4.2 pour les matériels prévus pour être connectés à des antennes extérieures; ou
– l'essai d'impulsion de 7.4.3 pour les matériels prévus pour être connectés à d'autres SYSTEMES DE DISTRIBUTION PAR CABLES.

Si un matériel est prévu pour la connexion à la fois à une antenne extérieure et à un autre SYSTEME DE DISTRIBUTION PAR CABLES, il doit passer avec succès à la fois les essais de 7.4.2 et de 7.4.3.

Les exigences ci-dessus ne s'appliquent à aucun des cas suivants:

– matériel prévu seulement pour être utilisé à l'intérieur, fourni avec une antenne incorporée (intégrée) et non équipé d'une connexion à UN SYSTEME DE DISTRIBUTION PAR CABLES;
– MATERIEL RELIE A DEMEURE, ou MATERIEL DE TYPE B RACCORDE PAR PRISE DE COURANT, dans lequel le circuit prévu pour être relié au SYSTEME DE DISTRIBUTION PAR CABLES est relié à la terre de protection conformément à 2.6.1 e);
– MATERIEL DE TYPE A RACCORDE PAR PRISE DE COURANT, dans lequel le circuit prévu pour être relié au SYSTEME DE DISTRIBUTION PAR CABLES est relié à la terre de protection conformément au 2.6.1 e), et qui soit:
  • est prévu pour être installé par le PERSONNEL DE MAINTENANCE et possède des instructions d'installation qui requièrent que le matériel soit raccordé à une prise de courant avec une connexion à la terre de protection; soit

- possède un moyen pour relier à demeure un CONDUCTEUR DE MISE A LA TERRE DE PROTECTION, accompagné des instructions pour l'installation de ce conducteur.

- matériel où:
  - le circuit considéré est un CIRCUIT TRT-1; et
  - la face du circuit commune ou reliée à la terre est connectée à l'écran du câble coaxial, et à toutes les parties accessibles et à tous les circuits (TBTS, parties métalliques accessibles et CIRCUITS A LIMITATION DE COURANT, le cas échéant); et
  - l'écran du câble coaxial est destiné à être connecté à la terre dans l'installation du bâtiment.

La vérification est effectuée par examen et, si nécessaire, par l'essai de surtensions de 7.4.2 ou l'essai d'impulsion de 7.4.3.

NOTE Les DISTANCES DANS L'AIR minimales sont déterminées par les exigences de 2.10.3 (ou de l'Annexe G). Il peut être nécessaire d'augmenter les DISTANCES DANS L'AIR entre CIRCUITS PRIMAIRES et CIRCUITS SECONDAIRES destinés à la connexion avec les SYSTEMES DE DISTRIBUTION PAR CABLES de telle sorte que les circuits puissent passer avec succès les essais de 7.4.2 ou 7.4.3.

7.4.2 Essai de surtension

L'essai est effectué entre, d'une part, les bornes du circuit d'alimentation et la borne principale de la mise à la terre de protection, s'il y en a une, reliées ensemble, et, d'autre part, les points de connexion du SYSTEME DE DISTRIBUTION PAR CABLES, excluant tout conducteur mis à la terre reliés ensemble. Tous les composants connectés entre les points de connexion pour le SYSTEME DE DISTRIBUTION PAR CABLES et la borne principale de mise à la terre de protection sont déconnectés avant l'essai. S'il existe un interrupteur marche/arrêt, celui-ci est en position "marche".

Des impulsions de conditionnement sont appliquées entre

– *les points de connexion pour le SYSTEME DE DISTRIBUTION PAR CABLES, à l'exclusion de tout conducteur relié à la terre, rassemblés, et*
– *les bornes du circuit d'alimentation et la principale borne de terre de protection, s'il y en a une, rassemblées.*

Cinquante décharges sont appliquées en utilisant la référence 3 de générateur d'impulsion d'essai du Tableau N.1 à une vitesse maximale de 12 impulsions à la minute, avec U_c égale à 10 kV.

A l'issue du conditionnement ci-dessus, les essais de rigidité diélectrique appropriés de 5.2.2 sont appliqués.

7.4.3 Essai d'impulsion

L'essai est effectué entre, d'une part, les bornes du circuit d'alimentation et la borne principale de la mise à la terre de protection, s'il y en a une, reliées ensemble, et, d'autre part, les points de connexion du SYSTEME DE DISTRIBUTION PAR CABLES, excluant tout conducteur, mis à la terre reliés ensemble. Tous les composants connectés entre les points de connexion pour le SYSTEME DE DISTRIBUTION PAR CABLES et la borne principale de mise à la terre de protection sont déconnectés avant l'essai. S'il existe un interrupteur marche/arrêt, celui-ci est en position "marche".

Dix impulsions de conditionnement de polarité alternée sont appliquées en utilisant la référence 3 de générateur d'impulsion d'essai du Tableau N.1. L'intervalle entre impulsions successives est de 60 s et U_c est égale à

– *5 kV pour les répéteurs téléalimentés;*
– *4 kV pour tous les autres terminaux et les matériels de réseau.*

A l'issue du conditionnement ci-dessus, les essais de rigidité diélectrique appropriés de 5.2.2 sont appliqués.

L'essai à 4 kV n'est pas nécessaire pour une séparation électrique qui satisfait à l'essai à 3 000 V efficace ou 4 242 V valeur de crête alternative ou continue, conformément à 5.2.2.

Annexe A
(normative)

Essais de résistance à la chaleur et au feu

Il convient de noter que des fumées toxiques peuvent être émises au cours des essais. Lorsque c'est approprié, il convient d'effectuer les essais soit sous une hotte ventilée soit dans une salle bien aérée mais exempte de courants d'air qui pourraient invalider les essais.

A.1 Essai d'inflammabilité pour les enveloppes contre le feu des matériels mobiles de masse totale supérieure à 18 kg et des matériels fixes
(voir 4.7.3.2)

A.1.1 Echantillons

L'essai est effectué sur trois échantillons constitués chacun d'une ENVELOPPE CONTRE LE FEU *complète ou d'une portion d'*ENVELOPPE CONTRE LE FEU *représentant la plus faible épaisseur significative de paroi et comprenant toute ouverture d'aération.*

A.1.2 Conditionnement des échantillons

Avant l'essai, les échantillons sont conditionnés pendant 7 jours (168 h) dans une étuve à circulation d'air, maintenue à une température uniforme, supérieure de 10 K à la température maximale du matériau mesurée pendant l'essai de 4.5.2 ou égale à 70 °C, suivant la valeur la plus élevée, puis refroidis jusqu'à la température ambiante.

A.1.3 Montage des échantillons

Les échantillons sont montés comme ils le seraient en usage normal. Une couche de coton chirurgical non traité est placée à 300 mm en dessous du point d'application de la flamme d'essai.

A.1.4 Essai à la flamme

L'essai à la flamme conformément à la CEI 60695-11-3 est utilisé.

A.1.5 Procédure d'essai

La flamme d'essai est appliquée sur une surface interne de l'échantillon, en un endroit jugé susceptible de s'enflammer en raison de sa proximité avec une source d'inflammation. S'il s'agit d'une section verticale, la flamme est appliquée sous un angle d'environ 20° par rapport à la verticale. S'il existe des ouvertures d'aération, la flamme est appliquée à un bord d'une ouverture, sinon la flamme est appliquée à une surface pleine. Dans tous les cas, la pointe du cône bleu intérieur de la flamme est en contact avec l'échantillon. La flamme est appliquée pendant 5 s, puis retirée pendant 5 s. L'opération est répétée, que l'échantillon soit en train de se consumer ou non, jusqu'à ce que l'échantillon ait été soumis à cinq applications de la flamme d'essai au même endroit.

*L'essai est répété sur les deux autres échantillons. S'il y a plusieurs parties de l'*ENVELOPPE CONTRE LE FEU *proches d'une source d'inflammation, chaque échantillon est essayé avec application de la flamme à un endroit différent.*

A.1.6 Critères de conformité

Pendant l'essai, l'échantillon ne doit pas émettre de gouttelettes ou de particules enflammées capables d'enflammer le coton chirurgical. L'échantillon ne doit pas continuer de brûler plus *de 1 min après la cinquième application de la flamme d'essai et ne doit pas être entièrement consumé.*

A.2 Essai d'inflammabilité pour les enveloppes contre le feu des matériels mobiles de masse totale inférieure ou égale à 18 kg et pour les matériaux placés à l'intérieur des enveloppes contre le feu (voir 4.7.3.2 et 4.7.3.4)

A.2.1 Echantillons

L'essai est effectué sur trois échantillons. Pour les ENVELOPPES CONTRE LE FEU chaque échantillon est constitué de l'ENVELOPPE CONTRE LE FEU complète ou d'une portion d'ENVELOPPE CONTRE LE FEU représentant l'épaisseur de paroi significative la plus faible et comprenant toute ouverture d'aération. Pour les matériaux à utiliser dans l'ENVELOPPE CONTRE LE FEU, chaque échantillon du matériau est constitué de:

– *la partie complète; ou*

– *une portion de la partie représentant l'épaisseur de paroi significative la plus faible; ou*

– *une plaque ou une barre d'essai d'épaisseur uniforme représentant la portion significative la plus faible de la partie.*

Pour les composants à placer dans l'ENVELOPPE CONTRE LE FEU, chaque échantillon doit être un composant complet.

A.2.2 Conditionnement des échantillons

Avant l'essai, les échantillons sont conditionnés pendant 7 jours (168 h) dans une étuve à circulation d'air, maintenue à une température uniforme, supérieure de 10 K à la température maximale de la partie mesurée pendant l'essai de 4.5.2 ou égale à 70 °C, suivant la valeur la plus élevée, puis refroidis jusqu'à la température ambiante.

A.2.3 Montage des échantillons

Les échantillons sont montés comme ils le seraient en usage normal.

A.2.4 Essai à la flamme

L'essai à la flamme conformément à la CEI 60695-11-4 est utilisé.

A.2.5 Procédure d'essai

La flamme d'essai est appliquée sur une surface interne de l'échantillon, en un point jugé susceptible de s'enflammer en raison de sa proximité avec une source d'inflammation. Pour l'évaluation des matériaux placés dans l'ENVELOPPE CONTRE LE FEU, il est permis d'appliquer la flamme d'essai sur une surface externe de l'échantillon. Pour l'évaluation des composants à placer dans l'ENVELOPPE CONTRE LE FEU, la flamme d'essai est appliquée directement sur le composant.

S'il s'agit d'une section verticale, la flamme est appliquée sous un angle d'environ 20° par rapport à la verticale. S'il existe des ouvertures d'aération, la flamme est appliquée à un bord d'une ouverture, sinon la flamme est appliquée à une surface pleine. Dans tous les cas, la pointe de la flamme est en contact avec l'échantillon. La flamme est appliquée pendant 30 s, puis retirée pendant 60 s puis elle est de nouveau appliquée au même endroit pendant 30 s, que l'échantillon soit en train de se consumer ou non.

L'essai est répété sur les deux autres échantillons. Si une partie quelconque à l'essai est proche d'une source d'inflammation en plus d'un point, chaque échantillon est essayé avec application à un endroit différent qui est proche de la source d'inflammation.

A.2.6 Critères de conformité

Pendant l'essai, l'échantillon ne doit pas continuer de brûler plus de 1 min après la deuxième application de la flamme d'essai et ne doit pas être entièrement consumé.

A.2.7 Essai en remplacement

En remplacement de la méthode et de l'appareillage spécifiés en A.2.4 et A.2.5, il est permis d'utiliser la méthode et l'appareillage décrits aux Articles 5 et 9 de la CEI 60695-11-5. Le nombre d'applications de la flamme, leur durée et la méthode sont conformes à ce qui est spécifié en A.2.5 et la vérification de conformité est en accord avec A.2.6.

NOTE La conformité à la méthode de A.2.4 et de A.2.5 ou de A.2.7 est acceptable; il n'est pas exigé de satisfaire aux deux méthodes.

A.3 Essai à l'huile chaude enflammée (voir 4.6.2)

A.3.1 Montage des échantillons

*Un échantillon du fond de l'*ENVELOPPE CONTRE LE FEU*, complet et apprêté, est disposé sur un support sur lequel il est solidement fixé, dans une position horizontale. De l'étamine blanchie d'environ 40 g/m*^{2} *est tendue en une seule épaisseur au-dessus d'un bac peu profond à fond plat, placé à environ 50 mm au-dessous de l'échantillon; elle a des dimensions telles qu'elle puisse recouvrir complètement l'ensemble des ouvertures dans l'échantillon sans être toutefois suffisamment large pour recueillir une portion quelconque de l'huile qui déborde de l'échantillon ou ne passe pas par les ouvertures.*

NOTE Il est recommandé d'entourer la zone d'essai d'un écran métallique ou d'une séparation en verre armé.

A.3.2 Procédure d'essai

Une petite louche métallique (de préférence n'ayant pas plus de 65 mm de diamètre) munie d'un bec verseur et d'une longue poignée dont l'axe longitudinal reste à l'horizontale durant le déversement est remplie partiellement avec 10 ml de mazout distillé, c'est-à-dire un distillat semi volatile ayant une masse volumique comprise entre 0,845 g/ml et 0,865 g/ml, un point d'éclair compris entre 43,5 °C et 93,5 °C, et une valeur calorifique moyenne de 38 MJ/l. La louche contenant l'huile est chauffée; on enflamme l'huile et on la laisse brûler pendant 1 min, après quoi on déverse toute l'huile chaude enflammée, à un débit constant de 1 ml/s approximativement, sur le centre géométrique de l'ensemble des ouvertures à partir d'une position située à environ 100 mm au-dessus de celles-ci.

*L'essai est répété deux fois à 5 min d'intervalle, en utilisant de l'*ETAMINE *propre.*

A.3.3 Critère de conformité

Pendant ces essais, l'étamine ne doit pas s'enflammer.

Annexe B
(normative)

Essais des moteurs dans les conditions anormales

(voir 4.7.2.2 et 5.3.2)

B.1 Exigences générales

Les moteurs autres que les moteurs à courant continu dans les CIRCUITS SECONDAIRES *doivent satisfaire aux essais des Articles B.4 et B.5 et, lorsqu'ils sont applicables, aux essais des Articles B.8, B.9 et B.10, avec l'exception que les moteurs suivants n'ont pas à satisfaire à l'essai de l'Article B.4:*

– *moteurs utilisés uniquement pour le brassage de l'air lorsque l'élément propulsant l'air est directement couplé à l'axe du moteur; et*

– *moteurs à bagues de déphasage dont les valeurs du courant à rotor bloqué et du courant à vide ne diffèrent pas de plus de 1 A et ont un rapport inférieur ou égal à 2/1.*

Les moteurs à courant continu dans des CIRCUITS SECONDAIRES *doivent satisfaire aux essais des Articles B.6, B.7 et B.10 à l'exception des moteurs qui, par leur fonctionnement intrinsèque, fonctionnent normalement dans les conditions de rotor bloqué, tels que les moteurs pas à pas, ne sont pas soumis à essai. En outre, les moteurs à courant continu dans des* CIRCUITS SECONDAIRES *qui sont utilisés uniquement pour le brassage de l'air lorsque l'élément propulsant l'air est directement couplé à l'axe du moteur n'ont pas à satisfaire à l'essai de l'Article B.6.*

B.2 Conditions d'essai

Sauf spécification contraire dans la présente annexe, pendant les essais, le matériel est mis en fonctionnement sous la TENSION ASSIGNÉE *ou sous la tension la plus élevée de la* PLAGE ASSIGNÉE DE TENSIONS.

Les essais sont effectués soit sur l'équipement soit dans des conditions simulées sur le banc. Il est permis d'utiliser des échantillons séparés pour les essais sur le banc. Les conditions simulées comprennent:

– *tout dispositif de protection qui protégerait le moteur dans le matériel complet; et*

– *l'utilisation de tout moyen de fixation qui peut servir à évacuer la chaleur de la carcasse du moteur.*

Les températures des enroulements sont mesurées comme spécifié en 1.4.13. Lorsque des couples thermoélectriques sont utilisés, ils sont appliqués sur la surface des enroulements du moteur. Les températures sont déterminées à la fin de la période d'essai lorsque cela est spécifié, sinon lorsque la température s'est stabilisée ou lors du fonctionnement des fusibles, des COUPE-CIRCUIT THERMIQUES*, des dispositifs de protection du moteur et des dispositifs analogues.*

Pour les moteurs entièrement fermés, protégés par impédance, les températures sont mesurées au moyen de couples thermoélectriques appliqués au carter du moteur.

Lorsque des moteurs sans protection thermique propre sont essayés dans des conditions simulées sur le banc, les températures mesurées sur les enroulements sont modifiées pour tenir compte de la température ambiante dans laquelle le moteur est placé normalement dans le matériel, comme mesurée pendant l'essai de 4.5.2.

B.3 Températures maximales

Pour les essais des Articles B.5, B.7, B.8 et B.9, les limites de température telles qu'elles sont spécifiées au Tableau B.1 ne doivent pas être dépassées pour chaque classe de matériau isolant.

Tableau B.1 – Limites des températures permises pour les enroulements de moteurs (à l'exception de l'essai de surcharge)

Température maximale °C

Méthode de protection	Classe thermique							
	105 (A)	**120 (E)**	**130 (B)**	**155 (F)**	**180 (H)**	**200**	**220**	**250**
Protection par impédance propre ou externe	150	165	175	200	225	245	265	295
Protection par un dispositif de protection qui fonctionne pendant la première heure	200	215	225	250	275	295	315	345
Protection par tout dispositif de protection:								
– maximum après la première heure	175	190	200	225	250	270	290	320
– moyenne arithmétique pendant la 2^e heure et la 72^e heure	150	165	175	200	225	245	265	295
Les désignations A à H, attribuées précédemment dans la CEI 60085 aux classes thermiques 105 à 180, sont données entre parenthèses.								

La moyenne arithmétique de la température est déterminée comme suit:

Le graphique de la température en fonction du temps (voir Figure B.1), alors que l'alimentation du moteur est ouverte et fermée, est tracé pour la période d'essai étudiée. La moyenne arithmétique de la température (t_A) est déterminée par la formule:

$$t_A = \frac{t_{max} + t_{min}}{2}$$

où

t_{max} *est la moyenne des valeurs maximales;*

t_{min} *est la moyenne des valeurs minimales.*

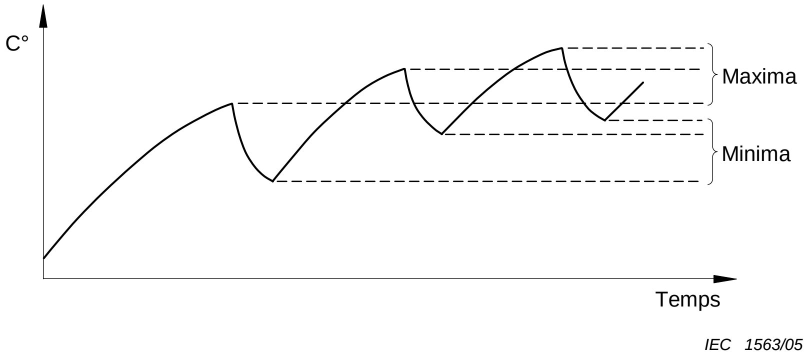


Figure B.1 – Détermination de la moyenne arithmétique des températures

Pour les essais des Articles B.4 et B.6, les limites de températures, telles qu'elles sont spécifiées dans le Tableau B.2, ne doivent pas être dépassées pour chaque classe de matériau isolant.

B.4 Essai de surcharge

Un essai de protection contre le fonctionnement en surcharge est effectué en faisant fonctionner le moteur sous la CHARGE NORMALE*. La charge est ensuite augmentée de telle façon que le courant croisse graduellement par échelons appropriés, la tension d'alimentation du moteur étant maintenue à sa valeur initiale. Après obtention de l'état d'équilibre, la charge est à nouveau augmentée. La charge est ainsi augmentée progressivement par échelons appropriés, mais sans atteindre les conditions de rotor bloqué (voir l'Article B.5), jusqu'à ce que le dispositif de protection contre le fonctionnement en surcharge fonctionne.*

Les températures des enroulements du moteur sont déterminées pendant chaque période d'équilibre et la température maximale relevée ne doit pas dépasser les valeurs spécifiées dans le Tableau B.2.

Tableau B.2 – Limites des températures permises pour les essais en surcharge

Température maximale °C

Classe thermique							
105 (A)	**120 (E)**	**130 (B)**	**155 (F)**	**180 (H)**	**200**	**220**	**250**
140	155	165	190	215	235	255	275
Les désignations A à H, attribuées précédemment dans la CEI 60085 aux classes thermiques 105 à 180, sont données entre parenthèses.							

B.5 Essai de surcharge à rotor bloqué

Un essai à rotor bloqué est effectué avec démarrage à la température ambiante.

La durée de l'essai est la suivante:

- *un moteur protégé par une impédance propre ou externe est mis en fonctionnement avec son rotor bloqué pendant 15 jours avec l'exception que l'essai est arrêté lorsque les enroulements du moteur, du type soit ouvert soit totalement fermé, atteignent une température constante, pourvu que la température constante ne soit pas supérieure à la température spécifiée en 4.5.3, Tableau 4B pour le système d'isolation utilisé;*
- *un moteur muni d'un dispositif de protection à réenclenchement automatique est mis en fonctionnement cyclique, avec son rotor calé pendant 18 jours;*
- *un moteur muni d'un dispositif de protection à réenclenchement manuel est mis en fonctionnement cyclique, avec son rotor bloqué, pendant 60 cycles, le dispositif de protection étant réenclenché après chacun de ses fonctionnements aussi rapidement que possible pour qu'il se maintienne fermé mais pas avant 30 s;*
- *un moteur muni d'un dispositif de protection non réenclenchable est mis en fonctionnement jusqu'à ce que le dispositif fonctionne.*

Les températures sont relevées à intervalles réguliers pendant les trois premiers jours pour les moteurs protégés par une impédance propre ou externe ou munis d'un dispositif de protection à réenclenchement automatique, ou pendant les dix premiers cycles pour les moteurs munis d'un dispositif de protection à réenclenchement manuel, ou au moment du fonctionnement des dispositifs de protection non réenclenchables.

Les températures ne doivent pas dépasser les valeurs spécifiées au Tableau B.1.

Pendant l'essai, les dispositifs de protection doivent fonctionner de façon sûre sans rupture de l'isolation avec la carcasse du moteur ou sans provoquer des dommages durables au moteur, y compris une détérioration excessive de l'isolation.

Des dommages durables sur le moteur comprennent:

– *les émissions de fumées ou l'inflammation fortes ou prolongées;*
– *le claquage électrique ou mécanique de toute partie de composant associé tel que condensateur ou relais de démarrage;*
– *l'écaillage, la friabilité ou la carbonisation de l'isolation.*

Une décoloration de l'isolation est permise mais la carbonisation ou la friabilité à un point tel que l'isolation s'écaille ou que le matériau s'enlève lorsque l'enroulement est frotté avec le pouce n'est pas permise.

Après la période spécifiée pour la mesure de la température et après refroidissement du moteur jusqu'à la température ambiante, le moteur doit satisfaire à l'essai de rigidité diélectrique de 5.2.2 et avec les tensions d'essai réduites à 60% des valeurs spécifiées. Il n'est pas exigé d'autre essai de rigidité diélectrique.

NOTE La poursuite de l'essai d'un dispositif de protection à réenclenchement automatique au-delà de 72 h et d'un dispositif de protection à réenclenchement manuel au-delà de 10 cycles a pour but de démontrer que le dispositif est capable de couper et d'établir le courant à rotor bloqué pendant une longue durée.

B.6 Essai de surcharge pour les moteurs à courant continu dans les circuits secondaires

B.6.1 Généralités

L'essai de fonctionnement en surcharge n'est effectué que si le risque de surcharge est déterminé par examen ou par l'étude de la conception. Il n'est pas nécessaire d'effectuer l'essai, par exemple, dans le cas où un circuit piloté par électronique maintient un courant pratiquement constant.

Les moteurs doivent satisfaire à l'essai de B.6.2 sauf que, lorsqu'il s'avère difficile d'obtenir des mesures de températures précises du fait de la petite taille ou de la conception non conventionnelle du moteur, la méthode de B.6.3 peut être utilisée à la place. La conformité peut être établie par l'une ou l'autre des méthodes.

B.6.2 Procédure d'essai

Le moteur est mis en fonctionnement sous sa CHARGE NORMALE. *La charge est ensuite augmentée de telle façon que le courant croisse graduellement par échelons appropriés, la tension d'alimentation du moteur étant maintenue à sa valeur initiale. Après obtention de l'état d'équilibre, la charge est à nouveau augmentée. La charge est ainsi augmentée progressivement par échelons appropriés jusqu'à ce que le dispositif de protection contre le fonctionnement en surcharge fonctionne, ou jusqu'à ce que l'enroulement devienne un circuit ouvert.*

Les températures des enroulements du moteur sont déterminées pendant chaque période d'équilibre et la température maximale relevée ne doit pas dépasser les valeurs dans le Tableau B.2.

B.6.3 Procédure d’essai en variante

Le moteur est placé sur une planche de bois recouverte d'une seule épaisseur de PAPIER MOUSSELINE *et le moteur, à son tour, est recouvert d'une seule couche d'*ETAMINE.

A la fin de l'essai, il ne doit pas y avoir inflammation du PAPIER MOUSSELINE *ou de l'*ETAMINE.

La conformité à l'une ou l'autre méthode est acceptable; il n'est pas nécessaire de satisfaire aux deux méthodes.

B.6.4 Essai de rigidité diélectrique

A la suite de l'essai de B.6.2 ou B.6.3, suivant celui qui est applicable, si la tension du moteur dépasse 42,4 V valeur de crête, ou 60 V courant continu, et après son refroidissement jusqu'à la température ambiante, le moteur doit satisfaire à l'essai de rigidité diélectrique de 5.2.2 mais avec les tensions d'essai réduites à 60 % des valeurs spécifiées.

B.7 Essai de surcharge à rotor bloqué pour les moteurs à courant continu dans les circuits secondaires

B.7.1 Généralités

Les moteurs doivent satisfaire à l'essai de B.7.2 sauf que, lorsqu'il s'avère difficile d'obtenir des mesures de températures précises du fait de la petite taille ou de la conception non conventionnelle du moteur, la méthode de B.7.3 peut être utilisée à la place. La conformité peut être établie par l'une ou l'autre des méthodes.

B.7.2 Procédure d’essai

Le moteur est mis en fonctionnement sous la tension utilisée dans son application et avec son rotor bloqué pendant 7 h ou jusqu'à obtention de l'état d’équilibre, ~~suivant la durée~~ la plus longue de ces deux durées étant retenue. Cependant, si l'enroulement du moteur s'ouvre, ou autrement le moteur devient non alimenté en permanence, l'essai est arrêté.

Les températures ne doivent pas dépasser les valeurs spécifiées dans le Tableau B.1.

B.7.3 Procédure d’essai en variante

Le moteur est placé sur une planche de bois recouverte d'une seule épaisseur de PAPIER MOUSSELINE *et le moteur, à son tour, est recouvert d'une seule épaisseur d'un tissu de coton blanchi d'environ 40 g/m^2.*

Le moteur est ensuite mis en fonctionnement ~~sous sa tension de service~~ à la tension utilisée dans son application et avec son rotor bloqué pendant 7 h ou jusqu'à obtention de l'état d’équilibre, ~~suivant la durée~~ la plus longue de ces deux durées étant retenue. Cependant, si l'enroulement du moteur s'ouvre, ou autrement le moteur devient non alimenté en permanence, l'essai est arrêté.

A la fin de l'essai, il ne doit pas y avoir inflammation du PAPIER MOUSSELINE *ou de l'*ETAMINE.

B.7.4 Essai de rigidité diélectrique

A la suite de l'essai de B.7.2 ou B.7.3, suivant celui qui est applicable, si la tension du moteur dépasse 42,4 V valeur de crête, ou 60 V courant continu, et après son refroidissement jusqu'à la température ambiante, le moteur doit satisfaire à l'essai de rigidité diélectrique de 5.2.2 mais avec les tensions d'essai réduites à 60 % des valeurs spécifiées.

B.8 Essais des moteurs à condensateurs

Les moteurs munis de condensateurs pour le changement de phase sont essayés dans les conditions de rotor bloqué avec les condensateurs court-circuités ou en circuit ouvert (suivant le cas le plus défavorable).

L'essai avec le condensateur court-circuité n'est pas effectué si le condensateur est prévu et marqué de telle sorte que, en cas de défaillance, il ne reste pas court-circuité.

Les températures ne doivent pas dépasser les valeurs spécifiées dans le Tableau B.1.

NOTE Il est spécifié de bloquer le rotor car certains moteurs pourraient ne pas démarrer et des résultats variables pourraient être obtenus.

B.9 Essais des moteurs triphasés

Les moteurs triphasés sont essayés sous la CHARGE NORMALE *avec un conducteur de ligne déconnecté à moins que les dispositifs de commande des circuits n'empêchent l'application de la tension au moteur avec un ou plusieurs conducteurs déconnectés.*

L'effet d'autres charges et circuits à l'intérieur du matériel peut rendre nécessaire d'effectuer l'essai sur le moteur à l'intérieur du matériel et avec chacun des trois conducteurs de ligne déconnecté un par un.

Les températures ne doivent pas dépasser les valeurs spécifiées dans le Tableau B.1.

B.10 Essais des moteurs série

Les moteurs série sont mis en fonctionnement sous une tension égale à 130 % leur tension nominale pendant 1 min avec la charge la plus faible possible.

Après l'essai, les enroulements et les connexions ne doivent pas s'être desserrés et aucun danger ne doit exister au sens de la présente norme.

Annexe C
(normative)

Transformateurs

(voir 1.5.4 et 5.3.3)

C.1 Essai de surcharge

Si les essais du présent article sont effectués dans des conditions simulées au banc d'essai, ces conditions doivent comprendre tout dispositif de protection qui protégerait le transformateur dans le matériel complet.

Les transformateurs pour les alimentations à découpage sont essayés dans l'alimentation complète ou dans le matériel complet. Les charges d'essai sont appliquées à la sortie de l'alimentation.

Chacun des enroulements secondaires d'un transformateur linéaire ou d'un transformateur à ferro-résonance est chargé tour à tour, les autres enroulements secondaires étant chargés entre zéro et leur charge maximale spécifiée pour obtenir l'effet d'échauffement maximal.

La sortie d'une alimentation à découpage est chargée pour obtenir l'effet d'échauffement maximal dans le transformateur.

NOTE Pour des exemples de charges donnant l'effet d'échauffement maximal, voir l'Annexe X.

Lorsqu'une surcharge ne peut survenir ou n'est pas susceptible de provoquer un danger, les essais ci-dessus ne sont pas effectués.

Les températures maximales des enroulements ne doivent pas dépasser les valeurs du Tableau C.1, lorsqu'elles sont mesurées comme spécifié en 1.4.12 et en 1.4.13 et déterminées comme spécifié ci-dessous:

– *avec une protection extérieure contre les surintensités: au moment du fonctionnement, pour la détermination du temps écoulé jusqu'à ce que la protection contre les surintensités fonctionne, il est permis de se référer à une feuille de caractéristiques du dispositif de protection contre les surintensités donnant le temps de déclenchement en fonction des caractéristiques de courant;*
– *avec un COUPE-CIRCUIT THERMIQUE A REENCLENCHEMENT AUTOMATIQUE: comme indiqué dans le Tableau C.1 et après 400 h;*
– *avec un COUPE-CIRCUIT THERMIQUE A REENCLENCHEMENT MANUEL: au moment du fonctionnement;*
– *pour les transformateurs limiteurs de courant: après stabilisation de la température.*

Si la température des enroulements d'un transformateur avec un noyau en ferrite, mesurée comme spécifié en 1.4.12, dépasse 180 °C, elle doit être essayée à nouveau à la valeur maximale de la température ambiante nominale (T_{amb} = T_{ma}), et non telle que calculée selon 1.4.12.

NOTE La procédure ci-dessus doit permettre de s'assurer que la détérioration des caractéristiques Curie de la ferrite aux températures approchant les 200 °C ne cause pas d'emballement thermique (augmentation imprévisible de la température).

Les enroulements secondaires qui dépassent les limites de température mais qui se mettent en circuit ouvert ou qui nécessitent, d'une autre façon, le remplacement du transformateur sont satisfaisants pour cet essai, si aucun danger n'est créé au sens de la présente norme.

Pour les critères de conformité, voir 5.3.9.

Tableau C.1 – Limites des températures permises pour les enroulements de transformateurs

Température maximale °C

Méthode de protection	Classe thermique							
	105 (A)	**120 (E)**	**130 (B)**	**155 (F)**	**180 (H)**	**200**	**220**	**250**
Protection par impédance propre ou externe	150	165	175	200	225	245	265	295
Protection par un dispositif de protection qui fonctionne pendant la première heure	200	215	225	250	275	295	315	345
Protection par tout dispositif de protection:								
– maximum après la première heure	175	190	200	225	250	270	290	320
– moyenne arithmétique pendant la 2e heure et la 72e heure	150	165	175	200	225	245	265	295
Les désignations A à H, attribuées précédemment dans la CEI 60085 aux classes thermiques 105 à 180, sont données entre parenthèses.								

La moyenne arithmétique de la température est déterminée comme suit:

Le graphique de la température en fonction du temps (voir Figure C.1), alors que l'alimentation du transformateur est ouverte et fermée, est tracé pour la période d'essai étudiée. La moyenne arithmétique de la température (t_A) est déterminée par la formule:

$$t_A = \frac{t_{max} + t_{min}}{2}$$

où

t_{max} *est la moyenne des valeurs maximales;*

t_{min} *est la moyenne des valeurs minimales.*

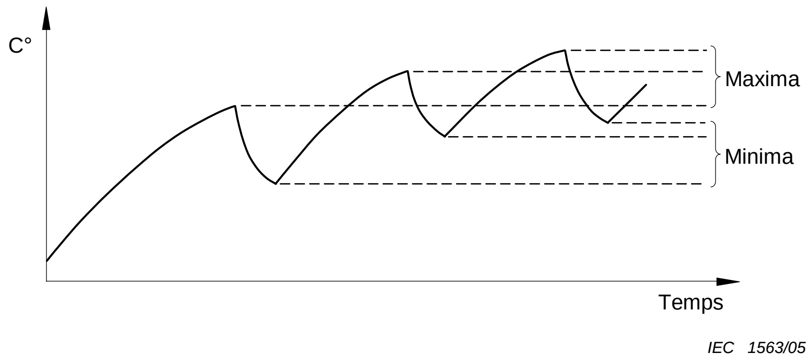


Figure C.1 – Détermination de la moyenne arithmétique des températures

C.2 Isolation

L'isolation dans les transformateurs doit satisfaire aux exigences suivantes.

Les enroulements et les parties conductrices des transformateurs doivent être traités comme des parties des circuits auxquels ils sont connectés, si cela s'applique. L'isolation entre eux doit satisfaire aux exigences applicables de 2.10 (ou de l'Annexe G) et satisfaire aux essais applicables de 5.2, suivant l'application de l'isolation dans le matériel (voir 2.9.3).

Des précautions doivent être prises pour empêcher la réduction en dessous des valeurs minimales spécifiées des DISTANCES DANS L'AIR et des LIGNES DE FUITE qui assurent l'ISOLATION PRINCIPALE, l'ISOLATION SUPPLEMENTAIRE ou l'ISOLATION RENFORCEE par:

– un déplacement des enroulements ou de leurs spires;
– un déplacement des conducteurs internes ou des conducteurs pour les connexions externes;
– un déplacement nuisible des parties des enroulements ou des conducteurs internes, en cas de rupture des conducteurs adjacents aux connexions ou de desserrage des connexions;
– un pontage de l'isolation par des conducteurs, des vis, des rondelles ou des organes analogues au cas où ils se desserreraient ou se détacheraient.

Il n'est pas envisagé que deux fixations indépendantes se desserrent en même temps.

Tous les enroulements doivent avoir des spires terminales maintenues par des moyens fiables.

La vérification est effectuée par examen, par des mesures et, si nécessaire, par les essais suivants.

Si le transformateur est équipé d'un écran pour des raisons de mise à la terre de protection, et que cet écran est séparé de l'enroulement primaire relié à un circuit SOUS TENSION DANGEREUSE *par une* ISOLATION PRINCIPALE *uniquement, l'écran doit remplir une des conditions suivantes:*

– *satisfaire aux exigences de 2.6.3.3;*
– *satisfaire aux exigences de 2.6.3.4 entre l'écran mis à la terre et la borne principale de mise à la terre de protection du matériel;*
– *satisfaire à un essai de simulation d'une rupture de l'*ISOLATION PRINCIPALE *entre l'écran et l'enroulement primaire associé. Le transformateur doit être protégé par tout dispositif de protection utilisé dans l'application finale. Le chemin de mise à la terre de protection et l'écran ne doivent pas être endommagés.*

Si les essais sont effectués, on utilise un spécimen de transformateur spécialement préparé ayant un fil de sortie relié à l'extrémité libre de l'écran, afin de s'assurer que pendant l'essai le courant passe à travers l'écran.

Exemples de formes acceptables de construction (voir 1.3.8):

– *des enroulements isolés les uns des autres placés sur des supports séparés d'un même noyau, avec ou sans bobines;*
– *des enroulements disposés sur une bobine unique avec une paroi de séparation, pourvu que la bobine et la paroi de séparation soient pressées ou moulées en une seule pièce, ou que, dans le cas où la paroi de séparation est rapportée, il existe une protection intermédiaire ou un recouvrement sur le joint entre la bobine et la paroi de séparation;*

- *des enroulements concentriques séparés sur une bobine en matière isolante sans rebords ou sur une isolation appliquée sous forme de feuilles minces sur le noyau du transformateur;*
- *une isolation est prévue entre les enroulements sous forme d'une feuille isolante s'étendant au-delà des spires terminales de chaque couche;*
- *des enroulements concentriques séparés par un écran conducteur mis à la terre, qui consiste en une feuille métallique qui s'étend sur toute la largeur de l'enroulement avec une isolation appropriée entre chaque enroulement et l'écran. L'écran conducteur et son conducteur de sortie ont une section suffisante pour garantir qu'en cas de défaillance de l'isolation, le dispositif de protection contre les surcharges ouvrira le circuit avant que l'écran ne soit détruit. Le dispositif de protection contre les surcharges peut être une partie du transformateur.*

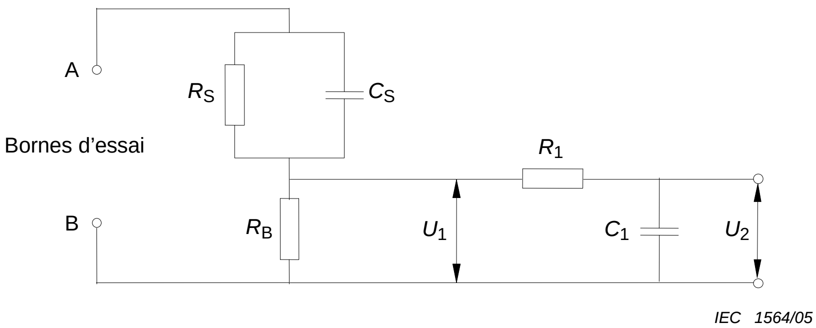
Annexe D
(normative)

Appareils de mesure pour les essais de courant de contact

(voir 5.1.4)

D.1 Appareil de mesure

L’appareil de mesure de la Figure D.1 est celui de la Figure 4 de la CEI 60990.

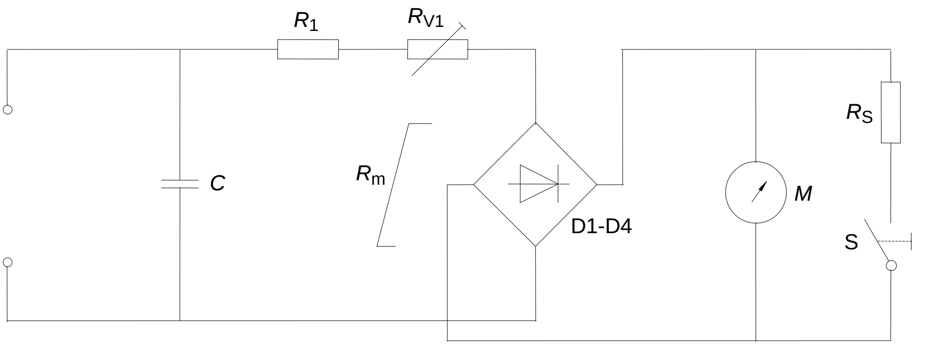


R_S	1 500 Ω	
R_B	500 Ω	
R_1	10 kΩ	
C_S	0,22 µF	
C_1	0,022 µF	
Voltmètre ou oscilloscope (lecture valeur efficace ou crête)	Résistance d’entrée:	~~>~~≥1 MΩ
	Capacité d’entrée:	<200 pF
	Plage de fréquences: (appropriée pour la plus haute fréquence intéressante, voir 1.4.7)	~~15~~ 20 Hz à 1 MHz

Figure D.1 – Appareil de mesure

L’appareil de mesure est étalonné par comparaison du facteur de fréquence de U_2 avec la ligne continue de la Figure F.2 de la CEI 60990 à différentes fréquences. Une courbe d’étalonnage est construite, montrant l’écart de U_2 par rapport à la courbe idéale en fonction de la fréquence.

D.2 Appareil de mesure en variante



M	0 mA – 1 mA mouvement de la bobine mobile
$R_1 + R_{V1} + R_m$ à 0,5 mA courant continu	1 500 Ω ± 1 % avec *C* = 150 nF ± 1 % ou 2 000 Ω ± 1 % avec *C* = 112 nF ± 1%
D1-D4	Redresseur
R_s	Shunt non inductif pour plage × 10
S	Bouton de sensibilité (appuyer pour sensibilité maximale)

Figure D.2 – Appareil de mesure en variante

L'appareil comprend un redresseur/compteur à bobine mobile avec des résistances complémentaires en série, les deux étant shuntées par un condensateur, comme indiqué dans la Figure D.2. L'effet du condensateur est de réduire la sensibilité aux harmoniques et autres fréquences au-dessus de la fréquence d'alimentation. L'appareil devrait également inclure une plage × 10 obtenue en shuntant la bobine du compteur par une résistance non inductive. Il est permis d'inclure également une protection contre les surintensités pourvu que la méthode utilisée n'affecte pas les caractéristiques de base de l'appareil.

R_{V1} est réglé pour la valeur désirée de résistance totale à 0,5 mA courant continu.

Le compteur est étalonné aux points d'étalonnage suivants sur la plage de sensibilité maximale à 50 Hz à 60 Hz, sinusoïdal:

0,25 mA, 0,5 mA, 0,75 mA.

La réponse de fréquence est vérifiée au point d'étalonnage 0,5 mA:

Sensibilité à 5 kHz sinusoïdal: 3,6 mA ± 5 %.

Annexe E
(normative)

Echauffement d'un enroulement

(voir 1.4.13)

La valeur de l'échauffement d'un enroulement est calculée à partir de la formule:

pour un enroulement en cuivre $$\Delta t = \frac{R_2 - R_1}{R_1}(234{,}5 + t_1) - (t_2 - t_1)$$

pour un enroulement en aluminium $$\Delta t = \frac{R_2 - R_1}{R_1}(225 + t_1) - (t_2 - t_1)$$

où

Δt *est l'échauffement, en kelvins;*

R_1 *est la résistance de l'enroulement au début de l'essai, en ohms;*

R_2 *est la résistance de l'enroulement à la fin de l'essai, en ohms;*

t_1 *est la température ambiante au début de l'essai, en degrés Celsius;*

t_2 *est la température ambiante à la fin de l'essai, en degrés Celsius.*

Au début de l'essai, les enroulements sont à la température ambiante.

Il est recommandé de déterminer la résistance des enroulements à la fin de l'essai en prenant des mesures de résistance dès que possible après la déconnexion, et ensuite à faibles intervalles de façon que la courbe de résistance en fonction du temps puisse être tracée pour s'assurer de la résistance au moment de la déconnexion.

Pour la comparaison des températures des enroulements déterminées par la méthode de mesure de la résistance de la présente annexe et des limites de températures du Tableau 4B, on ajoute 25 °C à l'échauffement calculé.

Annexe F
(normative)

Mesure des distances dans l'air et des lignes de fuite

(voir 2.10 et Annexe G)

Les méthodes de mesure des DISTANCES DANS L'AIR et des LIGNES DE FUITE qui sont spécifiées dans les figures suivantes sont utilisées dans l'interprétation des exigences de la présente norme.

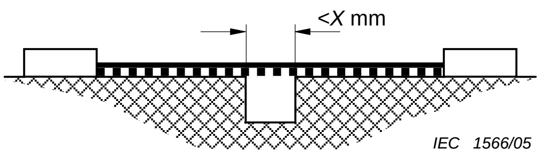
Dans les figures suivantes, la valeur de *X* est donnée dans le Tableau F.1. Lorsque la distance montrée est inférieure à *X*, la profondeur de l'ouverture ou de l'encoche n'est pas prise en compte pour la mesure d'une LIGNE DE FUITE.

Le Tableau F.1 est valable uniquement si la DISTANCE DANS L'AIR minimale spécifiée est de 3 mm ou plus. Si la DISTANCE DANS L'AIR minimale spécifiée est inférieure à 3 mm, la valeur de *X* est la valeur la plus faible de:

– la valeur applicable du Tableau F.1; ou
– un tiers de la DISTANCE DANS L'AIR minimale spécifiée.

Tableau F.1 – Valeur de *X*

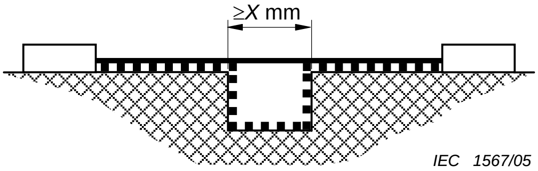
Degré de pollution (voir 2.10.1.2)	***X*** mm
1	0,25
2	1,0
3	1,5



Conditions: Le chemin comprend une encoche à flancs parallèles ou convergents, de profondeur quelconque et de largeur inférieure à *X* mm.

Règle: La DISTANCE DANS L'AIR et la LIGNE DE FUITE sont mesurées en ligne droite au-dessus de l'encoche.

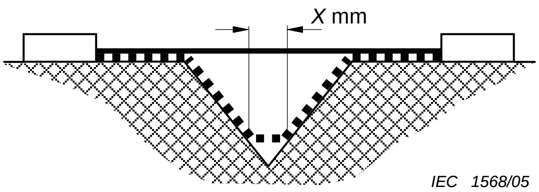
Figure F.1 – Encoche étroite



Conditions: Le chemin comprend une encoche à flancs parallèles de profondeur quelconque et de largeur supérieure ou égale à *X* mm.

Règle: La DISTANCE DANS L'AIR est la distance en ligne droite. Le chemin de la LIGNE DE FUITE longe le profil des encoches.

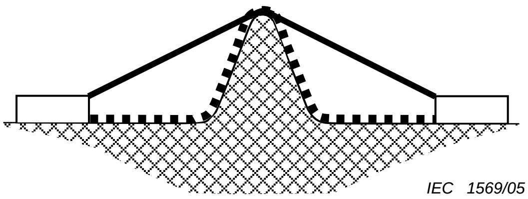
Figure F.2 – Encoche large



Conditions: Le chemin comprend une encoche en V dont l'angle d'ouverture est inférieur à 80° et dont la largeur est supérieure à *X* mm.

Règle: La DISTANCE DANS L'AIR est la distance en ligne droite. Le chemin de la LIGNE DE FUITE longe le profil de l'encoche, mais «court-circuite» le bas de l'encoche par un tronçon d'une longueur de *X* mm.

Figure F.3 – Encoche en forme de V

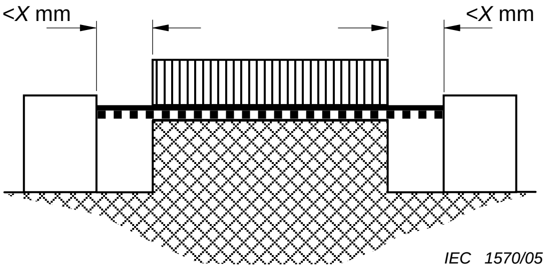


Conditions: Le chemin comprend une nervure.

Règle: La DISTANCE DANS L'AIR est le chemin dans l'air le plus court par-dessus le sommet de la nervure. Le chemin de la LIGNE DE FUITE longe le profil de la nervure.

Figure F.4 – Nervure

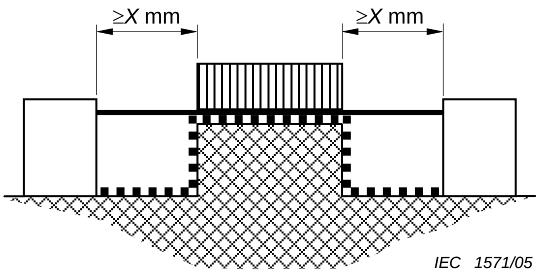
——— DISTANCE DANS L'AIR ■ ■ ■ ■ ■ ■ ■ LIGNE DE FUITE



Conditions: Le chemin comprend deux parties non collées avec des encoches de largeur inférieure à *X* mm de chaque côté.

Règle: Le chemin de la DISTANCE DANS L'AIR et de la LIGNE DE FUITE est la distance en ligne droite indiquée ci-dessus.

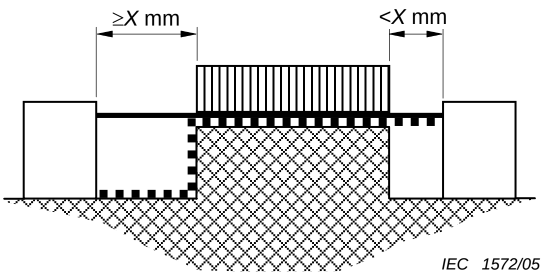
Figure F.5 – Parties non collées avec encoche étroite



Conditions: Le chemin comprend deux parties non collées avec des encoches de largeur égale ou supérieure à *X* mm de chaque côté.

Règle: La DISTANCE DANS L'AIR est la distance en ligne droite. Le chemin de la LIGNE DE FUITE longe le profil des encoches.

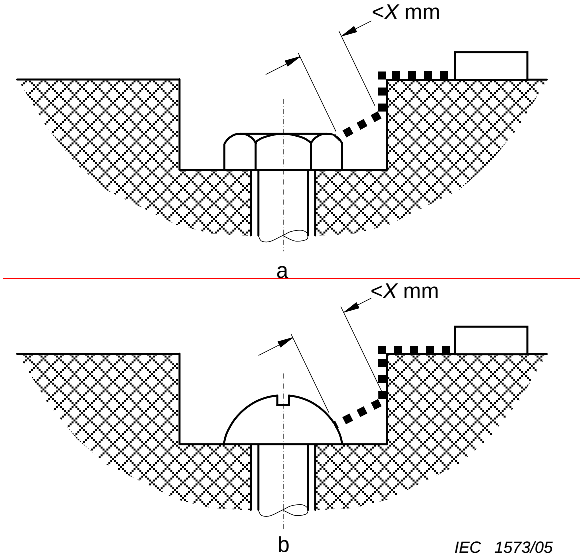
Figure F.6 – Parties non collées avec encoche large

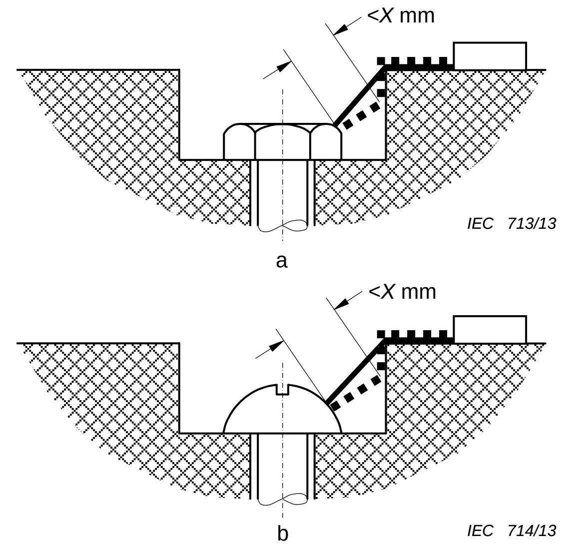


Conditions: Le chemin comprend deux parties non collées avec, d'un côté, une encoche de largeur inférieure à *X* mm et, de l'autre côté, une encoche de largeur égale ou supérieure à *X* mm.

Règle: Les chemins de la DISTANCE DANS L'AIR et de la LIGNE DE FUITE sont indiqués sur la figure.

Figure F.7 – Parties non collées avec encoches large et étroite



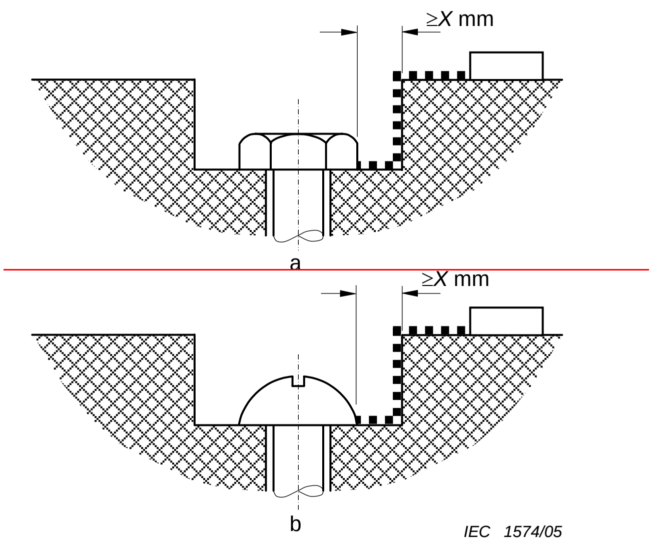


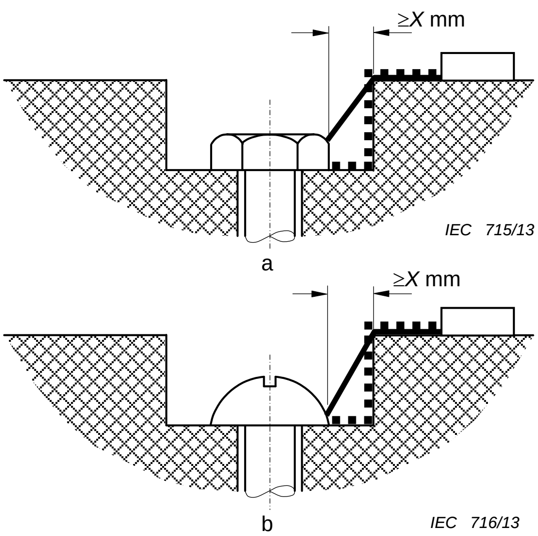
Distance entre tête de vis et paroi du logement trop faible pour être prise en compte.

La ligne de fuite est mesurée de la vis à la paroi, où la distance est égale à *X* mm..

Figure F.8 – Faible retrait

DISTANCE DANS L'AIR LIGNE DE FUITE





Distance entre tête de vis et paroi du logement suffisante pour être prise en compte.

Figure F.9 – Large retrait

~~LIGNE DE FUITE~~

DISTANCE DANS L'AIR ▪▪▪▪▪▪▪ LIGNE DE FUITE

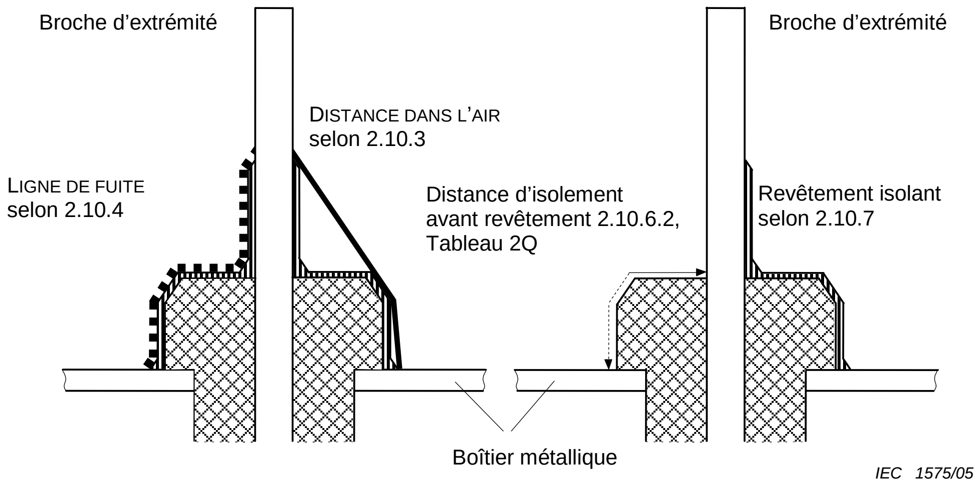


Figure F.10 – Revêtement autour des bornes

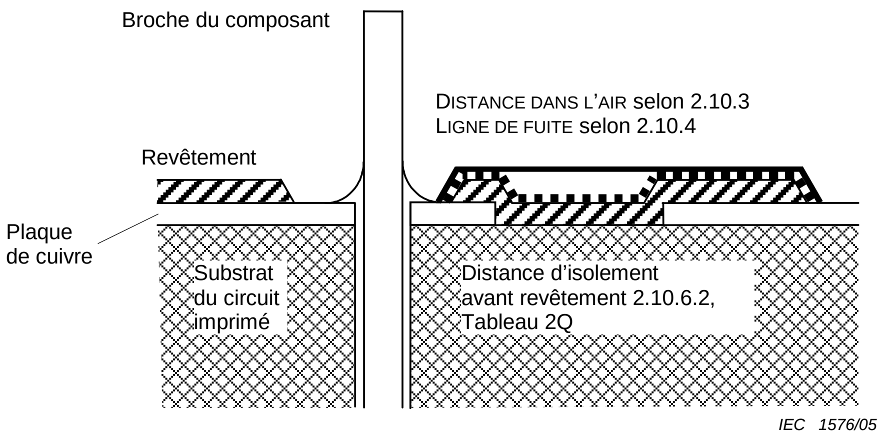
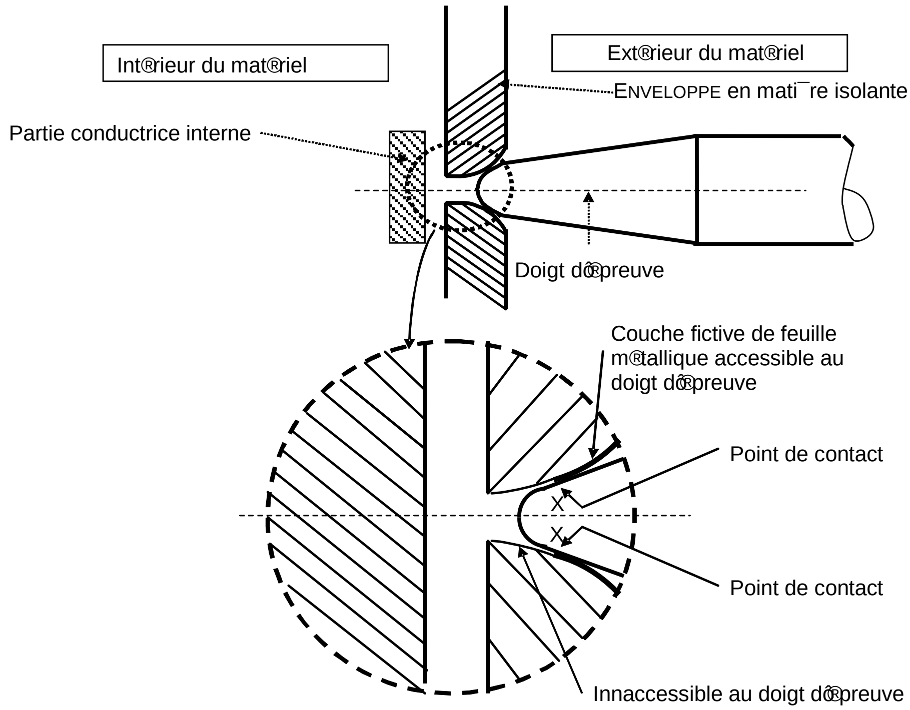


Figure F.11 – Revêtement sur des circuits imprimés



Le point X est utilis® pour les mesures des DISTANCE DANS LôAIR et des LIGNES DE FUITE depuis la SURFACE FRONTIERE dôune ENVELOPPE de mati¯re isolante jusquô une partie conductrice interne (voir 2.10.3.1 et 2.10.4)

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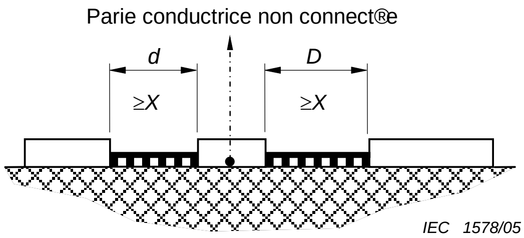
Figure F.12 – Mesures à travers des ouvertures dans les enveloppes



Conditions: Distance d'isolation avec une partie conductrice non connect®e intercal®e.

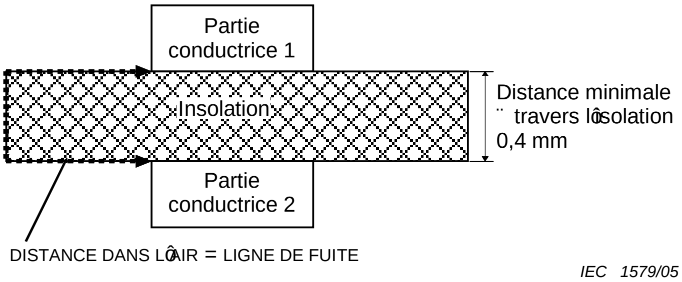
R¯gle: La DISTANCE DANS L'AIR est la distance *d* + *D*

La LIGNE DE FUITE est aussi *d* + *D*

Lorsque la valeur de *d* ou *D* est inf®rieure ¨ *X* elle doit °tre consid®r®e comme ®gale ¨ 0.

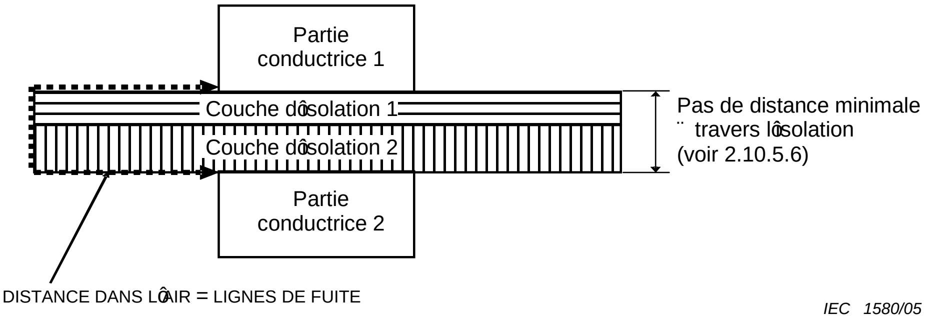
Figure F.13 – Partie conductrice non connectée intercalée

DISTANCE DANS LôAIR ■ ■ ■ ■ ■ ■ ■ LIGNE DE FUITE



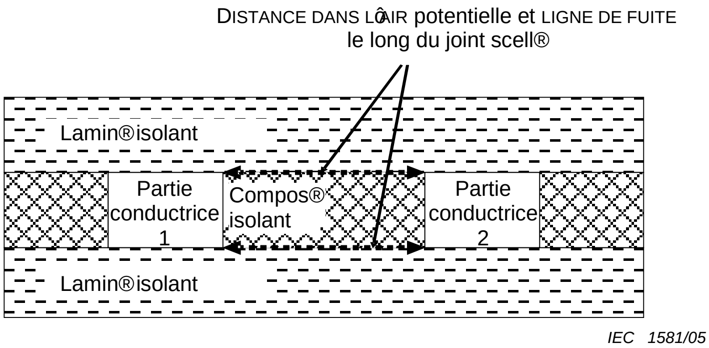
Feuille ®paisse ou mat®riau isolant solide comme ISOLATION SUPPLEMENTAIRE ou ISOLATION RENFORCEE

Figure F.14 – Matériau isolant solide



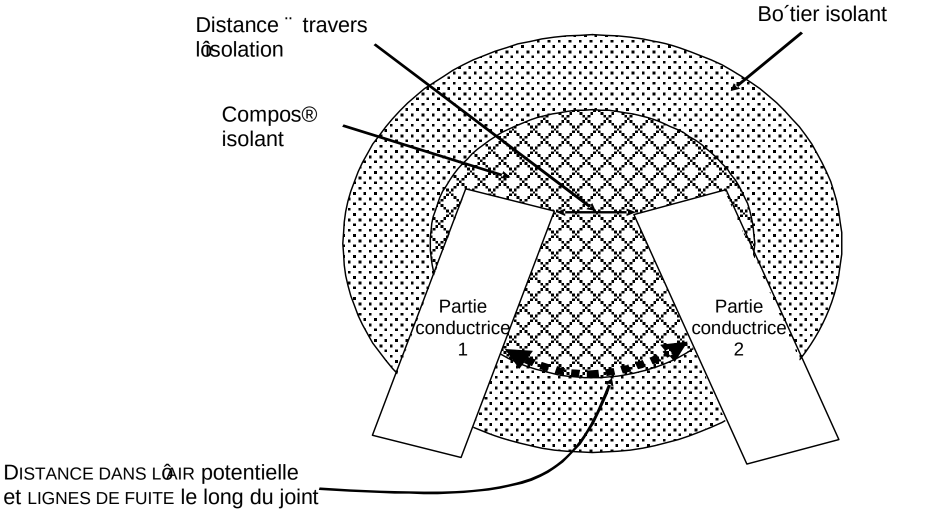
Deux couches d'un mat®riau en fines feuilles comme ISOLATION SUPPLEMENTAIRE ou ISOLATION RENFORCEE

Figure F.15 – Matériau isolant en fines feuilles



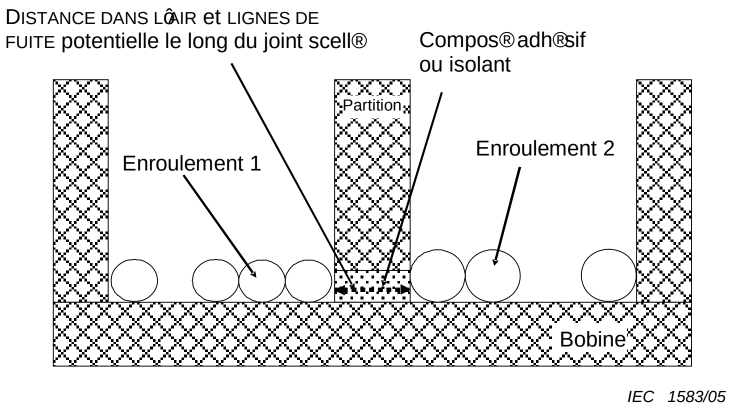
Compos® isolant comme ISOLATION SUPPLEMENTAIRE ou ISOLATION RENFORCEE

Figure F.16 – Joints scellés dans les cartes imprimées multi-couches



Compos® isolant comme ISOLATION SUPPLEMENTAIRE ou ISOLATION RENFORCEE ¨ l'int®rieur d'un composant

Figure F.17 – Composant rempli avec un composé isolant



Joint scell® comme ISOLATION SUPPLEMENTAIRE ou ISOLATION RENFORCEE

Figure F.18 – Bobine cloisonnée

Annexe G
(normative)

Autre méthode pour la détermination des distances dans l'air minimales

G.1 Distances dans l'air

G.1.1 Généralités

Les DISTANCES DANS L'AIR doivent être dimensionnées de telle façon que les surtensions y compris les transitoires qui peuvent entrer dans le matériel, et les tensions de crête qui peuvent être produites à l'intérieur du matériel, ne détruisent pas la DISTANCE DANS L'AIR.

Il est permis d'utiliser soit les exigences de 2.10.3 pour les catégories de surtensions I ou II en utilisant la VALEUR DE CRETE DE LA TENSION DE SERVICE soit les exigences de l'Annexe G pour les catégories de surtensions I, II, III ou IV en utilisant la TENSION DE TENUE PRESCRITE pour un composant ou un sous-ensemble particulier ou pour le matériel de son ensemble.

NOTE On considère comme bonne pratique le fait de concevoir une ISOLATION SOLIDE pour des surtensions transitoires plus élevées que les DISTANCES DANS L'AIR associées.

G.1.2 Résumé de la procédure pour la détermination des distances dans l'air minimales

NOTE 1 Les DISTANCES DANS L'AIR minimales pour l'ISOLATION FONCTIONNELLE, l'ISOLATION PRINCIPALE, l'ISOLATION SUPPLEMENTAIRE et l'ISOLATION RENFORCEE, que ce soit dans un CIRCUIT PRIMAIRE ou dans un autre circuit, dépendent de la TENSION DE TENUE PRESCRITE. La TENSION DE TENUE PRESCRITE dépend à son tour de l'effet combiné de la tension de fonctionnement normal (y compris les pics répétitifs dus à des circuits internes tels que les alimentations à découpage) et des surtensions non répétitives dues aux transitoires externes.

Pour déterminer la valeur minimale de chaque DISTANCE DANS L'AIR, les étapes suivantes doivent être suivies:

(1) Mesurer la TENSION DE TRAVAIL CRETE à travers la distance dans l'air concernée.

(2) Si le matériel est alimenté par le réseau:

- déterminer la TENSION TRANSITOIRE DU RESEAU (Article G.2); et
- pour les matériels destinés à être reliés au RESEAU D'ALIMENTATION EN COURANT ALTERNATIF, calculer la valeur de crête de la tension nominale du RESEAU D'ALIMENTATION EN COURANT ALTERNATIF.

(3) Utiliser les règles de G.4.1 et les valeurs de tension ci-dessus pour déterminer la TENSION DE TENUE PRESCRITE pour les transitoires du réseau et les pics répétitifs interne. En l'absence de transitoires provenant d'un RESEAU DE TELECOMMUNICATIONS, aller à l'étape 7.

(4) Si le matériel est destiné à être relié à un RESEAU DE TELECOMMUNICATIONS, déterminer la TENSION DE TRANSITOIRES DU RESEAU DE TELECOMMUNICATIONS (Article G.3).

(5) Utiliser la TENSION DE TRANSITOIRES DU RESEAU DE TELECOMMUNICATIONS et les règles de G.4.2 pour déterminer la TENSION DE TENUE PRESCRITE pour les ~~transitoires du~~ TRANSITOIRES DU RESEAU DE TELECOMMUNICATIONS. En l'absence de pics répétitifs du réseau d'alimentation et en interne, aller à l'étape 7.

(6) Utiliser la règle de G.4.3 pour déterminer la TENSION DE TENUE PRESCRITE totale.

(7) Utiliser la tension de tenue prescrite pour déterminer la distance dans l'air minimale (Article G.6).

NOTE 2 L'effet des transitoires provenant d'un SYSTEME DE DISTRIBUTION PAR CABLES n'est pas pris en compte (voir G.4.4 et 7.4.1).

G.2 Détermination de la tension de transitoires du réseau

G.2.1 Réseau d'alimentation en courant alternatif

Pour les matériels destinés à être alimentés par le RESEAU D'ALIMENTATION EN COURANT ALTERNATIF, la valeur de la TENSION TRANSITOIRE DU RESEAU dépend de la catégorie de surtension et de la tension du RESEAU D'ALIMENTATION EN COURANT ALTERNATIF. En général, les DISTANCES DANS L'AIR dans les matériels destinés à être connectés au RESEAU D'ALIMENTATION EN COURANT ALTERNATIF doivent être prévues pour la catégorie de surtension II.

NOTE 1 Voir l'Annexe Z pour des lignes directrices supplémentaires concernant la détermination de la catégorie de surtensions.

Les matériels qui, une fois installés, sont susceptibles de subir des surtensions transitoires dépassant celles de leur catégorie de surtension de conception devront être équipés d'une protection supplémentaire à prévoir à l'extérieur du matériel. Dans ce cas, les instructions d'installation doivent indiquer la nécessité d'une telle protection extérieure.

La valeur applicable de la TENSION TRANSITOIRE DU RESEAU doit être déterminée à partir de la catégorie de surtension et de la tension nominale du RESEAU D'ALIMENTATION EN COURANT ALTERNATIF, à l'aide du Tableau G.1.

Tableau G.1 – Tensions transitoires du réseau en courant alternatif

tension du RESEAU D'ALIMENTATION EN COURANT ALTERNATIF [a] **V efficace**	**TENSION TRANSITOIRE DU RESEAU** [b] **V crête**			
	Catégorie de surtension			
	I	**II**	**III**	**IV**
jusqu'à 50 inclus	330	500	800	1 500
de 50 à 100 inclus	500	800	1 500	2 500
supérieure à 100 jusqu'à 150 inclus [c]	800	1 500	2 500	4 000
supérieure à 150 jusqu'à inclus 300 [d]	1 500	2 500	4 000	6 000
supérieure à 300 jusqu'à inclus 600 [e]	2 500	4 000	6 000	8 000

[a] Pour les matériels conçus pour être connectés à une alimentation triphasée à trois fils dans laquelle il n'y a pas de conducteur neutre, la tension d'ALIMENTATION DU RESEAU EN COURANT ALTERNATIF est la tension entre lignes. Dans tous les autres cas où il existe un conducteur neutre, il s'agit de la tension entre ligne et neutre.

[b] La TENSION TRANSITOIRE DU RESEAU est toujours une des valeurs du tableau. L'interpolation n'est pas autorisée.

[c] Y compris 120/208 V et 120/240 V.

[d] Y compris 230/400 V et 277/480 V.

[e] Y compris 400/690 V.

NOTE 2 Au Japon, la valeur des TENSIONS TRANSITOIRES SUR LE RESEAU pour une tension nominale du RESEAU D'ALIMENTATION EN COURANT ALTERNATIF de 100 V est déterminée à partir des lignes applicables pour une tension du RESEAU D'ALIMENTATION EN COURANT ALTERNATIF de 150 V.

G.2.2 Réseaux d'alimentation en courant continu reliés à la terre

Si une ALIMENTATION DE RESEAU EN COURANT CONTINU est connectée à la terre de protection et se trouve entièrement à l'intérieur d'un même bâtiment, la TENSION TRANSITOIRE DU RESEAU doit être prise comme égale à 71 V, valeur de crête. Si cette connexion se situe à l'intérieur de l'appareil en essai, elle doit être conforme à 2.6.1 e).

NOTE La connexion à une terre de protection peut se situer à la source du RESEAU D'ALIMENTATION EN COURANT CONTINU ou à l'emplacement du matériel, ou les deux (voir la Recommandation UIT-T K.27).

G.2.3 Réseaux d'alimentation en courant continu non reliés à la terre

Si une ALIMENTATION DU RESEAU EN COURANT CONTINU n'est pas reliée à la terre et est située comme indiqué en G.2.2, la TENSION TRANSITOIRE DU RESEAU doit être prise comme égale à la TENSION TRANSITOIRE DU RESEAU dans le RESEAU D'ALIMENTATION EN COURANT ALTERNATIF qui fournit le RESEAU D'ALIMENTATION EN COURANT CONTINU.

G.2.4 Fonctionnement sur batterie

Si le matériel est alimenté par une batterie dédiée qui ne dispose d'aucun dispositif de charge à partir d'un RESEAU D'ALIMENTATION externe, la TENSION TRANSITOIRE DU RESEAU doit être prise comme 71 V, valeur de crête.

G.3 Détermination de la tension de transitoires du réseau de télécommunications

Si la TENSION TRANSITOIRE DU RESEAU DE TELECOMMUNICATIONS est connue pour le réseau concerné, il est permis d'utiliser la valeur connue en G.4.2.

Si la TENSION TRANSITOIRE DU RESEAU DE TELECOMMUNICATIONS n'est pas connue, une des valeurs suivantes doit être utilisée.

– 1 500 V valeur de crête si le circuit relié au RESEAU DE TELECOMMUNICATIONS est un CIRCUIT TRT-1 ou un CIRCUIT TRT-3; ou
– 800 V de crête si le circuit relié au RESEAU DE TELECOMMUNICATIONS est un CIRCUIT TBTS ou un CIRCUIT TRT-2.

L'effet du signal de sonnerie de téléphone n'est pas pris en compte à cet effet.

G.4 Détermination de la tension de tenue prescrite

G.4.1 Transitoires réseau et pics internes répétitifs

En G.4.1, l'effet des transitoires provenant d'un RESEAU DE TELECOMMUNICATIONS est ignoré (voir G.4.3).

La TENSION DE TENUE PRESCRITE est déterminée selon a), b) ou c).

NOTE Les points a) et b) s'appliquent seulement pour un RESEAU D'ALIMENTATION EN COURANT ALTERNATIF. Le point c) s'applique seulement pour une ALIMENTATION EN COURANT CONTINU.

Les abréviations suivantes sont utilisées.

U_{pw}	la VALEUR DE CRETE DE LA TENSION DE SERVICE de la DISTANCE DANS L'AIR
$U_{\text{crête réseau c.a.}}$	valeur de crête de la TENSION DU RESEAU D'ALIMENTATION EN COURANT ALTERNATIF dans la première colonne du Tableau G.1 correspondant à la TENSION ASSIGNEE ou à la LIMITE SUPERIEURE DE LA PLAGE DE TENSIONS ASSIGNEES.
$U_{\text{transitoires réseau}}$	la TENSION TRANSITOIRE DU RESEAU déterminée en G.2.1 ou en G.2.2
$U_{\text{mesurée}}$	la tension transitoire maximale provenant du réseau déterminée selon G.5 a)

a) **CIRCUITS PRIMAIRES**

Il est permis d'utiliser a1) ou a2).

a1) Les règles suivantes 1) et 2) doivent être appliquées:

Règle 1) Si $U_{pw} \leq U_{crête\ réseau\ c.a}$

$U_{tenue\ prescrite} = U_{transitoires\ du\ réseau}$

Règle 2) Si $U_{pw} > U_{crête\ réseau\ c.a}$

$U_{tenue\ prescrite} = U_{transitoires\ du\ réseau} + U_{pw} - U_{crête\ réseau\ c.a}$

a2) Les règles ci-dessus 1) et 2) doivent être appliquées, mais $U_{transitoires\ du\ réseau}$ doit être remplacé par $U_{mesurée}$.

b) **CIRCUITS SECONDAIRES dont le CIRCUIT PRIMAIRE est alimenté par un RESEAU D'ALIMENTATION EN COURANT ALTERNATIF**

Il est permis d'utiliser b1), b2) ou b3).

b1) La règle 3) suivante doit être appliquée:

Règle 3) $U_{tenue\ prescrite} = U_{transitoire\ réseau}$ ou $U_{pw,}$ en prenant la plus élevée des deux

b2) La règle 3) ci-dessus doit être appliquée mais avec $U_{transitoire\ réseau}$ remplacé par $U_{mesurée}$.

b3) La règle 3 ci-dessus doit être appliquée, mais avec $U_{transitoire\ réseau}$ remplacé par une tension d'un échelon inférieure dans la liste suivante tirée du Tableau G.1:

330, 500, 800, 1 500, 2 500, 4 000, 6 000 et 8 000 V crête.

Cela est autorisé dans les cas suivants:

– un CIRCUIT SECONDAIRE, dérivé d'une ALIMENTATION RESEAU EN COURANT ALTERNATIF, qui est connecté à la principale borne de mise à la terre de protection conformément à 2.6.1 e).
– un CIRCUIT SECONDAIRE, dérivé d'une ALIMENTATION DE RESEAU EN COURANT ALTERNATIF et séparé du CIRCUIT PRIMAIRE par un écran métallique qui est connecté à la principale borne de mise à la terre de protection conformément à 2.6.1 e);

c) **CIRCUIT SECONDAIRE alimenté par un RESEAU D'ALIMENTATION EN COURANT CONTINU**

Les points b1) ou b3) ci-dessus doivent s'appliquer.

G.4.2 Transitoires provenant de réseaux de télécommunications

En G.4.2, l'effet des transitoires provenant du réseau et des circuits internes est ignoré (voir G.4.3).

Pour les transitoires provenant d'un RESEAU DE TELECOMMUNICATIONS, la TENSION D'ESSAI PRESCRITE est:

– la TENSION TRANSITOIRE DU RESEAU DE TELECOMMUNICATIONS déterminée à l'Article G.3;
– ou la valeur mesurée conformément à G.5 b);

en prenant la valeur la plus faible.

G.4.3 Combinaison de transitoires

Si les transitoires décrits en G.4.1 et ceux décrits en G.4.2 affectent la même DISTANCE DANS L'AIR, la TENSION DE TENUE PRESCRITE est celle des deux valeurs qui est la plus élevée. Les deux valeurs ne doivent pas être additionnées.

G.4.4 Transitoires de RESEAUX DE DISTRIBUTION PAR CABLES

Les effets des transitoires provenant des SYSTEMES DE DISTRIBUTION PAR CABLES ne sont pas pris en compte pour la détermination de la TENSION DE TENUE PRESCRITE (voir toutefois 7.4.1).

G.5 Mesure des tensions transitoires

Les essais suivants sont effectués uniquement s'il est prescrit de déterminer si oui ou non la tension transitoire maximale à travers la DISTANCE DANS L'AIR dans un circuit quelconque est inférieure à la TENSION TRANSITOIRE DU RESEAU déterminée à l'Article G.2 (par exemple à cause de l'effet d'un filtre dans le matériel). Si ces essais ne sont pas effectués, la tension transitoire maximale à travers la DISTANCE DANS L'AIR doit être prise comme égale à la TENSION TRANSITOIRE DU RESEAU. Si la situation couverte par G.2.2 ou celle couverte par G.2.4 s'applique, la tension transitoire à travers la DISTANCE DANS L'AIR doit être estimée comme étant négligeable et aucun essai n'est effectué.

Si cela est nécessaire, la tension transitoire à travers la DISTANCE DANS L'AIR est mesurée à l'aide des procédures d'essai suivantes.

Pendant les essais, le matériel en essai est relié à son unité d'alimentation séparée, s'il elle existe, mais n'est pas relié au RESEAU D'ALIMENTATION, ni à aucun RÉSEAU DE TÉLÉCOMMUNICATIONS, et tous les parasurtenseurs des CIRCUITS PRIMAIRES sont déconnectés.

Un dispositif de mesure de tension est connecté à travers la DISTANCE DANS L'AIR concernée.

a) Transitoires provenant d'un RESEAU D'ALIMENTATION

Pour mesurer les tensions transitoires à travers une DISTANCE DANS L'AIR dues aux tensions transitoires sur un RESEAU D'ALIMENTATION, le générateur d'impulsions d'essai, référence 2 du Tableau N.1 est utilisé pour produire des impulsions de 1,2/50 µs. U_c est égal à la TENSION TRANSITOIRE DU RESEAU déterminée à l'Article G.2.

Trois à six impulsions de polarités alternées, avec des intervalles d'au moins 1 s entre les impulsions, sont appliquées entre tous les points suivants, lorsque c'est applicable:

Pour une ALIMENTATION DE RESEAU EN COURANT CONTINU:

- *entre lignes;*
- *tous les conducteurs de ligne reliés galvaniquement ensemble et le neutre;*
- *tous les conducteurs de ligne reliés galvaniquement ensemble et la terre de protection;*
- *le neutre et la principale borne de mise à la terre de protection.*

Pour une ALIMENTATION DE RESEAU EN COURANT CONTINU:

- *les points positif et négatif de connexion d'alimentation;*
- *tous les points de connexion d'alimentation reliés galvaniquement ensemble et la principale borne de terre de protection;*

b) Transitoires provenant d'un RESEAU DE TELECOMMUNICATIONS

Pour mesurer une tension transitoire à travers une DISTANCE DANS L'AIR due aux tensions transitoires sur un RESEAU DE TELECOMMUNICATIONS, le générateur d'impulsions d'essai, référence 1 du Tableau N.1 est utilisé pour produire des impulsions de 10/700 µs. U_C est égal à la TENSION TRANSITOIRE SUR LE RESEAU DE TELECOMMUNICATIONS déterminée à l'Article G.3.

Trois à six impulsions de polarités alternées, avec des intervalles d'au moins 1 s entre les impulsions, sont appliquées entre chacun des points de connexion suivants du RESEAU DE TELECOMMUNICATIONS de chaque type d'interface:

- *chaque paire de bornes (par exemple A et B ou données et sonnerie) d'une interface;*

– *toutes les bornes d'un type d'interface unique reliées ensemble et la terre.*

Lorsqu'il existe plusieurs circuits identiques, un seul est soumis aux essais.

G.6 Détermination des distances dans l'air minimales

Pour les matériels destinés à être utilisés jusqu'à 2 000 m au-dessus du niveau de la mer, chaque DISTANCE DANS L'AIR doit être conforme aux dimensions minimales données dans le Tableau G.2, en utilisant la valeur de TENSION DE TENUE PRESCRITE déterminée suivant l'Article G.4.

Pour les matériels destinés à être utilisés à plus de 2 000 m au-dessus du niveau de la mer, les DISTANCES DANS L'AIR minimales doivent être multipliées par le facteur donné au Tableau A.2 de la CEI 60664-1. L'interpolation linéaire est autorisée entre les deux points les plus proches du Tableau A.2 de la CEI 60664-1. La DISTANCE DANS L'AIR minimale calculée en utilisant ce facteur de multiplication doit être arrondie à l'échelon de 0,1 mm immédiatement supérieur.

Les DISTANCES DANS L'AIR minimales spécifiées sont soumises aux valeurs minimales absolues suivantes:

– 10 mm pour un intervalle d'air servant d'ISOLATION RENFORCEE entre une partie sous TENSION DANGEREUSE et une partie conductrice accessible de l'ENVELOPPE de matériels reposant sur le sol ou la surface supérieure non verticale d'un matériel de table;
– 2 mm pour un intervalle d'air des contacts servant d'ISOLATION PRINCIPALE entre une partie sous TENSION DANGEREUSE et une partie conductrice accessible reliée à la terre de l'ENVELOPPE de MATERIELS DE TYPE A RACCORDES PAR PRISE DE COURANT.

Les deux alinéas précédents ne s'appliquent pas entre une partie soumise à une TENSION DANGEREUSE et une SURFACE FRONTIERE.

A l'exception de ce qui est prescrit en 2.8.7.1, les DISTANCES DANS L'AIR minimales spécifiées ne s'appliquent pas à la distance entre les contacts de THERMOSTATS, de COUPE-CIRCUIT THERMIQUES, de dispositifs de protection contre les surcharges, d'interrupteurs à faible distance d'ouverture des contacts et dispositifs analogues, lorsque la distance varie avec les contacts.

NOTE 1 Pour les distances entre les contacts des dispositifs de connexion, voir 3.4.2. Pour les distances entre les contacts des interrupteurs de verrouillage, voir 2.8.7.1.

Les DISTANCES DANS L'AIR entre la SURFACE FRONTIERE d'un connecteur et les parties conductrices à l'intérieur du connecteur qui sont connectées à une TENSION DANGEREUSE doivent être conformes aux exigences D'ISOLATION RENFORCEE. A titre exceptionnel, pour les connecteurs qui sont

– fixés au matériel; et
– situés à l'intérieur de l'ENVELOPPE extérieure du matériel; et sont
– uniquement accessibles après retrait d'un sous-ensemble qui peut être remplacé par l'UTILISATEUR qui doit être en place en fonctionnement normal,

ces DISTANCES DANS L'AIR doivent être conformes aux exigences pour l'ISOLATION PRINCIPALE.

NOTE 2 Les essais de 2.1.1.1 pour l'accès aux parties dangereuses s'appliquent à de tels connecteurs après le retrait du sous-ensemble.

Pour toutes les autres DISTANCES DANS L'AIR dans les connecteurs, y compris les connecteurs qui ne sont pas fixés au matériel, les valeurs minimales spécifiées au Tableau G.2 s'appliquent.

Les DISTANCES DANS L'AIR minimales ci-dessus pour les connecteurs ne s'appliquent pas aux connecteurs qui sont conformes à une norme harmonisée avec la CEI 60083, la CEI 60309, la CEI 60320, la CEI 60906-1 ou la CEI 60906-2. Voir aussi 1.5.2.

Tableau G.2 – Distances dans l'air minimales jusqu'à 2 000 m au-dessus du niveau de la mer

DISTANCES DANS L'AIR en mm

TENSION DE TENUE PRESCRITE	**ISOLATION FONCTIONNELLE** [a]			ISOLATION PRINCIPALE **et** ISOLATION SUPPLEMENTAIRE			**ISOLATION RENFORCEE**		
V crête ou continue jusqu'à et y compris	**Degré de pollution**								
	1 [b]	**2**	**3**	**1** [b]	**2**	**3**	**1** [b]	**2**	**3**
400	0,1	0,2	0,8	0,2 (0,1)	0,2	0,8	0,4 (0,2)	0,4	1,6
800	0,1	0,2	0,8	0,2 (0,1)	0,2	0,8	0,4 (0,2)	0,4	1,6
1 000	0,2	0,2	0,8	0,3 (0,2)		0,8	0,6 (0,4)		1,6
1 200	0,3		0,8	0,4 (0,3)		0,8	0,8 (0,6)		1,6
1 500	0,5		0,8	0,8 (0,5)		0,8	1,6 (1,0)		1,6
2 000	1,0			1,3 (1,0)			2,6 (2,0)		
2 500	1,5			2,0 (1,5)			4,0 (3,0)		
3 000	2,0			2,6 (2,0)			5,2 (4,0)		
4 000	3,0			4,0 (3,0)			6,0		
6 000	5,5			7,5 (5,5)			11		
8 000	8,0			11 (8,0)			16		
10 000	11			15 (11)			22		
12 000	14			19 (14)			28		
15 000	18			24 (18)			36		
25 000	33			44 (33)			66		
40 000	60			80 (60)			120		
50 000	75			100 (75)			150		
60 000	90			120 (90)			180		
80 000	130			173 (130)			260		
100 000	170			227 (170)			340		

Il est permis de procéder par interpolation linéaire entre les deux points les plus proches, les DISTANCES DANS L'AIR minimales calculées étant arrondies à l'échelon de 0,1 mm immédiatement supérieur.

Les valeurs entre parenthèses sont applicables uniquement si la fabrication est soumise à un programme de contrôle de la qualité qui fournit un niveau d'assurance au moins égal à celui de l'exemple donné à l'Article R.2. La DOUBLE ISOLATION et l'ISOLATION RENFORCEE doivent être soumises à un ESSAI INDIVIDUEL DE SERIE pour la rigidité diélectrique.

Dans un CIRCUIT SECONDAIRE, une DISTANCE DANS L'AIR minimale de 5 mm remplace toute valeur supérieure, dans la mesure où l'isolation concernée passe avec succès un essai de rigidité diélectrique selon 5.2.2 en utilisant:

- une tension d'essai en courant alternatif dont la valeur efficace est égale à 106 % de la VALEUR DE CRETE DE LA TENSION DE SERVICE (valeur de crête 150 % de la VALEUR DE CRETE DE LA TENSION DE SERVICE), ou
- une tension d'essai en courant continu égale à 150 % de la VALEUR DE CRETE DE LA TENSION DE SERVICE.

Si le chemin de la DISTANCE DANS L'AIR suit partiellement la surface d'isolation qui n'appartient pas au groupe de matériau I, la tension d'essai est appliquée à travers l'espace et le groupe de matériau I uniquement. La partie du chemin le long de la surface de tout matériau isolant est contournée.

[a] Il n'existe pas de DISTANCE DANS L'AIR minimale pour l'ISOLATION FONCTIONNELLE sauf si cela est prescrit en 5.3.4 a).

[b] Il est permis d'utiliser les valeurs du degré de pollution 1 si un échantillon passe avec succès les essais de 2.10.10.

La vérification est effectuée par des mesures, en tenant compte de l'Annexe F. Les conditions suivantes s'appliquent:

– *les parties mobiles sont placées dans leurs positions les plus défavorables;*

– *pour le matériel équipé de* CÂBLES D'ALIMENTATION FIXES A DEMEURE *ordinaires, les mesures de* DISTANCES DANS L'AIR *sont effectuées avec des conducteurs d'alimentation de la plus forte section spécifiée en 3.3.4 et aussi sans conducteurs;*

NOTE 3 Les essais de force de 4.2.2, 4.2.3 et 4.2.4 s'appliquent.

– *lorsque les* DISTANCES DANS L'AIR*, à partir de la* SURFACE FRONTIERE *d'une* ENVELOPPE *en matière isolante, sont mesurées à travers une fente ou une ouverture dans l'*ENVELOPPE *ou à travers une ouverture dans un connecteur accessible, la surface accessible doit être considérée comme conductrice comme si elle était recouverte d'une feuille de métal partout où elle peut être touchée par le doigt d'épreuve, Figure 2A (voir 2.1.1.1), appliqué sans force appréciable (voir Figure F.12, point X).*

Il n'est pas nécessaire d'effectuer un essai de rigidité diélectrique pour vérifier les DISTANCES DANS L'AIR *à l'exception de ce qui est exigé au Tableau G.2 si une* DISTANCE DANS L'AIR *minimale de 5 mm est utilisée.*

Annexe H
(normative)

Rayonnements ionisants

(voir 4.3.13)

Les matériels qui risquent de produire des rayonnements ionisants sont vérifiés par une mesure du rayonnement émis.

Le rayonnement émis est déterminé au moyen d'un appareil de mesure du rayonnement du type chambre d'ionisation de section efficace égale à 1 000 mm^2, ou au moyen d'appareils de mesure d'autres types donnant des résultats équivalents.

Les mesures sont effectuées en utilisant le matériel alimenté à la tension la plus défavorable (voir 1.4.5), les commandes de l'OPÉRATEUR et les commandes de service étant réglées de manière à provoquer le maximum de rayonnement tout en maintenant le matériel apte à fonctionner normalement.

Les préréglages internes qu'il n'est pas prévu d'ajuster au cours de la vie du matériel ne sont pas considérés comme des commandes de service.

En aucun point situé à 50 mm de la surface de la ZONE D'ACCÈS DE L'OPÉRATEUR le taux d'exposition ne doit dépasser 36 pA/kg (5 µSv/h) (0,5 mR/h) (voir Note 1). Il est tenu compte du niveau de bruit de fond.

NOTE 1 Cette valeur est cohérente avec l'ICRP 60.

NOTE 2 Dans les pays membres du CENELEC, le taux des rayonnements ionisants est réglementé par la Directive européenne 96/29/Euratom du 13 mai 1996. Selon les exigences de cette directive, en tout point situé à 10 cm de la surface du matériel, le taux d'exposition ne doit pas dépasser 1 µSv/h (0,1 mR/h) en prenant en compte le niveau de fond.

Annexe J
(normative)

Tableau des potentiels électrochimiques (voir 2.6.5.6)

Tableau J.1 – Potentiels électrochimiques (V)

	~~Magnésium, alliages de magnésium~~	~~Zinc, alliages de zinc~~	~~Etain 80/20 Zn sur acier, Zn sur fer ou acier~~	~~Aluminium~~	~~Cd sur acier~~	~~Alliage Al/Mg~~	~~Acier doux~~	~~Duralumin~~	~~Plomb~~	~~Cr sur acier, soudure tendre~~	~~Cr sur Ni sur acier, étain sur acier, acier inoxydable 12 % Cr~~	~~Acier inoxydable à haute teneur en Cr~~	~~Cuivre, alliages de cuivre~~	~~Soudure à l'argent, acier inoxydable austénitique~~	~~Ni sur acier~~	~~Argent~~	~~Rh sur Ag sur Cu, alliage argent/or~~	~~Carbone~~	~~Or, platine~~
~~Magnésium, alliages de magnésium~~	~~0~~	~~0,5~~	~~0,55~~	~~0,7~~	~~0,8~~	~~0,85~~	~~0,9~~	~~1,0~~	~~1,05~~	~~1,1~~	~~1,15~~	~~1,25~~	~~1,35~~	~~1,4~~	~~1,45~~	~~1,6~~	~~1,65~~	~~1,7~~	~~1,75~~
~~Zinc, alliages de zinc~~		~~0~~	~~0,05~~	~~0,2~~	~~0,3~~	~~0,35~~	~~0,4~~	~~0,5~~	~~0,55~~	~~0,6~~	~~0,65~~	~~0,75~~	~~0,85~~	~~0,9~~	~~0,95~~	~~1,1~~	~~1,15~~	~~1,2~~	~~1,25~~
~~Etain 80/Zn 20 sur acier, Zn sur fer ou acier~~			~~0~~	~~0,15~~	~~0,25~~	~~0,3~~	~~0,35~~	~~0,45~~	~~0,5~~	~~0,5~~	~~0,6~~	~~0,7~~	~~0,8~~	~~0,85~~	~~0,9~~	~~1,05~~	~~1,1~~	~~1,15~~	~~1,2~~
~~Aluminium~~				~~0~~	~~0,1~~	~~0,15~~	~~0,2~~	~~0,3~~	~~0,35~~	~~0,4~~	~~0,45~~	~~0,55~~	~~0,65~~	~~0,7~~	~~0,75~~	~~0,9~~	~~0,95~~	~~1,0~~	~~1,05~~
~~Cd sur acier~~					~~0~~	~~0,05~~	~~0,1~~	~~0,2~~	~~0,25~~	~~0,3~~	~~0,35~~	~~0,45~~	~~0,55~~	~~0,6~~	~~0,65~~	~~0,8~~	~~0,85~~	~~0,9~~	~~0,95~~
~~Alliage Al/Mg~~						~~0~~	~~0,05~~	~~0,15~~	~~0,2~~	~~0,2~~	~~0,3~~	~~0,4~~	~~0,5~~	~~0,55~~	~~0,6~~	~~0,75~~	~~0,8~~	~~0,85~~	~~0,9~~
~~Acier doux~~							~~0~~	~~0,1~~	~~0,15~~	~~0,2~~	~~0,25~~	~~0,35~~	~~0,45~~	~~0,5~~	~~0,55~~	~~0,7~~	~~0,75~~	~~0,8~~	~~0,85~~
~~Duralumin~~								~~0~~	~~0,05~~	~~0,1~~	~~0,15~~	~~0,25~~	~~0,35~~	~~0,4~~	~~0,45~~	~~0,6~~	~~0,65~~	~~0,7~~	~~0,75~~
~~Plomb~~									~~0~~	~~0,5~~	~~0,1~~	~~0,2~~	~~0,3~~	~~0,35~~	~~0,4~~	~~0,55~~	~~0,6~~	~~0,66~~	~~0,7~~
~~Cr sur acier, soudure tendre~~										~~0~~	~~0,05~~	~~0,15~~	~~0,25~~	~~0,3~~	~~0,35~~	~~0,5~~	~~0,55~~	~~0,6~~	~~0,65~~
~~Cr sur Ni sur acier, étain sur acier inoxydable 12 % Cr~~											~~0~~	~~0,1~~	~~0,2~~	~~0,25~~	~~0,3~~	~~0,45~~	~~0,5~~	~~0,55~~	~~0,6~~
~~Acier inoxydable à haute teneur en Cr~~												~~0~~	~~0,1~~	~~0,15~~	~~0,2~~	~~0,35~~	~~0,4~~	~~0,45~~	~~0,5~~
~~Cuivre, alliages de cuivre~~													~~0~~	~~0,05~~	~~0,1~~	~~0,25~~	~~0,3~~	~~0,35~~	~~0,4~~
~~Soudure à l'argent, acier inoxydable austénitique~~														~~0~~	~~0,15~~	~~0,2~~	~~0,25~~	~~0,3~~	~~0,35~~
~~Ni sur acier~~															~~0~~	~~0,15~~	~~0,2~~	~~0,25~~	~~0,3~~
~~Argent~~																~~0~~	~~0,5~~	~~0,1~~	~~0,15~~
~~Rh sur Ag sur Cu, alliage argent/or~~																	~~0~~	~~0,05~~	~~0,1~~
~~Carbone~~																		~~0~~	~~0,5~~
~~Or, platine~~																			~~0~~

~~Ag Argent~~
~~Al Aluminium~~
~~Cd Cadmium~~
~~Cr Chrome~~
~~Cd Cuivre~~
~~Mg Magnésium~~
~~Ni Nickel~~
~~Rh Rhodium~~
~~Zn Zinc~~

~~NOTE La corrosion due à une action électrochimique entre métaux dissemblables qui sont en contact est minimisée si le potentiel électrochimique combiné est au-dessous d'environ 0,6 V. Ce tableau donne la liste des potentiels électrochimiques combinés pour un certain nombre de paires de métaux couramment employés. Il convient d'éviter les combinaisons situées au-dessus de la ligne de séparation.~~

	Zinc, zinc alloys	80 tin/20 zinc on steel, zinc on iron on steel	Aluminium	Cadmium on steel	Aluminium/magnesium alloy	Mild steel	Duralumin	Lead	Chromium on steel, soft solder	Cr on Ni on steel, tin on steel, 12 % Cr stainless steel	High chromium stainless steel	Copper, copper alloys	Silver solder, austenitic stainless steel	Nickel on steel	Silver	Rhodium on silver on copper, silver/gold alloy	Carbon	Gold, platinum	
0	0,5	0,55	0,7	0,8	0,85	0,9	1,0	1,05	1,1	1,15	1,25	1,35	1,4	1,45	1,6	1,65	1,7	1,75	Magnésium, alliages de magnésium
	0	0,05	0,2	0,3	0,35	0,4	0,5	0,55	0,6	0,65	0,75	0,85	0,9	0,95	1,1	1,15	1,2	1,25	Zinc, alliages de zinc
		0	0,15	0,25	0,3	0,35	0,45	0,5	0,55	0,6	0,7	0,8	0,85	0,9	1,05	1,1	1,15	1,2	Étain 80/zinc 20 sur acier, zinc sur fer ou acier
			0	0,1	0,15	0,2	0,3	0,35	0,4	0,45	0,55	0,65	0,7	0,75	0,9	0,95	1,0	1,05	Aluminium
				0	0,05	0,1	0,2	0,25	0,3	0,35	0,45	0,55	0,6	0,65	0,8	0,85	0,9	0,95	Cadmium sur acier
					0	0,05	0,15	0,2	0,25	0,3	0,4	0,5	0,55	0,6	0,75	0,8	0,85	0,9	Alliage aluminium/magnésium
						0	0,1	0,15	0,2	0,25	0,35	0,45	0,5	0,55	0,7	0,75	0,8	0,85	Acier doux
							0	0,05	0,1	0,15	0,25	0,35	0,4	0,45	0,6	0,65	0,7	0,75	Duralumin
								0	0,05	0,1	0,2	0,3	0,35	0,4	0,55	0,6	0,66	0,7	Plomb
									0	0,05	0,15	0,25	0,3	0,35	0,5	0,55	0,6	0,65	Chrome sur acier, soudure tendre
										0	0,1	0,2	0,25	0,3	0,45	0,5	0,55	0,6	Cr sur Ni sur acier, étain sur acier, acier inoxydable à 12 % Cr
											0	0,1	0,15	0,2	0,35	0,4	0,45	0,5	Acier inoxydable à haute teneur en Cr
												0	0,05	0,1	0,25	0,3	0,35	0,4	Cuivre, alliages de cuivre
													0	0,05	0,2	0,25	0,3	0,35	Soudure à l'argent, acier inoxydable austénitique
														0	0,15	0,2	0,25	0,3	Nickel sur acier
															0	0,05	0,1	0,15	Argent
																0	0,05	0,1	Rhodium sur argent sur cuivre, alliage argent/or
																	0	0,05	Carbone
																		0	Or, platine

Cr = chrome
Ni = nickel

NOTE La corrosion due à une action électrochimique entre métaux dissemblables qui sont en contact est réduite au maximum si le potentiel électrochimique combiné est au-dessous d'environ 0,6 V. Le tableau ci-dessus donne la liste des potentiels électrochimiques combinés pour un certain nombre de paires de métaux couramment employés. Il convient d'éviter les combinaisons situées au-dessus de la ligne de séparation.

Annexe K
(normative)

Dispositifs de commande thermiques

(voir 1.5.3 et 5.3.8)

K.1 Pouvoir de fermeture et pouvoir de coupure

Les THERMOSTATS et les LIMITEURS DE TEMPERATURES doivent avoir un pouvoir de fermeture et un pouvoir de coupure suffisants.

La vérification est effectuée en soumettant trois échantillons aux essais des Articles K.2 et K.3 ou aux essais de l'Article K.4 suivant ce qui est approprié. Si le composant est marqué T, un échantillon est essayé, la partie interrupteur étant à la température ambiante et deux échantillons sont essayés, cette partie étant à la température correspondant aux marques et indications.

Les composants qui ne portent pas l'indication de leurs propres caractéristiques assignées peuvent être essayés dans la machine ou séparément, suivant ce qui convient le mieux mais, s'ils sont essayés séparément, les conditions d'essai doivent être semblables à celles qui se présentent dans le matériel.

Pendant les essais, il ne doit se produire aucun arc permanent.

Après les essais, les échantillons ne doivent présenter aucun dommage nuisible à leur usage ultérieur. Les connexions électriques ne doivent pas s'être desserrées. Le composant doit satisfaire à un essai de rigidité diélectrique identique à l'essai spécifié en 5.2.2 avec l'exception suivante: la tension d'essai pour l'isolation entre les contacts est égale à deux fois la tension appliquée lorsque le matériel est alimenté sous la TENSION ASSIGNÉE ou sous la limite supérieure de la plage ASSIGNÉE DE TENSIONS.

Pour les besoins de l'essai, la fréquence de fonctionnement peut être augmentée au-delà de la fréquence normale de fonctionnement propre au matériel, pourvu qu'il n'en résulte pas une augmentation du risque de défaillance.

S'il n'est pas possible d'essayer le composant séparément, trois échantillons du matériel dans lequel il est utilisé sont essayés.

K.2 Fiabilité des thermostats

On fait fonctionner thermiquement les THERMOSTATS 200 fois (200 fermetures et 200 coupures) lorsque le matériel fonctionne sous une tension égale à 110 % la TENSION ASSIGNÉE ou 110% la limite supérieure de la PLAGE ASSIGNÉE DE TENSIONS, et sous la CHARGE NORMALE.

K.3 Essai d'endurance des thermostats

On fait fonctionner thermiquement les THERMOSTATS 10 000 fois (10 000 fermetures et 10 000 coupures) lorsque le matériel fonctionne sous la TENSION ASSIGNÉE ou sous la limite supérieure de la PLAGE ASSIGNÉE DE TENSIONS, et sous la CHARGE NORMALE.

K.4 Endurance des limiteurs de température

On fait fonctionner thermiquement les LIMITEURS DE TEMPÉRATURE *1 000 fois (1 000 fermetures et 1 000 coupures) lorsque le matériel fonctionne sous la* TENSION ASSIGNÉE *ou sous la tension la plus élevée de la* PLAGE ASSIGNÉE DE TENSIONS, *et sous la* CHARGE NORMALE.

K.5 Fiabilité des coupe-circuit thermiques

Les COUPE-CIRCUIT THERMIQUES doivent fonctionner de façon sûre.

La vérification est effectuée pendant que le matériel fonctionne dans les conditions spécifiées en 4.5.2.

On fait fonctionner 200 fois les COUPE-CIRCUIT THERMIQUES À RÉENCLENCHEMENT AUTOMATIQUE; *les* COUPE-CIRCUIT THERMIQUES À RÉENCLENCHEMENT MANUEL *sont réenclenchés après chaque déclenchement et ainsi mis en fonctionnement dix fois.*

Après les essais, les échantillons ne doivent présenter aucun dommage nuisible à leur usage ultérieur.

Il est permis de prévoir des périodes de ventilation forcée et de repos pour empêcher que le matériel ne soit endommagé.

K.6 Stabilité de fonctionnement

Les THERMOSTATS, les LIMITEURS DE TEMPERATURE et les COUPE-CIRCUIT THERMIQUES doivent être construits de façon que leur réglage ne soit pas modifié sensiblement par des échauffements, des vibrations, etc., se produisant en usage normal.

La vérification est effectuée par examen pendant les essais de fonctionnement anormal de 5.3.

Annexe L
(normative)

Conditions de charge normale pour quelques types de matériels de bureau électriques

(voir 1.2.2.1 et 4.5.2)

L.1 Machines à écrire

Les machines à écrire sont mises en fonctionnement à vide jusqu'à ce que l'état d'équilibre soit atteint. Les machines à écrire à touches manuelles sont alors mises en fonctionnement à une vitesse de 200 caractères à la minute, avec une manœuvre de changement de ligne tous les 60 caractères y compris les espaces, jusqu'à ce que l'état d'équilibre soit atteint. Les machines à écrire automatiques sont mises en fonctionnement à la vitesse maximale de dactylographie indiquée dans les instructions du fabricant.

L.2 Machines à additionner et caisses enregistreuses

Pour les machines à additionner et les caisses enregistreuses, des nombres de quatre chiffres sont introduits ou inscrits et la touche de répétition ou la barre motrice est actionnée 24 fois par minute, jusqu'à ce que l'état d'équilibre soit atteint, les nombres de quatre chiffres à employer étant ceux qui donnent la charge la plus élevée à la machine. Si la caisse enregistreuse a un tiroir qui s'ouvre chaque fois qu'un élément est inscrit, la caisse enregistreuse est mise en fonctionnement à une vitesse de 15 cycles de fonctionnement par minute, le tiroir étant fermé entre chaque fonctionnement, jusqu'à ce que l'état d'équilibre soit atteint. Pour une machine à additionner ou une caisse enregistreuse, une manœuvre consiste en une inscription ou une introduction des chiffres avec lesquels la machine doit fonctionner et ensuite à presser la barre motrice, la touche de répétition ou le dispositif analogue pour chaque manœuvre.

L.3 Effaceuses

Les effaceuses sont mises en fonctionnement continu à vide pendant 1 h.

L.4 Taille-crayons

Pour un taille-crayon, cinq crayons neufs sont taillés chacun huit fois selon le tableau suivant. Sauf pour les crayons neufs, la pointe est cassée avant chaque taillage.

Durée de taillage	*4 s pour un crayon neuf*
	2 s pour les taillages ultérieurs
Intervalle entre les taillages	*6 s*
Intervalle entre les crayons	*60 s*

Toutes ces durées sont approximatives.

L.5 Duplicateurs et machines à copier

Les duplicateurs et les machines à copier sont mis en fonctionnement continu à la vitesse maximale jusqu'à ce que l'état d'équilibre soit atteint. Il est permis d'introduire une période de repos de 3 min toutes les 500 copies si elle est compatible avec la conception de la machine.

L.6 Classeurs à moteur

Les classeurs à moteurs sont chargés de façon à simuler un déséquilibre causé par une répartition inégale du contenu. Lors du fonctionnement, la charge déséquilibrée est déplacée sur environ un tiers de la course totale du chariot, sur le parcours qui impose la charge maximale pendant chaque manœuvre. Cette manœuvre est répétée toutes les 15 s jusqu'à ce que l'état d'équilibre soit atteint.

On simule une charge provoquée par une répartition inégale du contenu de la façon suivante.

Dans le cas d'une alimentation verticale, on charge, sans laisser de vides, trois huitièmes de la plaque support de documents avec trois huitièmes de la charge admise. Avec cette charge, on parcourt la course totale de transport. Ce cycle de transport est renouvelé à des intervalles de 10 s, jusqu'à obtention de la température d'équilibre.

Dans le cas d'autres modes de transport, par exemple horizontaux ou circulaires, la charge totale est déplacée sur la course totale de transport. Ce cycle de transport est renouvelé à des intervalles de 15 s, jusqu'à obtention de la température d'équilibre.

L.7 Autres machines de bureau

Les autres machines de bureau sont mises en fonctionnement suivant le mode de fonctionnement le plus défavorable décrit dans la notice d'emploi du fabricant.

Annexe M
(normative)

Critères pour les signaux de sonnerie du téléphone

(voir 2.3.1)

M.1 Introduction

Les deux méthodes possibles décrites dans la présente annexe reflètent les expériences satisfaisantes acquises dans les différentes parties du monde. La méthode A est typique des réseaux téléphoniques analogiques européens et la méthode B des réseaux nord-américains. Ces deux méthodes conduisent à des normes de sécurité électrique qui sont largement équivalentes.

M.2 Méthode A

Cette méthode exige que les courants ~~I_{TSI}~~ I_{TS1} *et* I_{TS2} *traversant une résistance de 5 000 Ω placée entre deux conducteurs quelconques, ou entre un conducteur et la terre, ne dépassent pas les limites spécifiées ci-après.*

a) *pour un fonctionnement normal* ~~I_{TSI}~~ I_{TS1}*, le courant déterminé à partir du courant calculé ou mesuré pour toute période de sonnerie active unique* t_1 *(défini à la Figure M.1), ne dépasse pas:*

   1) *pour des signaux cadencés de sonnerie* ($t_1 < \infty$)*, le courant donné par la courbe de la Figure M.2 à* t_1*;*

   2) *pour une sonnerie continue* ($t_1 = \infty$)*, 16 mA.*

   ~~I_{TSI}~~ I_{TS1} *en mA, est donné par:*

$$I_{TS1} = \frac{I_p}{\sqrt{2}} \qquad \textit{pour} \quad (t_1 \leq 600\ ms)$$

$$I_{TS1} = \frac{t_1 - 600}{600} \times \frac{I_{pp}}{2\sqrt{2}} + \frac{1\,200 - t_1}{600} \times \frac{I_p}{\sqrt{2}} \qquad \textit{pour} \quad (600\ ms < t_1 < 1\,200\ ms)$$

$$I_{TS1} = \frac{I_{pp}}{2\sqrt{2}} \qquad \textit{pour} \quad (t_1 \geq 1\,200\ ms)$$

où

I_p *est la valeur crête du courant, en mA, de l'onde correspondante donnée à la Figure M.3;*

I_{pp} *est la valeur crête à crête du courant, en mA, de l'onde correspondante donnée à la Figure M.3;*

t_1 *est exprimé en ms.*

b) pour un fonctionnement normal I_{TS2}, la valeur moyenne du courant, pour des pointes répétées d'un signal cadencé de sonnerie, pour un cycle cadencé de sonnerie t_2 (comme indiqué à la Figure M.1), ne dépasse pas 16 mA efficace;

I_{TS2}, en mA, est donné par:

$$I_{TS2} = \left[\frac{t_1}{t_2} \times I_{TS1}^2 + \frac{t_2 - t_1}{t_2} \times \frac{I_{dc}^2}{3{,}75^2} \right]^{1/2}$$

où

~~I_{TSI}~~ I_{TS1} en mA, est donné au point a) de l'Article M.2;

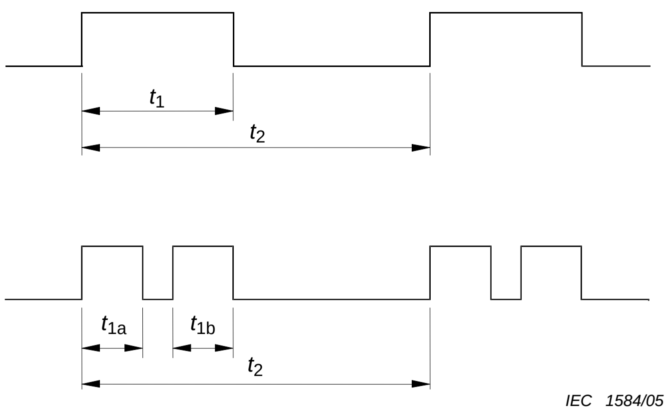
I_{dc} est le courant continu, en mA, traversant la résistance de 5 000 Ω pendant la période non active du cycle cadencé;

t_1 et t_2 sont exprimés en millisecondes.

NOTE Les fréquences de la sonnerie des téléphones sont normalement dans la bande de 14 Hz à 50 Hz.

c) Dans les conditions de premier défaut, y compris lorsque le signal cadencé devient continu:

- *I_{TS1} ne doit pas dépasser le courant donné par la courbe de la Figure M.2, ou 20 mA en fonction de la plus élevée de ces deux valeurs, et*
- *I_{TS2} ne doit pas dépasser une limite de 20 mA.*



t_1 est:

- *la durée d'une seule période de sonnerie lorsque la sonnerie est active pendant toute la période de sonnerie;*
- *la somme des périodes actives de sonnerie pendant une seule période de sonnerie, lorsque la seule période de sonnerie contient plusieurs périodes actives de sonnerie, comme dans l'exemple ci-contre pour lequel: $t_1 = t_{1a} + t_{1b}$.*

t_2 est la durée d'un cycle complet.

Figure M.1 – Définition d'une période de sonnerie et du cycle de sonnerie

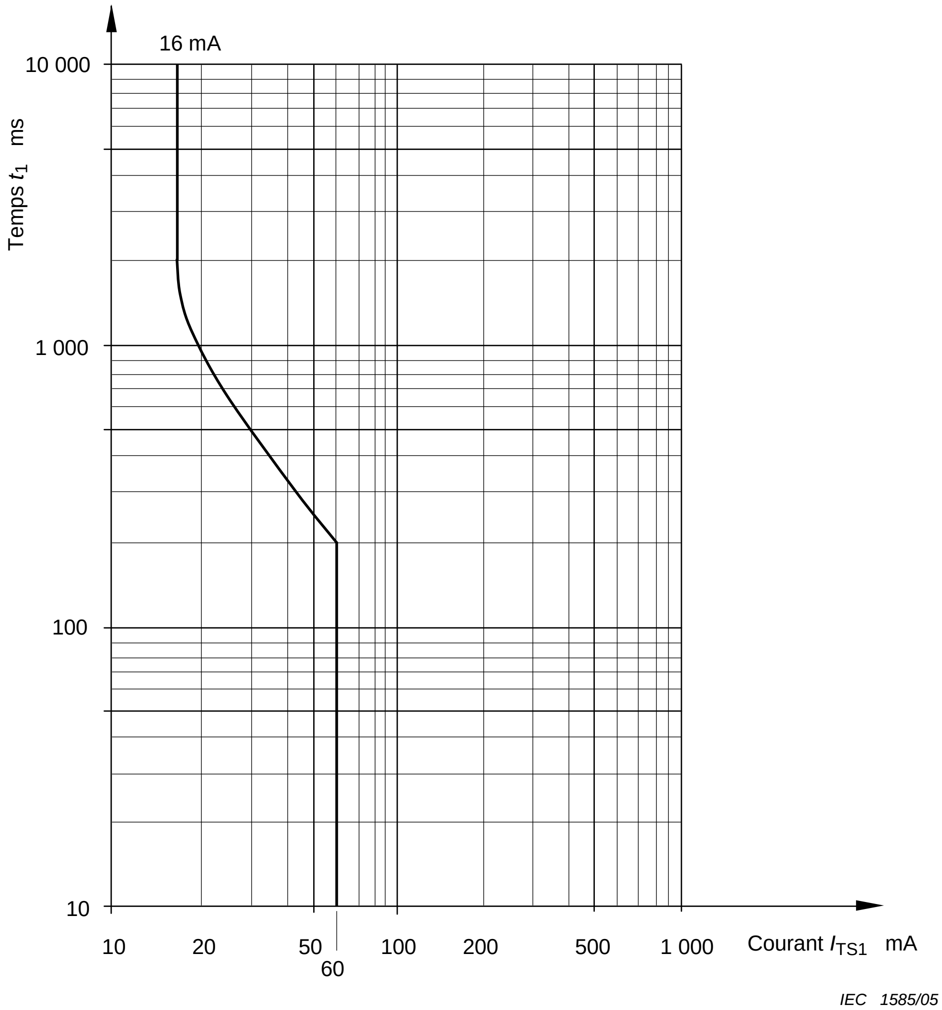
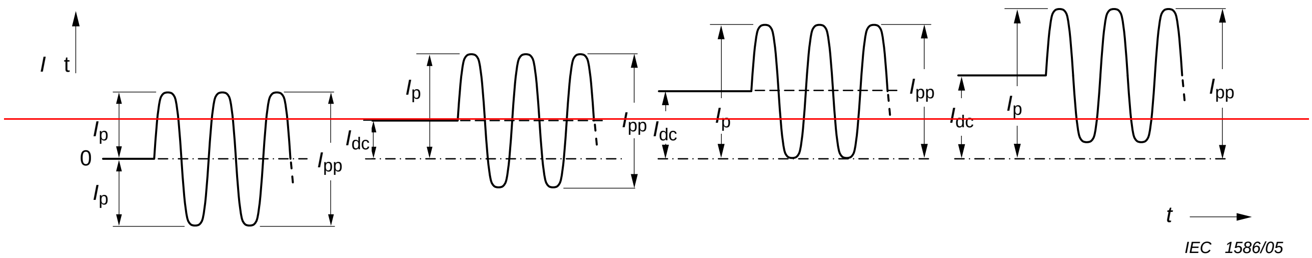


Figure M.2 – Courbe limite I_{TS1} pour les signaux cadencés de sonnerie



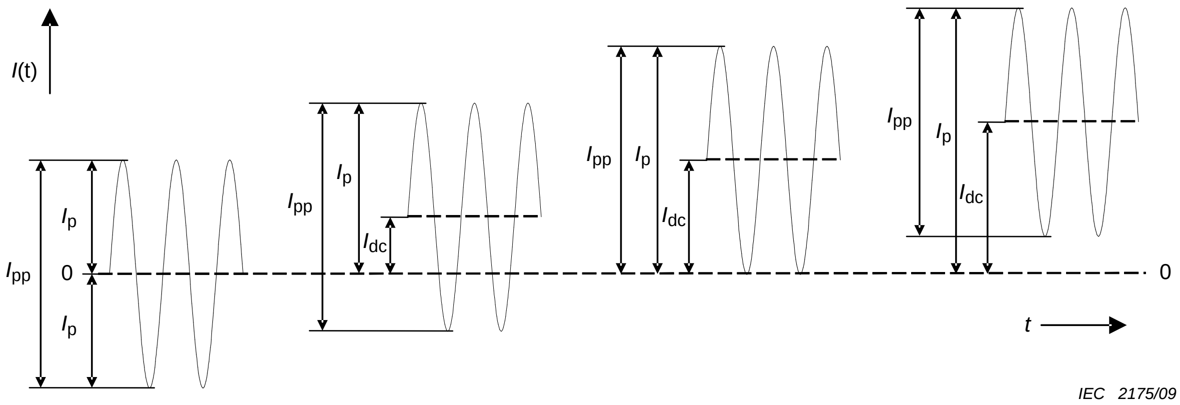


Figure M.3 – Courant de crête et courant crête à crête

M.3 Méthode B

NOTE Cette méthode est alignée sur le CFR 47 («FCC Rules») Part 68, Sub-part D, des Etats Unis, avec les exigences supplémentaires qui s'appliquent dans les conditions de défaut.

M.3.1 Signal de sonnerie

M.3.1.1 Fréquence

Le signal de sonnerie doit utiliser uniquement des fréquences ayant une composante fondamentale inférieure ou égale à 70 Hz.

M.3.1.2 Tension

La tension de sonnerie doit être inférieure à 300 V crête à crête et inférieure à 200 V crête par rapport à la terre mesurée à travers une résistance d'au moins 1 MΩ.

M.3.1.3 Cadence

La tension de sonnerie doit être interrompue de façon à créer des intervalles sans sonnerie d'au moins 1 s, séparés par au plus 5 s. Pendant les intervalles sans sonnerie, la tension par rapport à la terre ne doit pas dépasser 60 V tension continue.

M.3.1.4 Courant de premier défaut

Lorsque le signal cadencé devient continu à cause d'un premier défaut, le courant à travers une résistance de 5 000 Ω connectée entre deux conducteurs de sortie quelconques ou entre un conducteur de sortie quelconque et la terre ne doit pas dépasser 56,5 mA crête à crête, comme indiqué dans la Figure M.3.

M.3.2 Dispositif de déclenchement et tension de surveillance

M.3.2.1 Conditions d'utilisation du dispositif de déclenchement ou de la tension de surveillance

Une source de signal de sonnerie doit inclure un dispositif de déclenchement comme défini en M.3.2.2, ou fournir une tension de surveillance comme défini en M.3.2.3, ou les deux, suivant le courant circulant à travers une résistance spécifiée connectée entre le générateur de signal de sonnerie et la terre, comme indiqué ci-après:

– si le courant qui traverse une résistance de 500 Ω ou plus ne dépasse pas 100 mA crête à crête, il n'est exigé ni dispositif de déclenchement, ni tension de surveillance;

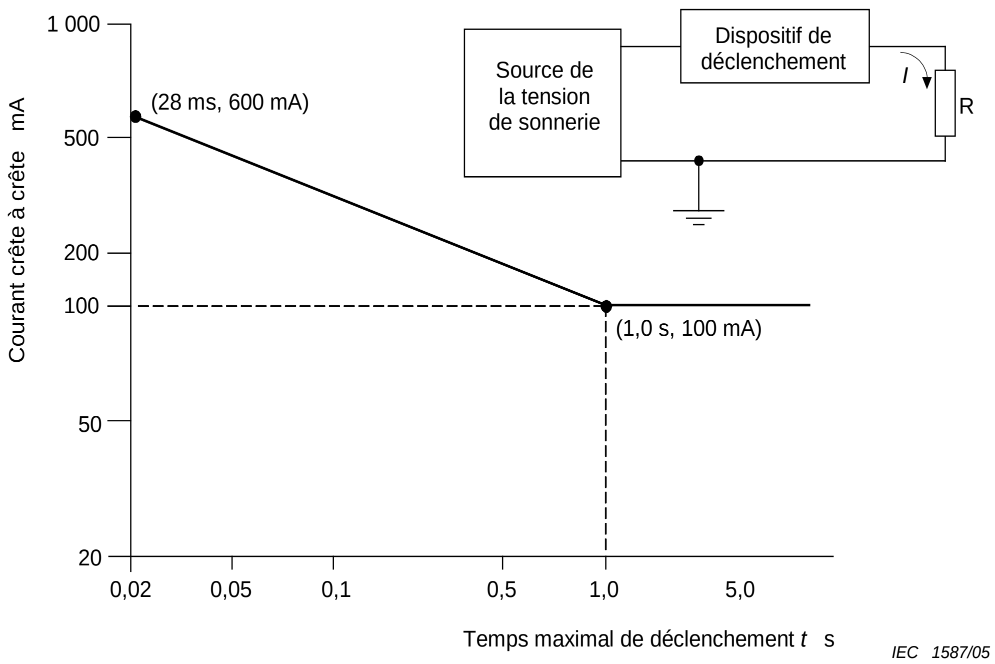
– si le courant qui traverse une résistance de 1 500 Ω ou plus dépasse 100 mA crête à crête, un dispositif de déclenchement doit être inclus. Si le dispositif de déclenchement répond aux critères de déclenchement spécifiés à la Figure M.4 avec R = 500 Ω ou plus, la tension de surveillance n'est pas exigée. Si, par contre, le dispositif de déclenchement ne respecte les critères de déclenchement que pour une résistance de R = 1 500 Ω ou plus, une tension de surveillance doit aussi être fournie;

– si le courant à travers une résistance de 500 Ω ou plus dépasse 100 mA crête à crête mais si le courant à travers une résistance de 1 500 Ω ou plus ne dépasse pas cette valeur, il doit être prévu:

  - soit un dispositif de déclenchement satisfaisant aux critères de déclenchement spécifiés dans la Figure M.4 avec toute résistance R = 500 Ω ou plus,
  - soit une tension de surveillance.

NOTE 1 Les dispositifs de déclenchement sont, en général, sensibles au courant et n'ont pas de réponse linéaire, due aux caractéristiques de résistance/de courant et de délai/facteur de réponse dans leur conception.

NOTE 2 Pour réduire la durée d'essai, il convient d'utiliser une boîte à résistance variable.



NOTE 1 *t* est mesuré depuis le moment de la connexion de la résistance R sur le circuit.

NOTE 2 La partie descendante de la courbe est définie comme $I = 100 / \sqrt{t}$.

Figure M.4 – Critères de déclenchement de la tension de sonnerie

M.3.2.2 Dispositif de déclenchement

Dispositif de déclenchement sensible au courant en série dans le conducteur de sonnerie, qui déclenchera la sonnerie comme spécifié dans la Figure M.4.

M.3.2.3 Tension de surveillance

Tension par rapport à la terre dans le conducteur de données ou de sonnerie avec une amplitude d'au moins 19 V valeur de crête, mais ne dépassant pas 60 V tension continue, chaque fois que la tension de sonnerie n'est pas présente (période de repos).

Annexe N
(normative)

Générateur d'impulsions d'essai

(voir 1.5.7.2, 1.5.7.3, 2.10.3.9, 6.2.2.1, 7.4.2, 7.4.3 et Article G.5)

NOTE Des précautions extrêmes sont nécessaires pendant l'utilisation de ces générateurs d'essai à cause de la grande quantité d'énergie stockée dans la capacité C_1.

N.1 Générateurs d'impulsions d'essai UIT-T

Le circuit de la Figure N.1, à l'aide des valeurs de composants des références 1 et 2 du Tableau N.1, est utilisé pour produire des impulsions, la capacité C_1 étant chargée initialement à la tension U_c.

Le circuit référence 1 du Tableau N.1 produit des impulsions 10/700 µs (10 µs de temps virtuel de montée, 700 µs de temps virtuel de descente à la demi-valeur) est le circuit spécifié dans la Recommandation K.44 de l'UIT-T destinée à simuler les effets de foudre dans le RESEAU DE TELECOMMUNICATIONS.

Le circuit référence 2 du Tableau N.1 produit des impulsions 1,2/50 µs (1,2 µs de temps virtuel de montée, 50 µs de temps virtuel de descente à la demi-valeur) est le circuit spécifié dans la Recommandation K.44 de l'UIT-T destinée à simuler les transitoires dans les systèmes de distribution d'énergie.

Les formes des ondes d'essai sont dans les conditions de circuit ouvert et peuvent être différentes dans les conditions de charge.

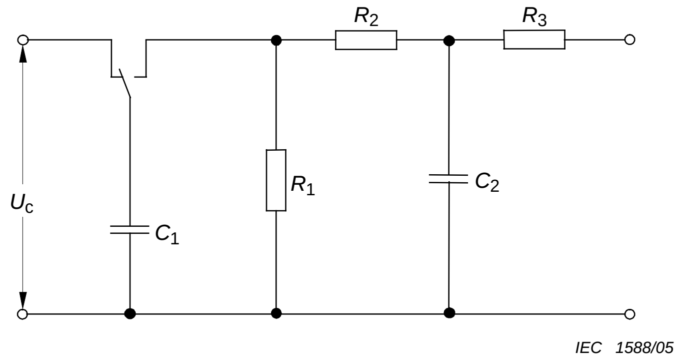


Figure N.1 – Circuit générateur d'impulsions de l'UIT-T

N.2 Générateurs d'impulsions d'essai CEI 60065

Le circuit de la Figure N.2, utilisant les valeurs des composants figurant sous la référence 3 du Tableau N.1, est utilisé pour produire des impulsions, le condensateur C_1 étant chargé initialement de la tension U_c. Le commutateur utilisé à la Figure N.2 est une partie critique du circuit. Voir 10.1 de la CEI 60065 pour plus d'informations.

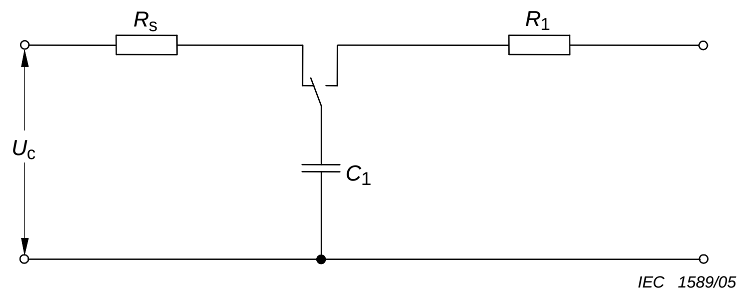


Figure N.2 – Circuit générateur d'impulsions de la CEI 60065

Tableau N.1 – Valeurs des composants pour les Figures N.1 et N.2

Référence	Impulsion d'essai	Figure	C_1	C_2	R_1	R_2	R_3	R_s	Voir
1 [a]	10/700 µs	N.1	20 µF	0,2 µF	50 Ω	15 Ω	25 Ω	–	1.5.7.3, 2.10.3.9, 6.2.2.1, 7.4.3 et point b) de l'Article G.5
2 [b]	1,2/50 µs	N.1	1 µF	30 nF	76 Ω	13 Ω	25 Ω	–	1.5.7.2, 2.10.3.9 et point a) de l'Article G.5
3 [c]	–	N.2	1 nF	–	1 kΩ	–	–	15 MΩ	1.5.7.3 et 7.4.2

[a] L'impulsion référence 1 est représentative des tensions induites dans des lignes téléphoniques et des câbles coaxiaux sur de longs trajets extérieurs provoquées par des coups de foudre à la terre à proximité.

[b] L'impulsion référence 2 est représentative des remontées de potentiel de terre provoquées par, soit des coups de foudre sur des lignes d'énergie, soit des défauts sur les lignes d'énergie.

[c] L'impulsion référence 3 est représentative des tensions induites dans les systèmes de câblage d'antenne provoquées par des coups de foudre à la terre à proximité.

Annexe P
(normative)

Références normatives

~~Les documents de référence suivants référencés sont indispensables pour l'application de la présente norme. Si la date du document de référence est indiquée, seule l'édition indiquée s'applique en excluant tout corrigendum ou amendement ultérieur. Pour les références non datées, la dernière édition du document de référence s'applique y compris tout éventuel corrigendum et amendement.~~

Les documents de référence suivants sont indispensables pour l'application du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements), en prenant en compte toute période de transition, date d'entrée en vigueur ou date de retrait établie pour le document existant.

Ces documents sont référencés, en totalité, en partie ou comme exigences en variante aux exigences contenues dans la présente norme. Leur utilisation est spécifiée, lorsque cela est nécessaire, pour l'application des exigences de la présente norme.

NOTE La liste ci-dessous est un récapitulatif de toutes les normes auxquelles il est fait référence dans la présente norme. L'apparition en soi d'une norme dans la liste ne signifie pas l'applicabilité de la norme ou des parties de celle-ci. Seules sont applicables les parties qui sont spécifiquement référencées dans la présente norme.

Des informations supplémentaires sur les documents de référence, y compris sur la manière de les obtenir, peuvent être trouvées sur les sites internet suivants:

http://www.iec.ch
http://www.iso.org
http://www.itu.int

Pour les passages de la norme dans lesquels ces documents sont mentionnés, voir l'Index.

CEI 60065:2001 , *Appareils audio, vidéo et appareils électroniques analogues – Exigences de sécurité*
Amendement 1[2)]

CEI 60068-2-78, *Essais d'environnement – Partie 2-78: Essais – Essai Cab: Chaleur humide – Essai continu*

CEI 60073, *Principes fondamentaux et de sécurité pour l'interface homme-machine, le marquage et l'identification – Principes de codage pour les dispositifs indicateurs et les organes de commande*

CEI 60083, *Prises de courant pour usages domestiques et analogues normalisées par les pays membres de la CEI*

CEI 60085:2004, *Isolation électrique – Classification thermique*

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2) A publier.

CEI 60112, *Méthode de détermination des indices de résistance et de tenue au cheminement des matériaux isolants solides*

CEI 60127-1, *Miniature fuses – Part 1: Definitions for miniature fuses and general requirements for miniature fuse-links* (disponible en anglais seulement)

~~CEI 60216-4-1, *Guide pour la détermination des propriétés d'endurance thermique de matériaux isolants électriques – Partie 4: Etuves de vieillissement – Section 1: Etuves à une seule chambre*~~

~~CEI 60227 (toutes les parties), *Conducteurs et câbles isolés au polychlorure de vinyle, de tension nominale au plus égale à 450/750 V*~~

CEI 60227-1:2007, *Conducteurs et câbles isolés au polychlorure de vinyle, de tension nominale au plus égale à 450/750 V – Partie 1: Exigences générales*

CEI 60227-2:1997, *Conducteurs et câbles isolés au polychlorure de vinyle, de tension nominale au plus égale à 450/750 V – Partie 2: Méthodes d'essais*
Amendement 1:2003

CEI 60245 (toutes les parties), *Conducteurs et câbles isolés au caoutchouc – Tension assignée au plus égale à 450/750 V*

CEI 60309 (toutes les parties), *Prises de courant pour usages industriels*

CEI 60317 (toutes les parties), *Spécifications pour types particuliers de fils de bobinage*

CEI 60317-43, *Spécifications pour types particuliers de fils de bobinage – Partie 43: Fil de section circulaire en cuivre recouvert d'un ruban de polyimide aromatique, classe 240*

CEI 60320 (toutes les parties), *Connecteurs pour usages domestiques et usages généraux analogues*

CEI 60364-1:2001, *Installations électriques des bâtiments – Partie 1: Principes fondamentaux, détermination des caractéristiques générales, définitions*

CEI 60384-14:1993, *Condensateurs fixes utilisés dans les équipements électroniques – Partie 14: Spécification intermédiaire: Condensateurs fixes d'antiparasitage et raccordement à l'alimentation*
Amendement 1 (1995)

CEI 60417-DB:2002[3], *Symboles graphiques utilisables sur le matériel*

CEI 60664-1:1992, *Coordination de l'isolement des matériels dans les systèmes (réseaux) à basse tension – Partie 1: Principes, prescriptions et essais*[4]
Amendement 1 (2000)
Amendement 2 (2002)

CEI 60695-2-11, *Essais relatifs aux risques du feu – Partie 2-11 Essais au fil incandescent/chauffant – Méthode d'essai d'inflammabilité pour produits finis*

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[3] « DB » se réfère à la base de données « on-line » de la CEI.

[4] Une édition consolidée 1.2 existe comprenant la CEI 60664-1:1992 et ses Amendements 1 (2000) et 2 (2002).

CEI 60695-2-20 *Essais relatifs aux risques du feu – Partie 2-20: Méthodes d'essai au fil chauffant ou incandescent – Allumabilité par bobine de fil chauffant – Appareillage, méthode d'essai et lignes directrices*

CEI 60695-10-2, *Essais relatifs aux risques du feu – Partie 10-2: Chaleurs anormales – Essai à la bille*

CEI 60695-10-3, *Essais relatifs aux risques du feu – Partie 10-3: Chaleur anormale – Essai de déformation par réduction des contraintes de moulage*

CEI 60695-11-3, *Essais relatifs aux risques du feu – Partie 11-3: Flammes d'essai – Flammes de 500 W – Appareillage et méthodes d'essai de vérification*

CEI 60695-11-4, *Essais relatifs aux risques du feu – Partie 11-4: Flammes d'essai – Flamme de 50 W – Appareillages et méthodes d'essai de vérification*

CEI 60695-11-5:2004, *Essais relatifs aux risques du feu – Partie 11-5: Flammes d'essai – Méthode d'essai au brûleur-aiguille – Appareillage, dispositif d'essai de vérification et lignes directrices*

CEI 60695-11-10, *Essais relatifs aux risques du feu – Partie 11-10: Flammes d'essai – Méthodes d'essai horizontale et verticale à la flamme de 50 W*

CEI 60695-11-20, *Essais relatifs aux risques du feu – Partie 11-20: Flammes d'essai – Méthodes d'essai à la flamme de 500 W*

CEI 60730-1:1999, *Dispositifs de commande électrique automatiques à usage domestique et analogue – Partie 1: Règles générales* [5]
Amendement 1 (2003)

CEI 60747-5-5,___[6] *Discrete semiconductor devices – Part 5-5: Optoelectronic devices – Photocouplers, optocouplers* (disponible en anglais seulement)

CEI 60825-1, *Sécurité des appareils à laser – Partie 1: Classification des matériels, prescriptions et guide de l'utilisateur*

CEI 60825-2, *Safety of laser products – Part 2: Safety of optical fibre communication systems (OFCS)* (disponible en anglais seulement)

CEI 60825-9, *Sécurité des appareils à laser – Partie 9: Exposition maximale admissible au rayonnement lumineux incohérent*

CEI 60825-12, *Sécurité des appareils à laser – Partie 12: Sécurité des systèmes de communications optiques en espace libre utilisés pour la transmission d'informations*

~~CEI 60851-3:1996~~ CEI 60851-3:2009, *Fils de bobinage – Méthodes d'essai – Partie 3: Propriétés mécaniques*[~~7~~)]
~~Amendement 1 (1997)~~

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[5] Une édition consolidée 3.1 existe comprenant la CEI 60730-1:1999 et son Amendement 1 (2003).

[6] A publier.

~~7) Une édition consolidée 2.1 existe comprenant la CEI IEC 60851-3:1996 et son Amendement 1 (1997).~~

~~CEI 60851-5:1996~~ CEI 60851-5:2008, *Fils de bobinage – Méthodes d'essai – Partie 5: Propriétés électriques* ~~[8]~~
~~Amendement 1 (1997)~~
~~Amendement 2 (2004)~~

CEI 60851-6:1996, *Méthodes d'essai des fils de bobinage – Partie 6: Propriétés thermiques*

CEI 60885-1:1987, *Méthodes d'essais électriques pour les câbles électriques – Première partie: Essais électriques pour les câbles, les conducteurs et les fils, pour une tension inférieure ou égale à 450/750 V*

CEI 60906-1, *Système CEI de prises de courant pour usages domestiques et analogues– Première partie: Prises de courant 16 A 250 V c.a.*

CEI 60906-2, *Système CEI de prises de courant pour usages domestiques et analogues – Partie* 2: *Prises de courant 15 A 125 V courant alternatif*

CEI 60947-1:2004, *Appareillage à basse tension – Partie 1: Règles générales*

CEI 60990:1999, *Méthodes de mesure du courant de contact et du courant dans le conducteur de protection*

CEI 60998-1, *Dispositifs de connexion pour circuits basse tension pour usage domestique et analogue – Partie 1: Règles générales*

CEI 60999-1, *Dispositifs de connexion – Conducteurs électriques en cuivre – Prescriptions de sécurité pour organes de serrage à vis et sans vis – Partie 1: Prescriptions générales et particulières pour les organes de serrage pour les conducteurs de 0,2 mm^2 à 35 mm^2 (inclus)*

CEI 60999-2, *Dispositifs de connexion – Conducteurs électriques en cuivre – Prescriptions de sécurité pour organes de serrage à vis et sans vis – Partie 2: Prescriptions particulières pour les organes de serrage pour conducteurs au-dessus de 35 mm^2 et jusqu'à 300 mm^2 (inclus)*

CEI 61051-2:1991, *Varistances utilisées dans les équipements électroniques – Deuxième partie: Spécification intermédiaire pour varistances pour limitations de surtensions transitoires*

CEI 61058-1:2000, *Interrupteurs pour appareils – Partie 1: Règles générales*

CEI 62133:2012, *Accumulateurs alcalins et autres accumulateurs à électrolyte non acide – Exigences de sécurité pour les accumulateurs portables étanches, et pour les batteries qui en sont constituées, destinés à l'utilisation dans des applications portables*

CEI 62368-1, *Equipements des technologies de l'audio/vidéo, de l'information et de la communication – Partie 1: Exigences de sécurité*

CEI 62471:2006, *Sécurité photobiologique des lampes et des appareils utilisant des lampes*

ISO 178*, Plastiques – Détermination des propriétés en flexion*

ISO 179 (toutes les parties)*, Plastiques – Détermination des caractéristiques au choc Charpy*

ISO 180, *Plastiques – Détermination de la résistance au choc Izod*

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[8] ~~Une édition consolidée 3.2 existe comprenant la CEI 60851-5:1996 et ses Amendements 1 (1997) et 2 (2004).~~

ISO 261, *Filetages métriques ISO pour usages généraux – Vue d'ensemble*

ISO 262, *Filetages métriques ISO pour usages généraux – Sélection de dimensions pour la boulonnerie*

ISO 527 (toutes les parties), *Plastiques – Détermination des propriétés en traction*

ISO 3864 (toutes les parties), *Symboles graphiques – Couleurs et signaux de sécurité*

ISO 4892-1, *Plastiques – Méthodes d'exposition à des sources lumineuses de laboratoire – Partie 1: Guide général*

ISO 4892-2, *Plastiques – Méthodes d'exposition à des sources lumineuses de laboratoire – Partie 2: Sources à arc au xénon*

ISO 4892-4, *Plastiques – Méthodes d'exposition à des sources lumineuses de laboratoire – Partie 4: Lampes à arc au carbone (disponible en anglais seulement)*

ISO 7000-DB:2004[9)], *Symboles graphiques utilisables sur le matériel – Index et tableau synoptique*

ISO 8256, *Plastiques – Détermination de la résistance au choc-traction*

ISO 9772, *Plastiques alvéolaires – Détermination des caractéristiques de combustion de petites éprouvettes en position horizontale, soumises à une petite flamme*

ISO 9773, *Plastiques – Détermination du comportement au feu d'éprouvettes minces verticales souples au contact d'une petite flamme comme source d'allumage*

UIT-T Recommandation K.44, *Tests d'immunité des équipements de télécommunication exposés aux surtensions et aux surintensités – Recommandation de base*

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9) « DB » se réfère à la base de données « on-line » de la CEI et de l'ISO.

Annexe Q
(normative)

Résistances sensibles à la tension
(Voltage dependent resistors – VDR)

(voir 1.5.9.1)

~~Une VDR utilisée dans un CIRCUIT PRIMAIRE doit être conforme à la CEI 61051-2, avec les détails suivants.~~

~~**a) Catégories climatiques préférentielles (2.1.1 de la CEI 61051-2)**~~

~~Température de catégorie inférieure: -10 °C~~

~~Température de catégorie supérieure: + 85 °C~~

~~Durée de l'essai continu de chaleur humide: 21 jours~~

~~**b) Tension continue maximale (2.1.2 de la CEI 61051-2)**~~

~~La tension en courant alternatif continue maximale est choisie dans la liste des tensions préférentielles et elle doit être d'au moins 120 % de~~

~~– la TENSION ASSIGNEE du matériel ou~~

~~– la tension supérieure de la PLAGE ASSIGNEE DE TENSIONS du matériel.~~

~~**c) Courant d'impulsion (Tableau I groupe 1 de la CEI 61051-2)**~~

~~*Les impulsions en combinaison de 6 kV/3 kA de polarité alternée sont utilisées, avec une forme d'impulsion de 1,2/50 µs pour la tension et de 8/20 µs pour le courant.*~~

~~*En plus des exigences de performances du Tableau I groupe 1, la tension d'écrêtage après l'essai ne doit pas avoir changé de plus de 10 % lorsqu'elle est mesurée avec le courant spécifié par le fabricant.*~~

Une VDR doit se conformer à la CEI 61051-2, qu'une ENVELOPPE CONTRE LE FEU soit fournie ou non, en tenant compte de tout ce qui suit:

- Catégories climatiques préférentielles (2.1.1 de la CEI 61051-2:1991):
  - température de catégorie inférieure: – 10 °C
  - température de catégorie supérieure: + 85 °C
  - durée de l'essai continu de chaleur humide: 21 jours.
- Tension continue maximale
  - au moins 1,25 fois la tension assignée du matériel ou
  - au moins 1,25 fois la tension supérieure de la plage assignée de tensions.

NOTE Les tensions continues maximales ne se limitent pas aux valeurs spécifiées en 2.1.2 de la CEI 61051-2:1991. D'autres tensions sont autorisées.

- Impulsion de combinaison (Tableau I Groupe 1 de la CEI 61051-2:1991, y compris l'Amendement 1:2009).

  Pour l'essai, une impulsion de combinaison est choisie à partir du 2.3.6 de la CEI 61051-2: 1991, Amendement 1:2009. L'essai consiste en 10 impulsions positives ou 10 impulsions négatives, chacune ayant une forme de 1,2/50 µs pour la tension et de 8/20 µs pour le courant.

Pour la sélection, la tension du RESEAU D'ALIMENTATION EN COURANT ALTERNATIF et la catégorie de surtension, voir le Tableau G.1.

Le RESEAU D'ALIMENTATION en dessous de 300 V est considéré comme étant de 300 V.

Pour la catégorie de surtension IV du Tableau G.1, une impulsion de combinaison 6 kV/3 kA est utilisée, sauf pour le matériel destiné à la connexion à un système d'alimentation de 600 V, pour lequel une impulsion de combinaison de 8 kV/4 kA est utilisée. L'essai d'impulsion de combinaison de la CEI 61051-2:1991, Amendement 1:2009 (2.3.6, Tableau I Groupe 1 et Annexe A), y compris la prise en considération de la tension nominale du RESEAU D'ALIMENTATION et de la catégorie de surtension, est acceptable comme variante de l'essai de 6 kV/3 kA.

En plus des exigences de performance données dans le Tableau I Groupe 1 de la CEI 61051-2:1991 et de son Amendement 1:2009, la tension de VDR au courant spécifié par le fabricant après l'essai ne doit pas varier de plus de 10 % par rapport aux valeurs avant essai.

Le corps de la VDR doit se conformer au brûleur-aiguille, selon la CEI 60695-11-5, avec les degrés de sévérité d'essai suivants:

- durée d'application de la flamme d'essai: 10 s;
- durée de persistance de flammes: 5 s.

Si le corps de la VDR est conforme aux exigences relatives à un MATERIAU DE CLASSE V-1, l'essai au brûleur-aiguille peut ne pas être effectué.

Annexe R
(informative)

Exemples d'exigences pour un programme de contrôle de la qualité

NOTE La présente annexe donne des exemples d'exigences pour un programme de contrôle de la qualité comme spécifié en 2.10.6.2 pour les distances minimales de séparation pour les cartes imprimées avec revêtement et en 2.10.3 et à l'Article G.2 pour les DISTANCES DANS L'AIR réduites.

R.1 Distances minimales de séparation pour les cartes imprimées revêtues non équipées (voir 2.10.6.2)

Lorsqu'un fabricant souhaite utiliser la réduction des distances de séparation autorisée par le Tableau 2Q de 2.10.6.2, il doit mettre en œuvre un programme de contrôle de la qualité pour les différentes caractéristiques des cartes qui sont énumérées dans le Tableau R.1. Ce programme doit comprendre des contrôles de la qualité spécifiques pour les outils et pour les matériaux qui affectent l'espace entre conducteurs, un examen visuel adéquat des dessins et des espaces, de la propreté, de l'épaisseur du revêtement, des essais électriques pour les courts-circuits, de la résistance d'isolement et de la tension de rigidité diélectrique.

Le fabricant doit également identifier et prévoir la protection et, lorsque c'est applicable, les processus d'installation qui affectent directement la qualité, et il doit s'assurer que ces processus se déroulent dans des conditions contrôlées. Les conditions contrôlées doivent comprendre ce qui suit:

– des instructions de travail documentées définissant le processus, le matériel, l'environnement et la méthode de production lorsque l'absence de telles instructions affecterait défavorablement la qualité, la méthode de production appropriée, les équipements d'installation, l'environnement de travail adapté, la conformité aux normes et spécifications de référence et les plans de qualité;
– la surveillance et le contrôle des processus convenables et des caractéristiques de produits pendant la production et l'installation dans le matériel;
– les critères pour l'exécution donnés, dans la mesure où c'est nécessaire, sous forme de spécifications écrites ou au moyen d'échantillons représentatifs;
– la conservation des enregistrements pour les processus, le matériel et le personnel qualifié suivant ce qui est approprié.

Le Tableau R.1 donne un plan d'échantillonnage pour les attributs et les essais nécessaires à la conformité aux exigences de 2.10.6.2. Le nombre d'échantillons de cartes de production nécessaires doit être basé sur la CEI 60410 ou l'ISO 2859-1 ou des normes nationales équivalentes.

Tableau R.1 – Règles pour l'échantillonnage et l'examen – cartes imprimées avec revêtement

Essais	ISOLATION PRINCIPALE	ISOLATION SUPPLEMENTAIRE	ISOLATION RENFORCEE
Espacement mm [a]	Echantillonnage S2 AQL 1,0	Echantillonnage S2 AQL 1,0	Echantillonnage S2 AQL 1,0
Essai de rigidité diélectrique [b]	Echantillonnage S2 AQL 2,5	Echantillonnage S2 AQL 2,5	ESSAI INDIVIDUEL DE SERIE Une défaillance entraîne obligatoirement la recherche de la cause
Résistance à l'abrasion	Echantillonnage S1 AQL 2,5	Echantillonnage S1 AQL 2,5	Echantillonnage S1 AQL 2,5
Vieillissement thermique [c]	Echantillonnage S3 AQL 4	Echantillonnage S3 AQL 4	Echantillonnage S3 AQL 4
Cycles thermiques [c]	Echantillonnage S1 AQL 1,5	Echantillonnage S1 AQL 1,5	Echantillonnage S1 AQL 1,5
Résistance d'isolement [d]	Echantillonnage S2 AQL 2,5	Echantillonnage S2 AQL 2,5	Echantillonnage S2 AQL 2,5
Examen visuel du revêtement [e]	ESSAI INDIVIDUEL DE SERIE	ESSAI INDIVIDUEL DE SERIE	ESSAI INDIVIDUEL DE SERIE

[a] Pour réduire les durées d'essai et d'examen, il est permis de remplacer les mesures des distances de séparation par des mesures de la tension d'amorçage. Au départ, la tension d'amorçage est établie pour dix cartes non revêtues pour lesquelles les mesures des espaces corrects ont été confirmées. La tension d'amorçage appliquée aux cartes de production non revêtues suivantes est ensuite comparée à une limite plus faible égale à la tension minimale d'amorçage des dix premières cartes diminuée de 100 V. S'il y a amorçage à cette limite plus faible, une carte est considérée comme défaillante à moins qu'une mesure directe de l'espace ne soit conforme à l'exigence.

[b] L'essai de rigidité diélectrique doit être effectué conformément à 5.2.2, à l'exception de la durée qui doit être comprise entre 1 s et 5 s.

[c] Les essais de vieillissement thermique et de cycles thermiques doivent être effectués à chaque changement de type de matériau de revêtement, de matériau de carte imprimée ou de procédé. Il est recommandé qu'ils soient effectués au moins une fois par an.

[d] La résistance d'isolement ne doit pas être inférieure à 1 000 MΩ.

[e] Un examen visuel sans grossissement optique ou un examen optique automatisé avec une résolution équivalente ne doit montrer ni craquelure, ni bulle, ni trou d'épingles, ni décollement du revêtement dans la zone des espaces réduits. N'importe lequel de ces défauts est un motif de rejet de la carte imprimée.

R.2 Distances dans l'air réduites (voir 2.10.3)

Lorsqu'un fabricant souhaite utiliser la réduction des DISTANCES DANS L'AIR autorisée en 2.10.3, Tableaux 2J, 2K, 2L et G.2, il doit mettre en œuvre un programme de contrôle de la qualité pour les différentes caractéristiques de construction énumérées dans le Tableau R.2. Ce programme doit comprendre les contrôles de la qualité spécifiques pour les outils et pour les matériaux qui affectent les DISTANCES DANS L'AIR.

Le fabricant doit également identifier et prévoir la protection et, lorsque c'est applicable, les processus d'installation qui affectent directement la qualité, et il doit s'assurer que ces processus se déroulent dans des conditions contrôlées. Les conditions contrôlées doivent comprendre ce qui suit:

– des instructions de travail documentées définissant le processus, le matériel, l'environnement et la méthode de production lorsque l'absence de telles instructions affecterait défavorablement la qualité, l'environnement de travail adapté, la conformité aux normes ou spécifications de référence et les plans de qualité;

– la surveillance et le contrôle des processus convenables et des caractéristiques de produits pendant la production et l'installation dans le matériel;
– les critères pour l'exécution donnés, dans la mesure où c'est nécessaire, sous forme de spécifications écrites ou au moyen d'échantillons représentatifs;
– la conservation des enregistrements pour les processus, le matériel et le personnel qualifié suivant ce qui est approprié.

Le Tableau R.2 donne un plan d'échantillonnage pour les attributs et les essais nécessaires à la conformité aux exigences de 2.10.3. Le nombre d'échantillons de parties de constructions ou d'ensembles doit être basé sur la CEI 60410 ou l'ISO 2859-1 ou sur des normes nationales équivalentes.

Tableau R.2 – Règles pour l'échantillonnage et l'examen – distances dans l'air réduites

Essais	ISOLATION PRINCIPALE	ISOLATION SUPPLEMENTAIRE	ISOLATION RENFORCEE
DISTANCE DANS L'AIR [a]	Echantillonnage S2 AQL 4	Echantillonnage S2 AQL 4	Echantillonnage S2 AQL 4
Essai de rigidité diélectrique [b]	Pas d'essai	Pas d'essai	ESSAI INDIVIDUEL DE SERIE Une défaillance entraîne obligatoirement la recherche de la cause

[a] Pour réduire les durées d'essai et d'examen, il est permis de remplacer les mesures de DISTANCES DANS L'AIR par des mesures de la tension d'amorçage. Au départ, la tension d'amorçage est établie pour dix échantillons pour lesquels les mesures des DISTANCES DANS L'AIR correctes ont été confirmées. La tension d'amorçage appliquée aux parties et ensembles suivants est ensuite comparée à une limite plus faible égale à la tension d'amorçage minimale des dix premiers échantillons diminuée de 100 V. S'il y a amorçage à cette limite plus faible, une partie ou un ensemble est considéré comme un défaut à moins qu'une mesure directe des DISTANCES DANS L'AIR ne soit conforme à l'exigence.

[b] L'essai de rigidité diélectrique pour l'ISOLATION RENFORCEE doit être l'un des trois suivants:

- six impulsions de polarité alternée, en utilisant une impulsion de 1,2/50 µs avec une amplitude égale à la valeur de crête de la tension d'essai conforme à 5.2.2;
- un train d'impulsions de trois cycles à la fréquence d'alimentation avec une amplitude égale à la tension d'essai conforme à 5.2.2;
- six impulsions de polarité alternée, en utilisant une impulsion de 10 ms en courant continu avec une amplitude égale à la valeur de crête de la tension d'essai conforme en 5.2.2.

Annexe S
(informative)

Procédure pour les essais en impulsions

(voir 6.2.2.3)

S.1 Equipement d’essai

Un générateur d'impulsions conformément à l'Annexe N.

Un oscilloscope à mémoire avec une bande de quelques MHz.

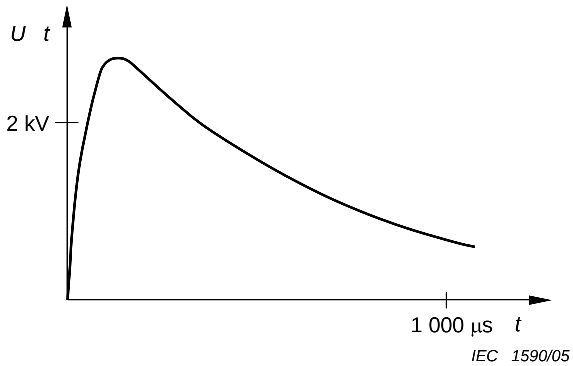
Une sonde haute tension avec des éléments de compensation.

S.2 Procédure d’essai

Appliquer le nombre prescrit d'impulsions au matériel à l'essai et mettre en mémoire toutes les formes d'onde.

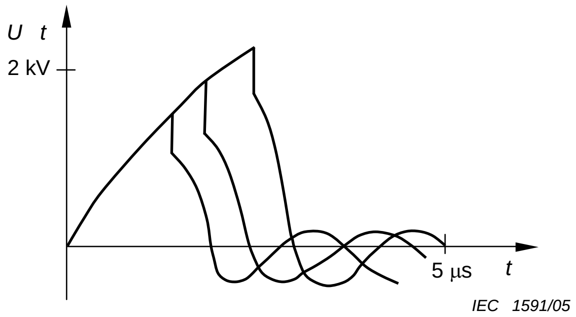
L'Article S.3 donne des exemples pour aider à juger si un parasurtenseur a fonctionné ou non, ou s'il y a eu rupture de l'isolation.

S.3 Exemples de forme d'onde pendant l'essai en impulsions



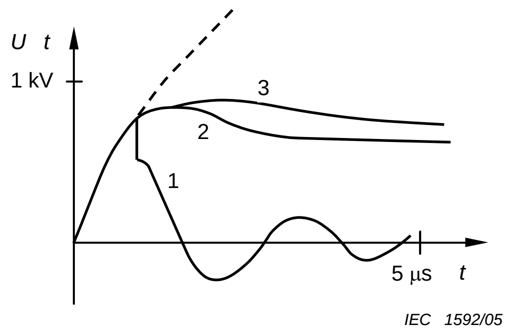
Les impulsions consécutives ont des formes d'onde identiques.

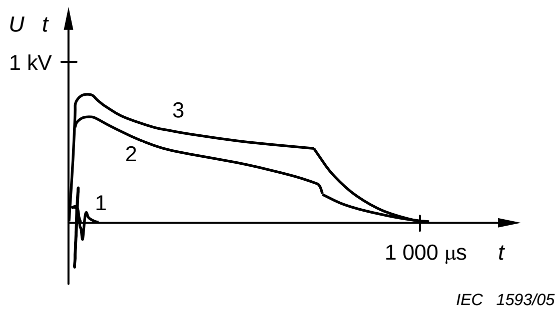
Figure S.1 – Forme d'onde pour une isolation sans parasurtenseur et sans rupture d'isolation



Les impulsions consécutives n'ont pas des formes d'onde identiques. La forme de l'impulsion change d'une impulsion à l'autre jusqu'à ce qu'un chemin résistant stable se soit établi à travers l'isolation. La rupture d'isolation peut être aisément reconnue à la forme de l'impulsion de tension à l'oscilloscope.

Figure S.2 – Formes d'onde pour une isolation pendant une rupture d'isolation sans parasurtenseurs





1 – type à décharge de gaz

2 – type à semiconducteur

3 – type à oxyde métallique

Les impulsions consécutives ont des formes d'onde identiques.

Figure S.3 – Forme d'onde pour une isolation avec parasurtenseurs en fonctionnement

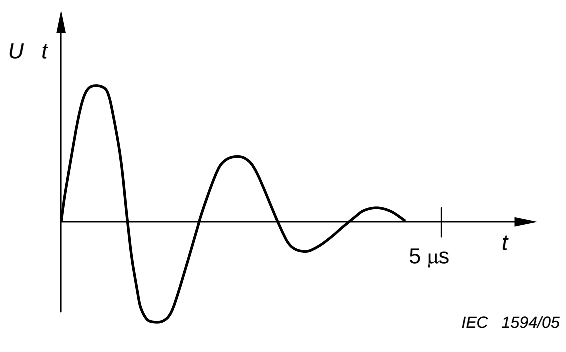


Figure S.4 – Forme d'onde pour un parasurtenseur et une isolation court-circuités

Annexe T
(informative)

Guide pour la protection contre la pénétration d'eau

(voir 1.1.2)

Lorsque l'application envisagée est telle que la pénétration d'eau est possible, il convient que le fabricant choisisse un degré de protection approprié autre que IPX0 parmi ceux de la CEI 60529, dont un extrait est donné dans la présente annexe.

Il y a donc lieu d'inclure d'autres critères de conception pour assurer que la pénétration d'eau n'affecte pas l'isolation.

La CEI 60529 donne les conditions d'essai pour les degrés de protection autres que IPX0. Il convient d'appliquer au matériel les conditions appropriées pour le degré choisi et de les faire suivre immédiatement par un essai de rigidité diélectrique comme spécifié en 5.2.2 sur toute isolation qui aurait pu devenir humide. De plus, il convient de démontrer par un examen que l'eau n'a pas créé un risque de feu ou de blessure aux personnes. En particulier, il convient qu'il n'y ait pas de trace d'eau sur des isolations qui ne sont pas conçues pour fonctionner alors qu'elles sont mouillées.

Si le matériel est pourvu de trous d'écoulement, l'examen doit montrer que l'eau qui entre ne s'accumule pas et disparaît sans affecter la conformité.

Si le matériel n'est pas pourvu de trous d'écoulement, il y a lieu de tenir compte de la présence possible d'eau.

Lorsqu'un matériel est exposé seulement en partie à la pénétration d'eau, par exemple lorsqu'il est installé à travers une ouverture dans un mur extérieur, il convient de soumettre uniquement les parties exposées aux conditions d'essai de la CEI 60529. Pour ces essais, il convient d'installer ces matériels dans un montage d'essai approprié, simulant les conditions réelles d'installation suivant les instructions d'installation, y compris l'utilisation d'un ensemble pour le scellement des parties lorsque c'est nécessaire.

Il est recommandé qu'il ne soit pas possible d'enlever sans l'aide d'un OUTIL les parties qui assurent le degré de protection exigé contre la pénétration d'eau.

Les informations du Tableau T.1 sont extraites de la CEI 60529.

Tableau T.1 – Extraits de la CEI 60529

Deuxième chiffre caractéristique	Degré de protection	
	Description abrégée	Définition
0	Non protégé	–
1	Protégé contre les chutes verticales de gouttes d'eau	Les gouttes tombant verticalement ne doivent pas avoir d'effets nuisibles
2	Protégé contre les chutes verticales de gouttes d'eau avec une ENVELOPPE inclinée de 15°	Les gouttes tombant verticalement ne doivent pas avoir d'effets nuisibles quand l'ENVELOPPE est inclinée jusqu'à 15° de part et d'autre de la verticale
3	Protégé contre l'eau en pluie	L'eau tombant en pluie fine dans une direction faisant un angle inférieur ou égal à 60° de part et d'autre de la verticale ne doit pas avoir d'effets nuisibles
4	Protégé contre les projections d'eau	L'eau projetée de toutes les directions sur l'ENVELOPPE ne doit pas avoir d'effets nuisibles
5	Protégé contre les jets d'eau	L'eau projetée en jets de toutes les directions sur l'ENVELOPPE ne doit pas avoir d'effets nuisibles
6	Protégé contre les jets d'eau puissants	L'eau projetée en jets puissants de toutes les directions sur l'ENVELOPPE ne doit pas avoir d'effets nuisibles
7	Protégé contre les effets d'une immersion temporaire dans l'eau	La pénétration d'eau en quantité ayant des effets nuisibles ne doit pas être possible à l'intérieur de l'ENVELOPPE immergée temporairement dans l'eau dans des conditions normalisées de pression et de durée
8	Protégé contre les effets d'une immersion prolongée dans l'eau	La pénétration d'eau en quantité ayant des effets nuisibles ne doit pas être possible à l'intérieur de l'ENVELOPPE immergée d'une manière prolongée dans l'eau dans des conditions soumises à accord entre le fabricant et l'utilisateur, mais qui sont plus sévères que pour le chiffre 7

Annexe U
(normative)

Fils de bobinage isolés pour utilisation sans intercouche

(voir 2.10.5.4)

~~La présente annexe spécifie les fils de bobinage dont l'isolation peut être utilisée pour fournir une ISOLATION PRINCIPALE, une ISOLATION SUPPLEMENTAIRE, une DOUBLE ISOLATION ou une ISOLATION RENFORCEE dans les composants bobinés sans isolation intercouche.~~

~~Cette annexe s'applique aux couvre les fils de bobinage ronds de section circulaire rigide ayant des diamètres entre 0,05 mm et 5,0 mm et les fils de bobinages toronnés avec une section équivalente.~~

~~U.1 Construction des conducteurs~~

~~Si le conducteur est isolé avec un ruban enroulé en spirale, le recouvrement doit être adapté pour assurer un recouvrement permanent pendant la fabrication du composant bobiné. Les recouvrements doivent être suffisamment fixés pour maintenir la part de recouvrement.~~

~~U.2 Essais de type~~

~~Le conducteur doit satisfaire aux essais de U.2.1 à U.2.4 effectués à une température comprise entre 15 °C et 35 °C et une humidité relative comprise entre 45 % et 75 %, sauf indication contraire.~~

~~U.2.1 Rigidité électrique~~

~~L'échantillon est préparé selon 4.4.1 de la CEI 60851-5, (pour une paire torsadée). L'échantillon est ensuite soumis à l'essai de 5.2.2 de la présente norme. La tension d'essai doit être au moins égale à deux fois la tension appropriée selon 5.2.2 de la présente norme, avec un minimum de:~~

- *~~3 000 V valeur efficace en courant alternatif pour l'ISOLATION PRINCIPALE ou l'ISOLATION SUPPLEMENTAIRE; ou~~*
- *~~6 000 V valeur efficace en courant alternatif pour l'ISLOLATION RENFORCEE.~~*

~~U.2.2 Flexibilité et adhérence~~

~~Essai 8 de 5.1.1 de la CEI 60851-3 est appliqué utilisant les diamètres du mandrin du Tableau U.1. L'échantillon est ensuite examiné selon 5.1.1.4 de la CEI 60851-3, puis essayé selon 5.2.2 de la présente norme à l'exception de la tension d'essai qui est appliquée entre le fil et le mandrin. La tension d'essai doit être au moins égale à la tension appropriée selon 5.2.2 de la présente norme, avec un minimum de:~~

- *~~1 500 V valeur efficace en courant alternatif pour l'ISOLATION PRINCIPALE ou l'ISOLATION SUPPLEMENTAIRE; ou~~*
- *~~3 000 V valeur efficace en courant alternatif pour l'ISLOLATION RENFORCEE.~~*

~~Tableau U.1 – Diamètre du mandrin~~

~~Diamètre nominal du conducteur~~ ~~mm~~	~~Diamètre de mandrin~~ ~~mm ± 0,2 mm~~
~~0,05 – 0,34~~	~~4,0~~
~~0,35 – 0,49~~	~~6,0~~
~~0,50 – 0,74~~	~~8,0~~
~~0,75 – 2,49~~	~~10,0~~
~~2,50 – 5,00~~	~~quatre fois le diamètre nominal du conducteur [a]~~
~~[a] Conformément à la CEI 60317-43~~	

~~La tension à appliquer au conducteur pendant le bobinage sur le mandrin est calculée à partir du diamètre de fil équivalant à 118 MPa ± 10 % (118 N/mm~~^{2} *~~± 10 %).~~*

~~U.2.3 Choc thermique~~

~~Essai 9 de la CEI 60851-6, suivi de l'essai de rigidité diélectrique de 5.2.2 de cette norme à l'exception de la tension d'essai qui est appliquée entre le fil et le mandrin. La tension doit être au moins égale à la tension appropriée selon 5.2.2 de la présente norme, avec un minimum de:~~

- *~~1 500 V valeur efficace en courant alternatif pour l'ISOLATION PRINCIPALE ou l'ISOLATION SUPPLEMENTAIRE; ou~~*
- *~~3 000 V valeur efficace en courant alternatif pour l'ISLOLATION RENFORCEE.~~*

~~La température du four est la température applicable pour la classe thermique de matériau du Tableau U.2.~~

~~Le diamètre du mandrin et la tension appliquée durant le bobinage sont comme en U.2.2.~~

~~L'essai de rigidité diélectrique est effectué à la température ambiante après enlèvement du four.~~

~~Tableau U.2 – Température du four~~

~~Classe thermique~~	~~Température du four~~ ~~°C ± 5 °C~~
~~105 (A)~~	~~200~~
~~120 (E)~~	~~215~~
~~130 (B)~~	~~225~~
~~155 (F)~~	~~250~~
~~180 (H)~~	~~275~~
~~200~~	~~295~~
~~220~~	~~315~~
~~250~~	~~345~~
~~Les désignations A à H, attribuées précédemment dans la CEI 60085 aux classes thermiques 105 à 180, sont données entre parenthèses.~~	

~~U.2.4 Rétention de la rigidité diélectrique après courbure~~

~~*Cinq échantillons sont préparés comme en U.2.2 ci-dessus et essayés comme suit. Chaque échantillon est retiré du mandrin et placé dans un récipient de façon qu'il soit entouré par 5 mm de grenaille au moins. Les extrémités du conducteur dans l'échantillon doivent être suffisamment longues pour éviter les contournements. La grenaille métallique ne doit pas avoir plus de 2 mm de diamètre et doit être composée de billes en acier inoxydable, en nickel ou en acier nickelé. Le récipient est rempli doucement de grenaille jusqu'à ce que l'échantillon soit recouvert d'au moins 5 mm de grenaille. La grenaille doit être nettoyée périodiquement à l'aide d'un solvant approprié (par exemple 1,1,1-trichloroéthane).*~~

~~NOTE La procédure d'essai ci-dessus est reproduite de 4.6.1 c) de la CEI 60851-5 (deuxième édition comprenant l'amendement 1), maintenant retirée. Elle n'a pas été reproduite dans la troisième édition de cette norme.~~

~~*La tension d'essai doit être au moins égale à la tension appropriée selon 5.2.2 de la présente norme, avec un minimum de:*~~

- ~~*1 500 V valeur efficace en courant alternatif pour l'ISOLATION PRINCIPALE ou l'ISOLATION SUPPLEMENTAIRE; ou*~~
- ~~*3 000 V valeur efficace en courant alternatif pour l'ISLOLATION RENFORCEE.*~~

~~*La tension d'essai est appliquée entre la grenaille et le conducteur.*~~

~~*Le diamètre du mandrin et la tension appliquée durant le bobinage sont comme en U.2.2.*~~

~~U.3 Essais pendant la fabrication~~

~~*Le conducteur doit être soumis par le fabricant de câbles à des essais de rigidité diélectrique, pendant la fabrication, conformément à U.3.1 et U.3.2.*~~

~~U.3.1 Essai individuel de série~~

~~*La tension d'essai pour les ESSAIS INDIVIDUELS DE SERIE doit être au moins égale à la tension d'essai appropriée selon 5.2.2 de la présente norme, avec un minimum de:*~~

- ~~*1 500 V valeur efficace en courant alternatif pour l'ISOLATION PRINCIPALE ou l'ISOLATION SUPPLEMENTAIRE; ou*~~
- ~~*3 000 V valeur efficace en courant alternatif pour l'ISLOLATION RENFORCEE.*~~

~~U.3.2 Essais d'échantillonnage~~

~~*Les échantillons de paires torsadées doivent être essayés conformément à 4.4.1 de la CEI 60851-5. La tension minimale de rupture de l'isolation doit être au moins égale à deux fois la tension appropriée de 5.2.2 de la présente norme, avec un minimum de:*~~

- ~~*3 000 V valeur efficace en courant alternatif pour l'ISOLATION PRINCIPALE ou l'ISOLATION SUPPLEMENTAIRE; ou*~~
- ~~*6 000 V valeur efficace en courant alternatif pour l'ISLOLATION RENFORCEE.*~~

U.1 Généralités

La présente annexe spécifie les fils de bobinage dont l'isolation peut être utilisée pour fournir une ISOLATION PRINCIPALE, une ISOLATION SUPPLEMENTAIRE, une DOUBLE ISOLATION ou une ISOLATION RENFORCEE dans les composants bobinés sans isolation intercouche.

La présente annexe s'applique aux fils de bobinage ronds et massifs de diamètres compris entre 0,01 mm et 5,0 mm, aux fils de bobinage à âme câblée avec des sections équivalentes et aux fils de bobinage massifs de section carrée et massifs de section rectangulaire (flexion à plat) avec des sections de 0,000 079 mm^2 à 19,6 mm^2.

NOTE Voir 2.10.5.12 pour le nombre minimal de couches qui se chevauchent.

U.2 Essais de type

U.2.1 Généralités

Le fil de bobinage doit satisfaire aux ESSAIS DE TYPE *suivants, effectués à une température comprise entre 15 °C et 35 °C et une humidité relative comprise entre 45 % et 75 %, sauf spécification contraire.*

U.2.2 Rigidité diélectrique

U.2.2.1 Fils de bobinage ronds et massifs et fils de bobinage à âme câblée

U.2.2.1.1 Fils avec un diamètre nominal du conducteur inférieur ou égal à 0,100 mm

L'échantillon d'essai est préparé selon 4.3 de la CEI 60851-5:2008. L'échantillon est ensuite soumis à l'essai de rigidité diélectrique de 5.2.2 entre le conducteur du fil et le cylindre, avec une tension d'essai minimale de:

- *3 kV valeur efficace ou 4,2 kV valeur de crête pour une ISOLATION RENFORCEE, ou*
- *1,5 kV valeur efficace ou 2,1 kV valeur de crête pour une ISOLATION PRINCIPALE ou une ISOLATION SUPPLEMENTAIRE.*

U.2.2.1.2 Fils avec un diamètre nominal du conducteur compris entre 0,100 mm et 2,500 mm

L'échantillon d'essai est préparé selon 4.4.1 de la CEI 60851-5:2008 (paire torsadée). L'échantillon est ensuite soumis à l'essai de rigidité diélectrique de 5.2.2, avec une tension d'essai supérieure ou égale à deux fois la tension appropriée de 5.2.2, avec un minimum de:

- *6 kV valeur efficace ou 8,4 kV valeur de crête pour une ISOLATION RENFORCEE, ou*
- *3 kV valeur efficace ou 4,2 kV valeur de crête pour une ISOLATION PRINCIPALE ou une ISOLATION SUPPLEMENTAIRE.*

U.2.2.1.3 Fils avec un diamètre nominal du conducteur supérieur à 2,500 mm

L'échantillon d'essai est préparé selon 4.5 de la CEI 60851-5:2008. L'échantillon est ensuite soumis à l'essai de rigidité diélectrique de 5.2.2 entre le conducteur du fil et la grenaille, avec une tension d'essai minimale de:

- *3 kV valeur efficace ou 4,2 kV valeur de crête pour une ISOLATION RENFORCEE, ou*
- *1,5 kV valeur efficace ou 2,1 kV valeur de crête pour une ISOLATION PRINCIPALE ou une ISOLATION SUPPLEMENTAIRE.*

U.2.2.2 Conducteurs de section carrée ou rectangulaire

L'échantillon d'essai est préparé selon 4.7.1 de la CEI 60851-5:2008 (conducteur unique entouré de grenaille métallique). L'échantillon est ensuite soumis à l'essai de rigidité diélectrique de 5.2.2, avec une tension d'essai minimale de:

- *3 kV valeur efficace ou 4,2 kV valeur de crête pour une ISOLATION RENFORCEE, ou*
- *1,5 kV valeur efficace ou 2,1 kV valeur de crête pour une ISOLATION PRINCIPALE ou une ISOLATION SUPPLEMENTAIRE.*

U.2.3 Flexibilité et adhérence

Le 5.1 (dans Essai 8) de la CEI 60851-3:2009 doit être utilisé, avec des diamètres de mandrin selon le Tableau U.1.

L'échantillon d'essai est ensuite examiné conformément à 5.1.1.4 de la CEI 60851-3:2009, suivi d'un essai de rigidité diélectrique selon 5.2.2 de la présente norme, avec une tension d'essai minimale de:

- *3 kV valeur efficace ou 4,2 kV valeur de crête pour une ISOLATION RENFORCEE, ou*
- *1,5 kV valeur efficace ou 2,1 kV valeur de crête pour une ISOLATION PRINCIPALE ou une ISOLATION SUPPLEMENTAIRE.*

La tension d'essai est appliquée entre le conducteur et le mandrin.

Tableau U.1 – Diamètre de mandrin

Diamètre nominal ou épaisseur nominale du conducteur mm **inférieur(e) à**	**Diamètre de mandrin** mm
0,35	4,0 ± 0,2
0,50	6,0 ± 0,2
0,75	8,0 ± 0,2
2,50	10,0 ± 0,2
5,00	Quatre fois le diamètre ou l'épaisseur du conducteur [a]

[a] Conformément à la CEI 60317-43.

La tension à appliquer au conducteur pendant le bobinage sur le mandrin est calculée à partir du diamètre de fil équivalant à 118 MPa ± 10 % (118 N/mm^2 ± 10 %).

La flexion sur chant sur un côté de plus petite dimension (largeur) n'est pas exigée pour les conducteurs à section rectangulaire.

Pour l'essai de bobinage sur mandrin des conducteurs à section carrée et rectangulaire, deux spires adjacentes peuvent ne pas être au contact l'une de l'autre.

U.2.4 Choc thermique

L'échantillon d'essai doit être préparé conformément à 3.1.1 (dans Essai 9) de la CEI 60851-6:1996, suivi d'un essai de rigidité diélectrique selon 5.2.2 de la présente norme, avec une tension d'essai minimale de:

- *3 kV valeur efficace ou 4,2 kV valeur de crête pour une ISOLATION RENFORCEE, ou*
- *1,5 kV valeur efficace ou 2,1 kV valeur de crête pour une ISOLATION PRINCIPALE ou une ISOLATION SUPPLEMENTAIRE.*

La tension d'essai est appliquée entre le conducteur et le mandrin. La température du four est la température applicable de la classe thermique d'isolation du Tableau U.2. Le diamètre du mandrin et la tension appliquée au conducteur durant le bobinage sont comme dans le Tableau U.1. L'essai de rigidité diélectrique est effectué à la température ambiante après enlèvement du four.

Tableau U.2 – Température du four

Classe thermique	**Classe 105 (A)**	**Classe 120 (E)**	**Classe 130 (B)**	**Classe 155 (F)**	**Classe 180 (H)**	**Classe 200 (N)**	**Classe 220 (R)**	**Classe 250 -**
Température du four °C	200	215	225	250	275	295	315	345
La température du four doit être maintenue, à ±5 ° près, à la température spécifiée. Les classes sont relatives à la classification des matériaux isolants électriques et des systèmes d'isolation électrique (EIS, *Electrical Insulation Systems*), conformément à la CEI 60085. Les désignations littérales assignées sont données entre parenthèses.								

La flexion sur chant sur un côté de plus petite dimension (largeur) n'est pas exigée pour les conducteurs à section rectangulaire.

NOTE Le 3.1.2 dans l'Essai 9 de la CEI 60851-6:1996 n'est pas utilisé dans le cas des fils de bobinage massifs à section carrée et massifs à section rectangulaire.

U.2.5 Rétention de la rigidité diélectrique après courbure

Cinq échantillons sont préparés comme en U.2.3, et soumis à essai comme suit. Chaque échantillon est retiré du mandrin et placé dans un récipient, de façon qu'il puisse être entouré par 5 mm de grenaille au moins. Les extrémités du conducteur dans l'échantillon doivent être suffisamment longues pour éviter les contournements. La grenaille ne doit pas avoir plus de 2 mm de diamètre et doit être composée de billes en acier inoxydable, en nickel ou en acier nickelé. Le récipient est rempli doucement de grenaille jusqu'à ce que l'échantillon en essai soit recouvert d'au moins 5 mm de grenaille. La grenaille doit être nettoyée périodiquement à l'aide d'un solvant approprié.

L'échantillon doit être soumis à l'essai de rigidité diélectrique de 5.2.2, avec une tension d'essai minimale de:

– *3 kV valeur efficace ou 4,2 kV valeur de crête pour une ISOLATION RENFORCEE, ou*

– *1,5 kV valeur efficace ou 2,1 kV valeur de crête pour une ISOLATION PRINCIPALE ou une ISOLATION SUPPLEMENTAIRE.*

Le diamètre du mandrin et la tension appliquée au conducteur durant le bobinage sont comme dans le Tableau U.1.

U.3 Essais pendant la fabrication

U.3.1 Généralités

Le conducteur doit être soumis par le fabricant de câbles à des essais de rigidité diélectrique, pendant la fabrication, tel que spécifié en U.3.2 et U.3.3.

U.3.2 Essai individuel de série

La tension d'essai pour l'ESSAI INDIVIDUEL DE SERIE doit être conforme à l'essai de rigidité diélectrique de 5.2.2, avec un minimum de:

– *3 kV valeur efficace ou 4,2 kV valeur de crête pour une ISOLATION RENFORCEE, ou*

– *1,5 kV valeur efficace ou 2,1 kV valeur de crête pour une ISOLATION PRINCIPALE ou une ISOLATION SUPPLEMENTAIRE.*

U.3.3 Essai d'échantillonnage

L'essai d'échantillonnage doit être réalisé conformément à l'essai approprié spécifié en U.2.2.

Annexe V
(normative)

Schémas de distribution de l'alimentation en courant alternatif

(voir 1.6.1)

V.1 Introduction

En 3.1.2 de la CEI 60364-1, les schémas de distribution de l'alimentation en courant alternatif sont classifiés TN, TT et IT, suivant l'arrangement des conducteurs transportant le courant et la méthode de mise à la terre. Les classes et les codes sont expliqués dans la présente annexe. Quelques exemples de chaque classe sont donnés dans les figures. D'autres configurations existent aussi.

Dans les figures:

– dans la plupart des cas, le schéma d'alimentation s'applique au matériel monophasé et au matériel triphasé mais, pour simplifier, seul le matériel monophasé est illustré;
– les sources de puissance peuvent être des secondaires de transformateurs, des motogénérateurs ou des alimentations sans interruption;
– pour les transformateurs à l'intérieur de l'installation du bâtiment, certaines figures s'appliquent, et la limite du bâtiment représente un plancher du bâtiment;
– certains schémas de distribution d'alimentation ont des points de mise à la terre supplémentaires, par exemple aux points d'entrée de l'alimentation du bâtiment des utilisateurs (voir 413.1.3.1 Notes 1 et 2 de la CEI 60364-4-41).

Les types suivants de connexion de matériels sont pris en compte. Les nombres de conducteurs mentionnés ne comprennent pas les conducteurs utilisés exclusivement pour la mise à la terre.

Monophasé, deux conducteurs

Monophasé, trois conducteurs

Biphasé, trois conducteurs

Triphasé, trois conducteurs

Triphasé, quatre conducteurs

Les codes utilisés ont la signification suivante:

– Première lettre: situation de l'alimentation par rapport à la terre;

T signifie une liaison directe d'un pôle avec la terre,

I signifie soit une isolation de toutes les parties actives par rapport à la terre, soit une liaison d'un point à la terre à travers une impédance.

– Deuxième lettre: mise à la terre du matériel;

T signifie une liaison électrique directe du matériel à la terre, indépendamment de la mise à la terre éventuelle d'un point de l'alimentation,

N signifie une liaison électrique directe du matériel au point de l'alimentation mis à la terre (en courant alternatif, le point mis à la terre est normalement le point neutre ou, si un point neutre n'est pas disponible, un conducteur de phase).

– Autres lettres éventuelles: disposition du conducteur neutre et du conducteur de protection:

S signifie que la fonction de protection est assurée par un conducteur distinct depuis le neutre ou depuis le conducteur de ligne mis à la terre (dans les systèmes à courant alternatif, un conducteur de phase mis à la terre);

C signifie que les fonctions de neutre et de protection sont combinées en un seul conducteur (conducteur PEN).

V.2 Schémas d'alimentation TN

Les schémas de distribution d'énergie TN sont reliés directement à la terre, les parties de l'installation nécessitant une mise à la terre étant reliées par des CONDUCTEURS DE MISE A LA TERRE DE PROTECTION. Trois types de schémas d'alimentation TN sont définis:

– schéma d'alimentation TN-S,	– dans lequel le conducteur neutre et le conducteur de protection sont séparés dans l'ensemble du schéma;
– schéma d'alimentation TN-C-S,	– dans lequel les fonctions de neutre et de protection sont combinées en un seul conducteur dans une partie du schéma;
– schéma d'alimentation TN-C,	– dans lequel les fonctions de neutre et de protection sont combinées en un seul conducteur dans l'ensemble du schéma.

Certains schémas de distribution TN sont alimentés par l'intermédiaire de l'enroulement secondaire d'un transformateur qui a un point central (neutre) mis à la terre. Lorsque les deux conducteurs de phase et le conducteur de neutre sont disponibles, ces schémas sont appelés communément «schémas d'alimentation monophasés à trois conducteurs».

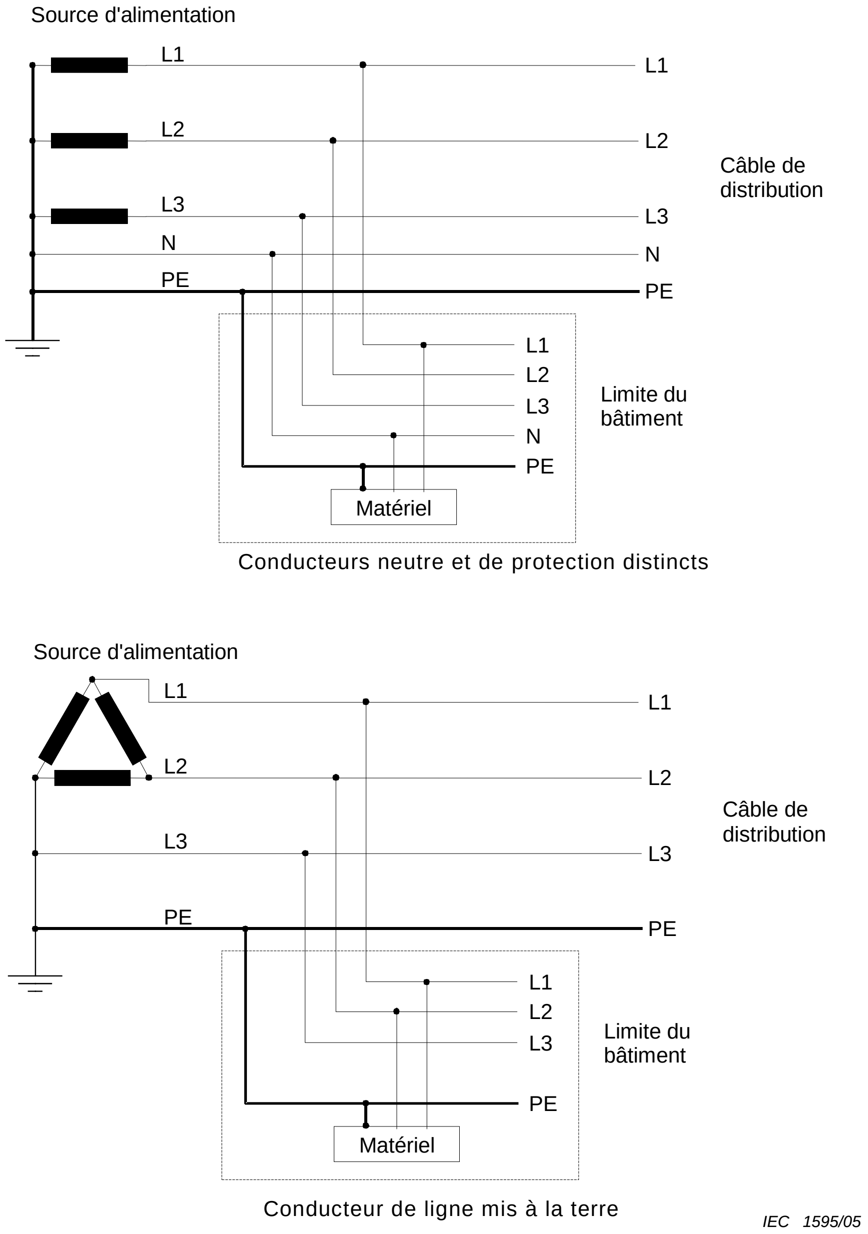
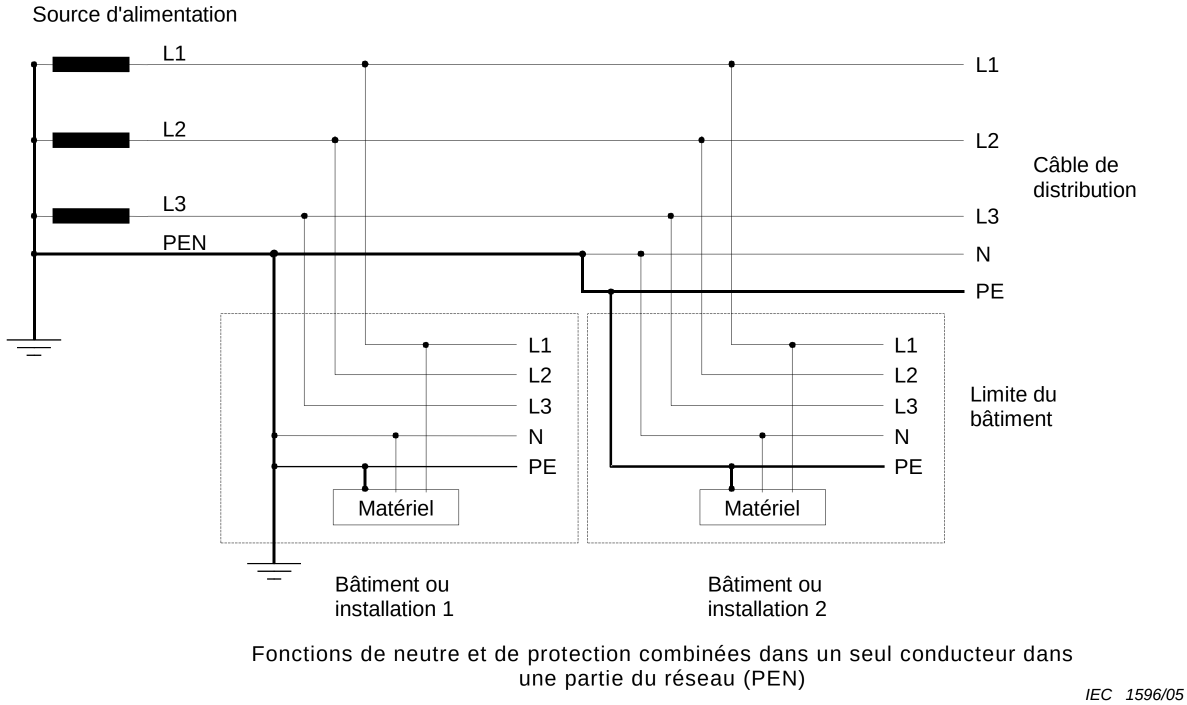


Figure V.1 – Exemples de schémas d'alimentation TN-S



NOTE Le point où le conducteur PEN est séparé en conducteur de terre de protection et conducteur neutre peut se situer à l'entrée du bâtiment ou au tableau de distribution dans le bâtiment.

Figure V.2 – Exemple de schéma d'alimentation TN-C-S

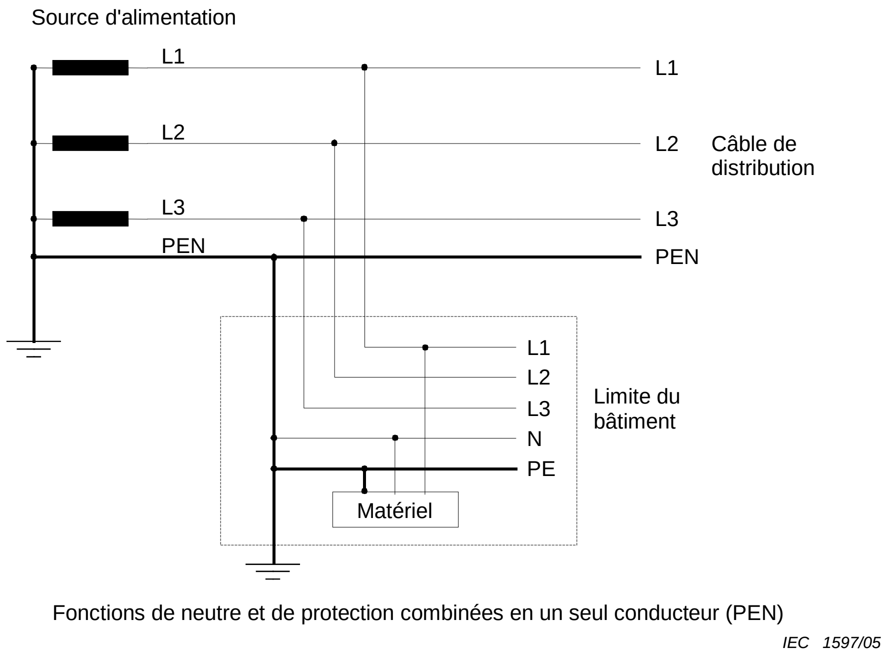
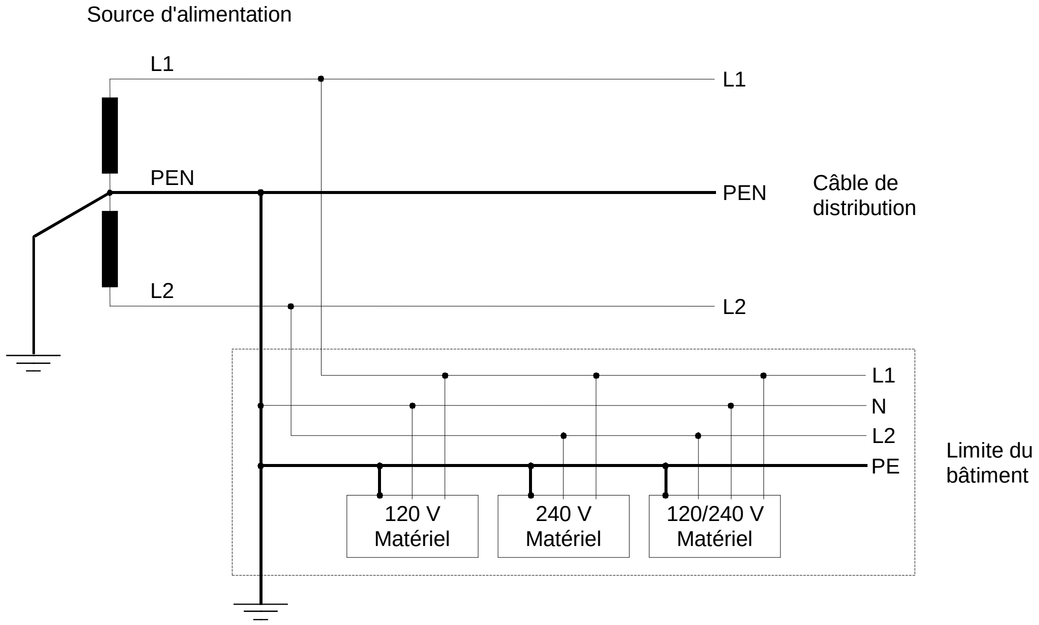


Figure V.3 – Exemple de schéma d'alimentation TN-C



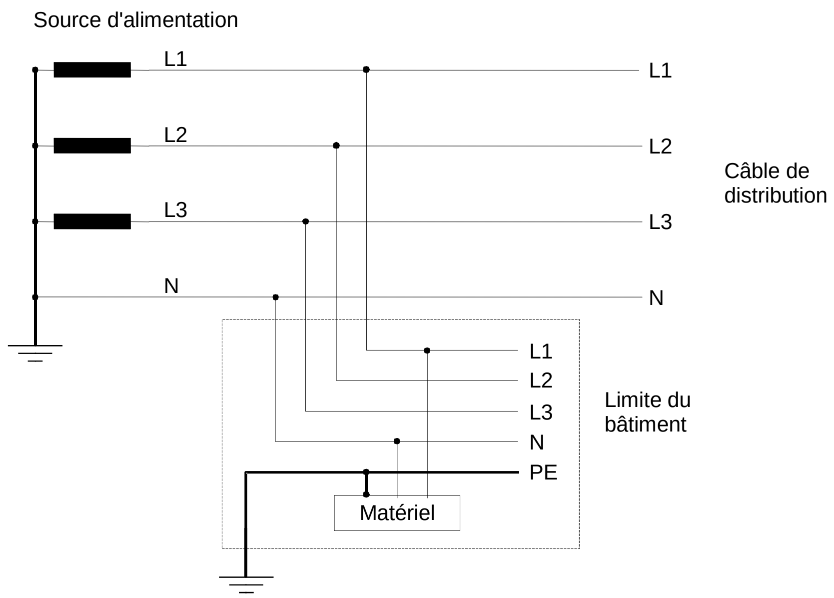
Fonctions de neutre et de protection combinées en un seul conducteur (PEN)
Ce schéma est largement utilisé en Amérique du Nord à 120/240 V.

IEC 1598/05

Figure V.4 – Exemple de schéma d'alimentation TN-C monophasé, trois conducteurs

V.3 Schémas d'alimentation TT

Les schémas d'alimentation TT ont un point directement relié à la terre, les parties du matériel devant être mises à la terre étant reliées, dans les locaux de l'usager, à des prises de terre électriquement indépendantes des prises de terre du système de distribution de l'alimentation.



Neutre mis à la terre et mise à la terre du matériel indépendante

IEC 1599/05

Figure V.5 – Exemple de schéma d'alimentation TT triphasé avec neutre

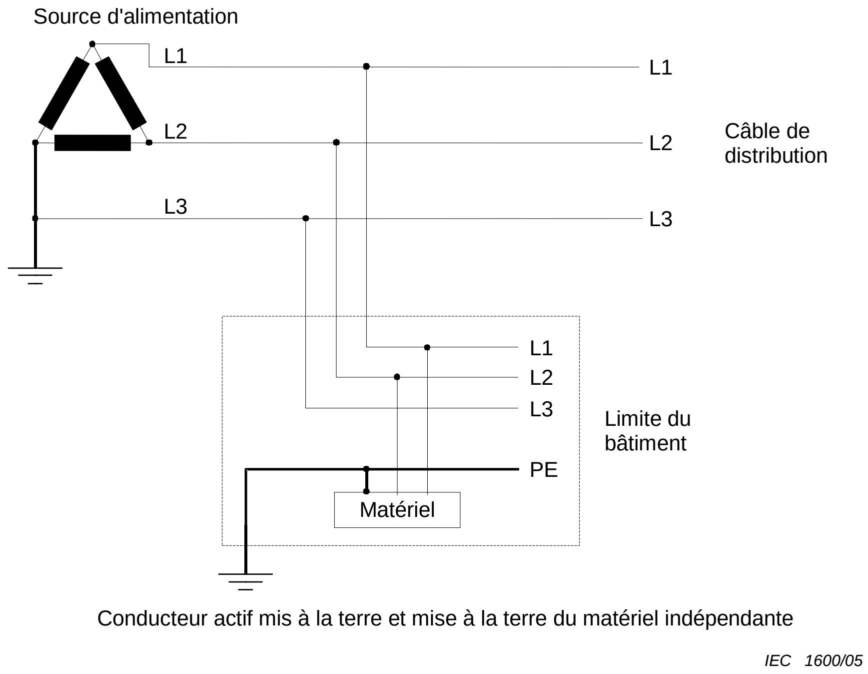
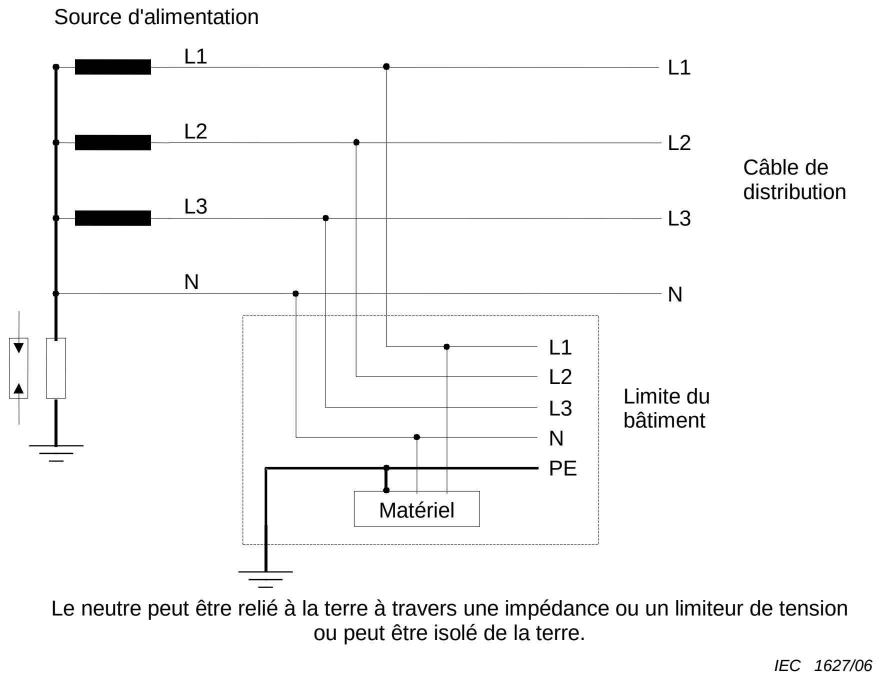


Figure V.6 – Exemple de schéma d'alimentation TT triphasé sans neutre

V.4 Schémas d'alimentation IT

Les schémas d'alimentation IT sont isolés de la terre, avec l'exception qu'un point peut être relié à la terre à travers une impédance ou un limiteur de tension. Les parties du matériel devant être mises à la terre sont reliées aux bornes de terre dans les locaux de l'usager.



Ce schéma est largement utilisé isolé de la terre, dans certaines installations en France, avec une impédance à la terre à 230/400 V et en Norvège, avec un parasurtenseur, le neutre non distribué, à 230 V phase-phase.

Figure V.7 – Exemple de schéma d'alimentation IT triphasé (et neutre)

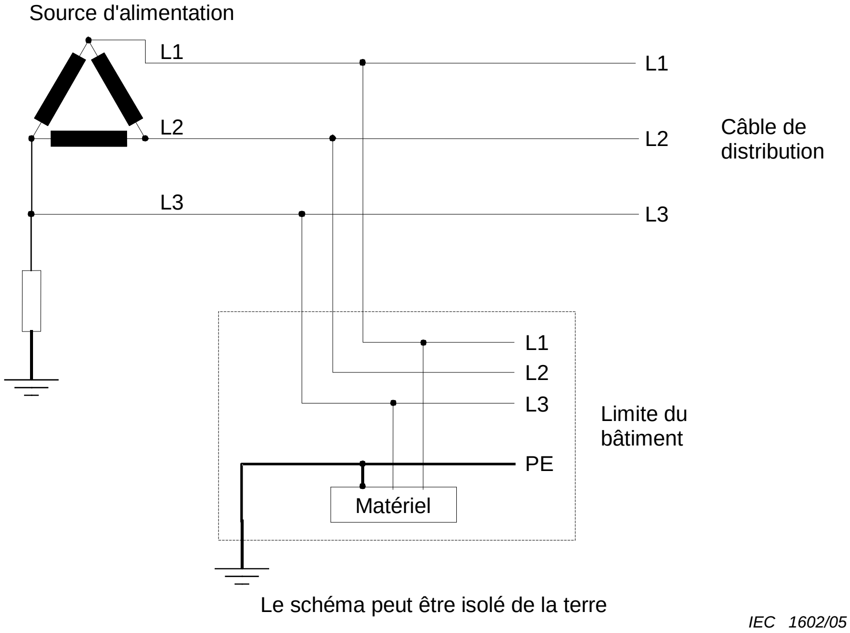


Figure V.8 – Exemple de schéma d'alimentation IT triphasé

Annexe W
(informative)

Sommation des courants de contact

La présente annexe explique la base des exigences et essais de 5.1.8.2.

W.1 Courants de contact venant des circuits électroniques

Il y a deux mécanismes très différents qui déterminent le courant à travers un corps humain qui touche un circuit électronique (ou un bus de puissance) suivant que le circuit est mis à la terre ou non. Cette distinction entre circuit mis à la terre et circuit non mis à la terre (flottant) n'est pas la même qu'entre MATERIEL DE LA CLASSE I et MATERIEL DE LA CLASSE II. Les circuits flottants peuvent exister dans les MATERIELS DE LA CLASSE I et les circuits mis à la terre peuvent exister dans les MATERIELS DE LA CLASSE II. Les circuits flottants sont communément, mais pas exclusivement, utilisés dans les matériels de télécommunications, et les circuits mis à la terre dans les matériels de traitement de l'information, mais pas exclusivement.

Afin de considérer le pire des cas, il sera supposé dans la présente annexe que les RESEAUX DE TELECOMMUNICATIONS sont flottants et que le RESEAU D'ALIMENTATION EN COURANT ALTERNATIF et les corps humains (PERSONNEL DE MAINTENANCE ou UTILISATEURS) sont mis à la terre. Il convient de noter que le PERSONNEL DE MAINTENANCE peut toucher certaines parties qui ne sont pas accessibles à l'UTILISATEUR. Un circuit «mis à la terre» signifie que le circuit est directement mis à la terre ou bien référencé d'une manière ou d'une autre par rapport à la terre de telle sorte que son potentiel par rapport à la terre est fixé.

W.1.1 Circuits flottants

Si le circuit n'est pas mis à la terre, le courant (I_c) à travers le corps humain est une «fuite» dans la capacité de fuite ou additionnelle (C) au travers de l'isolation dans le transformateur d'alimentation (voir Figure W.1).

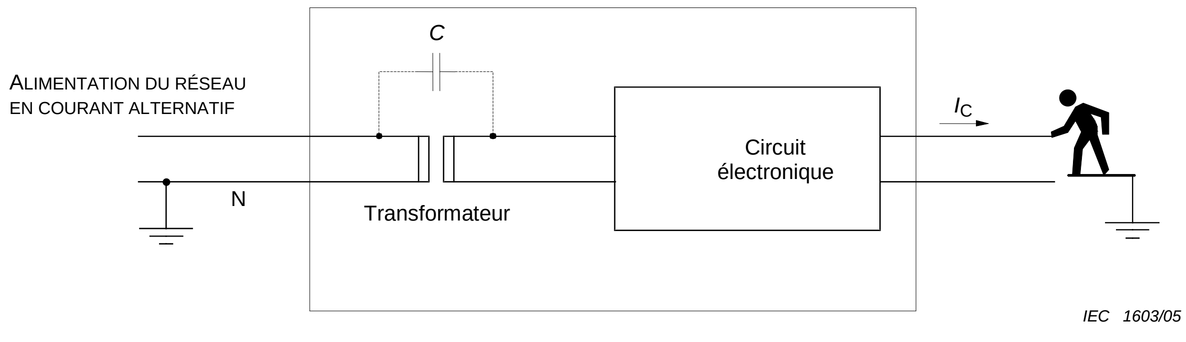


Figure W.1 – Courant de contact venant d'un circuit flottant

Ce courant vient d'une tension relativement élevée, d'une source de haute impédance, et sa valeur est très peu affectée par la tension de fonctionnement sur le circuit électronique. Dans la présente norme, le courant de corps (I_c) est limité par application d'un essai utilisant l'appareil de mesure de l'Annexe D, qui simule grossièrement un corps humain.

W.1.2 Circuits mis à la terre

Si le circuit électronique est mis à la terre, le courant à travers le corps humain (I_v) est dû à la tension de travail (V) du circuit, qui est une source de basse impédance comparée au corps (voir la Figure W.2). Tout courant de fuite venant du transformateur d'alimentation (voir W.1.1) partira à la terre et ne passera pas à travers le corps.

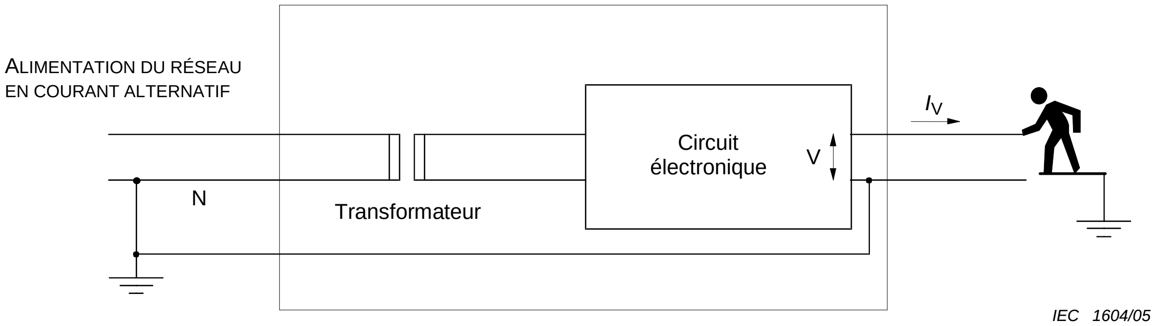


Figure W.2 – Courant de contact venant d'un circuit mis à la terre

Dans la présente norme, le courant du corps (I_v) est limité par spécification des valeurs de tension maximales pour le circuit accessible qui doit être un CIRCUIT TBTS ou (avec une accessibilité restreinte) un CIRCUIT TRT.

W.2 Interconnexion de plusieurs matériels

C'est une caractéristique des matériels de traitement de l'information, en particulier dans les applications de télécommunications, que de nombreux matériels peuvent être connectés à un seul matériel central dans une topologie «en étoile». Comme exemples, on peut citer les extensions téléphoniques ou les terminaux de données reliées à un PABX, qui peut avoir des dizaines ou des centaines de ports. Cet exemple est utilisé dans la description suivante (voir la Figure W.3).

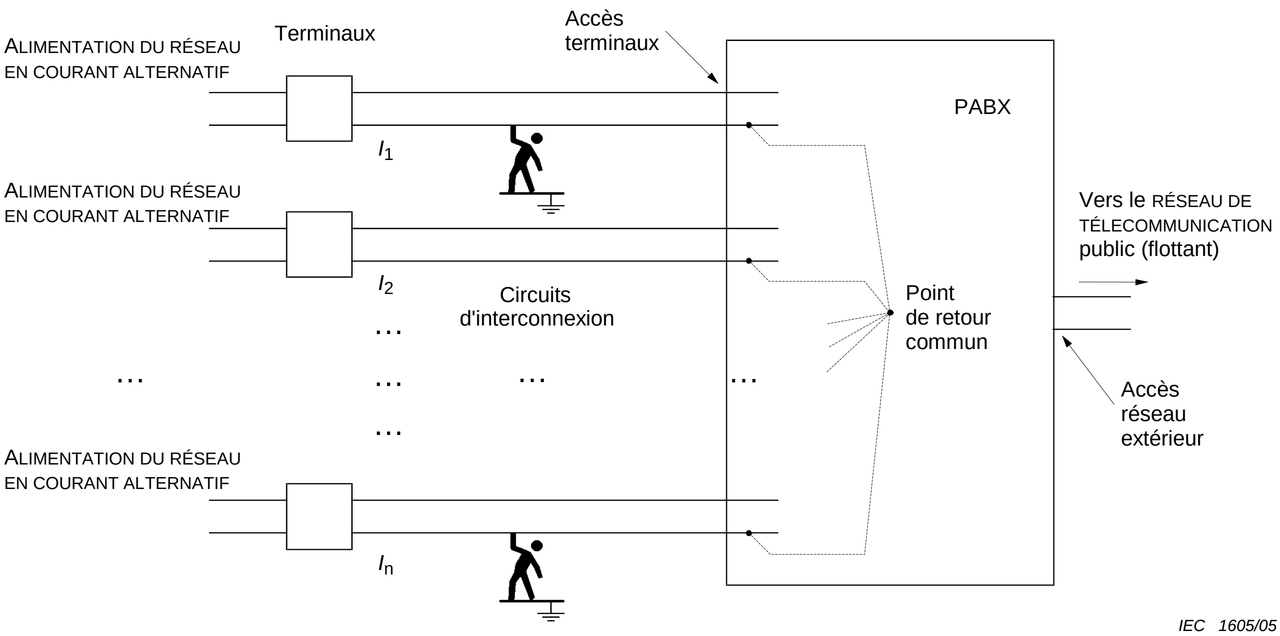


Figure W.3 – Sommation des courants de contact dans un PABX

Chaque matériel terminal peut fournir un courant à un corps humain touchant le circuit d'interconnexion (I_1, I_2 etc.), additionné à tout courant venant des circuits de l'accès du PABX. Si plusieurs circuits sont connectés à un point commun, leurs COURANTS DE CONTACT individuels s'additionneront, et cela représente un risque possible pour un corps humain mis à la terre qui touche le circuit d'interconnexion.

Différents moyens d'éviter les risques sont considérés dans les paragraphes suivants.

W.2.1 Isolation

Isoler tous les circuits d'interconnexion, les uns des autres et de la terre, et limiter I_1, I_2 etc. comme décrit en W.1.1. Cela implique, soit l'usage, dans le PABX, d'une alimentation séparée pour chaque port, soit la fourniture d'un transformateur de ligne (signal) individuel pour chaque port. De telles solutions peuvent entraîner beaucoup de frais.

W.2.2 Retour commun isolé de la terre

Connecter tous les circuits d'interconnexion à un point de retour commun qui est isolé de la terre. (De telles connexions à un point commun peuvent en tout cas être nécessaires pour des raisons fonctionnelles.) Dans ce cas le courant total venant de tous les circuits d'interconnexion passera à travers un corps humain mis à la terre qui touche un fil quelconque d'un circuit d'interconnexion quelconque. Ce courant peut être limité uniquement par surveillance des valeurs I_1, I_2... I_n en rapport avec le nombre de ports sur le PABX. Toutefois, la valeur du courant total sera probablement inférieure à $I_1 + I_2 +...+ I_n$ par suite des harmoniques et des autres effets.

W.2.3 Retour commun connecté à la terre de protection

Connecter tous les circuits d'interconnexion à un point de retour commun et le relier à la terre de protection. La situation décrite en W.1.2 s'applique quel que soit le nombre de ports. Comme la sécurité dépend de la présence de la connexion de terre, il peut être nécessaire d'utiliser des dispositions de mise à la terre de haute intégrité, suivant la valeur maximale du courant total qui peut circuler.

Annexe X
(informative)

Echauffement maximal dans les essais de transformateurs

(voir Article C.1)

L'Article C.1 prescrit que les transformateurs soient chargés de manière à obtenir l'échauffement maximal. Dans la présente annexe, des exemples de différentes méthodes sont donnés pour produire ces conditions. D'autres méthodes sont possibles et la vérification de conformité avec l'Article C.1 n'est pas limitée à ces exemples.

X.1 Détermination du courant maximal d'entrée

La valeur du courant d'entrée à charge nominale est établie. Cette valeur est I_r, voir étape A du Tableau X.1. Cette valeur peut être établie à partir d'essais ou à partir des données du fabricant.

Une charge est appliquée à l'enroulement de sortie ou à la sortie de l'alimentation à découpage pendant la mesure du courant d'entrée. La charge est ajustée aussi rapidement que possible afin d'obtenir la valeur maximale du courant d'entrée qui peut être maintenu pendant environ 10 s de fonctionnement. Cette valeur est I_m, voir étape B du Tableau X.1. L'essai est alors répété conformément à l'étape C et, si cela est nécessaire suivant les étapes D à J du Tableau X.1. La valeur du courant d'entrée est notée à chaque étape et est maintenue jusqu'à ce que:

a) la température du transformateur se stabilise sans la mise en fonctionnement d'un quelconque composant ou dispositif de protection (protection inhérente), auquel cas aucun essai supplémentaire n'est réalisé; ou alors

b) un composant ou un dispositif de protection fonctionne, auquel cas la température de l'enroulement est notée immédiatement. L'essai de l'Article X.2 est alors effectué en fonction du type de protection.

Si un composant ou un dispositif de protection fonctionne dans les 10 s après l'application de la tension primaire, I_m est la valeur relevée juste avant que le composant ou le dispositif de protection fonctionne.

En déroulant les essais décrits dans les étapes C à J du Tableau X.1, la charge variable est réglée à la valeur prescrite aussi rapidement que possible, et réajustée, si nécessaire, 1 min après l'application de la tension primaire. Le séquencement des étapes C à J peut être inversé.

Tableau X.1 – Etapes d'essais

Etapes	Courant d'entrée du transformateur ou de l'alimentation à découpage
A	Courant d'entrée à charge nominale = I_r
B	Valeur maximale du courant d'entrée après 10 s de fonctionnement = I_m
C	$I_r + 0{,}75\ (I_m - I_r)$
D	$I_r + 0{,}50\ (I_m - I_r)$
E	$I_r + 0{,}25\ (I_m - I_r)$
F	$I_r + 0{,}20\ (I_m - I_r)$
G	$I_r + 0{,}15\ (I_m - I_r)$
H	$I_r + 0{,}10\ (I_m - I_r)$
J	$I_r + 0{,}05\ (I_m - I_r)$

X.2 Procédure d'essais de surcharge

Si le résultat de l'essai de l'Article X.1 est celui de la condition X.1 b), ce qui suit s'applique en fonction du type de protection.

Protection électronique: *Le courant est soit réduit par pas de 5 % à partir de la condition X.1 b) soit augmenté par pas de 5 % à partir de la charge assignée pour déterminer la surcharge maximale à laquelle la température se stabilise sans la mise en fonctionnement d'une protection électronique.*

Protection thermique: *Une surcharge est appliquée de telle manière que la température de fonctionnement reste inférieure de quelques degrés à la température assignée d'ouverture de la protection thermique.*

Protection contre les surintensités: *Une surcharge est appliquée de telle manière que le courant circule conformément à la courbe du courant en fonction du temps du dispositif de protection contre les surintensités.*

Annexe Y
(normative)

Essai de conditionnement à la lumière ultraviolette

(voir 4.3.13.3)

Y.1 Appareillage d'essai

Les éprouvettes sont exposées à la lumière ultraviolette en utilisant un des appareils suivants:

- *une lampe à double arc au carbone, (voir Article Y.3), fournissant une exposition continue pendant un minimum de 720 h. L'appareil d'essai doit fonctionner avec une température de panneau noir de 63 °C ± 3 °C dans une humidité relative de (50 ~~%~~ ± 5) %; ou*
- *une lampe à arc au xénon, (voir Article Y.4), fournissant une exposition continue pendant un minimum de 1 000 h. L'appareil d'essai doit fonctionner avec une lampe à arc au xénon de 6 500 W refroidie à l'eau, ayant un éclairement spectral énergétique de 0,35 W/m^2 à 340 nm et une température de panneau noir de 63 °C ± 3 °C dans une humidité relative de (50 ~~%~~ ± 5) %.*

Y.2 Montage des échantillons d'essai

Les éprouvettes sont montées verticalement à l'intérieur du cylindre de l'appareil d'exposition à la lumière, avec leur plus large partie faisant face aux arcs. Les éprouvettes sont placées de manière à ne pas être en contact les unes avec les autres.

Y.3 Appareil d'exposition à la lumière doté d'une lampe à arc au carbone

L'appareil décrit dans l'ISO 4892-4, ou l'équivalent, est utilisé selon les procédures données dans l'ISO 4892-1 et l'ISO 4892-4, en utilisant le filtre de type 1, sans arrosage à l'eau.

Les matériaux soumis à essai avec arrosage d'eau sont également considérés acceptables.

Y.4 Appareil d'exposition à la lumière doté d'une lampe à arc au xénon

L'appareil décrit dans l'ISO 4892-2, ou l'équivalent, est utilisé selon les procédures données dans l'ISO 4892-1 et l'ISO 4892-2, en utilisant la méthode A, sans arrosage à l'eau.

Les matériaux soumis à essai avec arrosage d'eau sont également considérés acceptables.

NOTE L'expression «sans arrosage à l'eau» signifie que les éprouvettes ne sont pas aspergées d'eau pendant l'essai. Il convient de ne pas confondre avec le refroidissement par eau qui est nécessaire pour le fonctionnement de l'appareil.

Annexe Z
(informative)

Catégories de surtensions

(voir 2.10.3.2 et Article G.2)

La valeur de crête la plus élevée de la surtension transitoire susceptible de se produire à l'interface d'entrée du matériel connecté à un RESEAU D'ALIMENTATION est connue sous l'appellation de TENSION TRANSITOIRE DU RESEAU. Dans la présente norme, les DISTANCES DANS L'AIR minimales pour l'isolation dans les CIRCUITS PRIMAIRES sont fondées sur la TENSION TRANSITOIRE DU RESEAU.

Selon la CEI 60664-1, la valeur de la TENSION TRANSITOIRE DU RESEAU d'un RESEAU D'ALIMENTATION EN COURANT ALTERNATIF dépend de la TENSION DU RESEAU D'ALIMENTATION EN COURANT ALTERNATIF et de la catégorie de surtension, I à IV, voir aussi le Tableau G.1.

La catégorie de surtension doit donc être identifiée pour chaque matériel destiné à être connecté au RESEAU D'ALIMENTATION EN COURANT ALTERNATIF.

La catégorie de surtension dépend de la manière dont le matériel est connecté aux alimentations du bâtiment. Elle est normalement considérée comme indiqué au Tableau Z.1. Lorsque des mesures de limitation des transitoires sont prévues, comme des filtres externes dans le RESEAU D'ALIMENTATION EN COURANT ALTERNATIF, le matériel peut être utilisé avec une catégorie de surtension supérieure.

Le terme catégorie de surtension n'est pas utilisé pour les connexions avec les RESEAUX D'ALIMENTATION EN COURANT CONTINU.

Tableau Z.1 – Catégories de surtensions

Catégorie de surtension	Matériel et son point de connexion au RESEAU D'ALIMENTATION EN COURANT ALTERNATIF	Exemples de matériel
IV	Matériel qui sera connecté au point où le RESEAU D'ALMENTATION EN COURANT ALTERNATIF entre dans le bâtiment	Compteurs électriques ATI de communication pour comptage à distance de l'électricité
III	Matériel qui sera une partie intégrante du câblage du bâtiment	Socles de prises, panneaux de fusibles et tableaux de commutateurs Matériel de surveillance du courant
II	MATERIEL RELIE A DEMEURE ou RACCORDE PAR PRISE DE COURANT qui sera alimenté par le câblage du bâtiment	Appareils électrodomestiques, outils portatifs, électronique domestique La plupart des appareils de traitement de l'information utilisés dans le bâtiment
I	Matériel qui sera connecté à un RESEAU D'ALIMENTATION EN COURANT ALTERNATIF spécial dans lequel des mesures ont été prises pour réduire les transitoires	Appareils de traitement de l'information alimentés via un filtre externe ou un générateur à moteur

Annexe AA
(normative)

Essai de mandrin
(voir 2.10.5.8)

NOTE Cet essai est fondé sur la CEI 61558-1 et il donnera les mêmes résultats.

Trois échantillons d'essai sont utilisés, chaque échantillon individuel se composant de trois couches ou plus de matériau en fines feuilles non séparables formant l'ISOLATION RENFORCEE. Un échantillon est fixé au mandrin du dispositif d'essai (Figure AA.1), comme représenté à la Figure AA.2.

Dimenions en millimètres

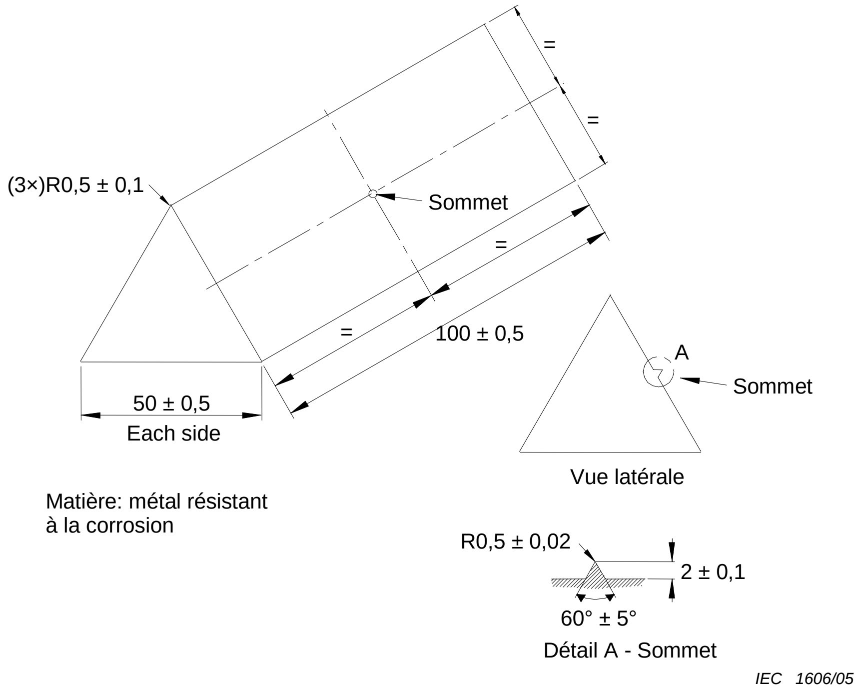


Figure AA.1 – Mandrin

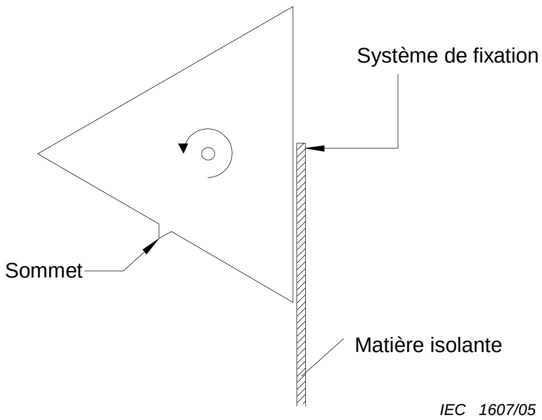
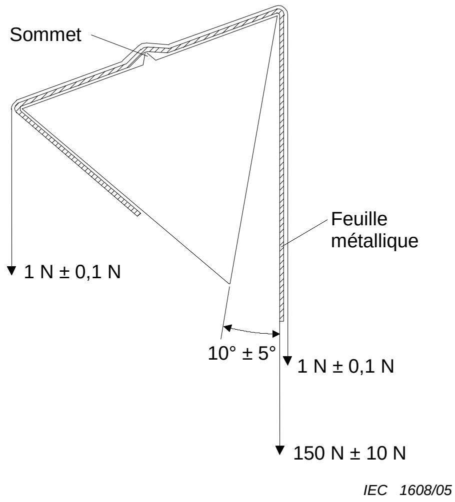


Figure AA.2 – Position initiale du mandrin



La position finale du mandrin est tournée de 230° ± 5° par rapport à la position initiale

Figure AA.3 – Position finale du mandrin

Une force dirigée vers le bas de 150 N ± 10 N est appliquée à l'extrémité libre de l'échantillon (voir Figure AA.3), en utilisant un dispositif de serrage approprié. Le mandrin est tourné

- *de la position initiale (Figure AA.2) à la position finale (Figure AA.3) et vice-versa;*
- *comme ci-dessus pour la deuxième fois;*
- *de la position initiale à la position finale.*

Si un échantillon se casse au cours de la rotation là où il est fixé au mandrin ou au dispositif de serrage, cela ne constitue par une défaillance. Si un échantillon se casse à tout autre endroit, l'essai a échoué.

Après l'essai décrit ci-dessus, une feuille métallique, d'épaisseur 0,035 mm ± 0,005 mm, de longueur minimale 200 mm, est placée le long de la surface de l'échantillon, retombant de chaque côté du mandrin (voir Figure AA.3). La surface de la feuille en contact avec l'échantillon doit être conductrice, non oxydée ou autrement isolée. La feuille est positionnée de telle sorte que ses bords ne soient pas situés à moins de 18 mm des bords de l'échantillon (voir Figure AA.4). La feuille est ensuite resserrée par deux poids égaux, un à chaque extrémité, utilisant des dispositifs de serrage appropriés.

Dimensions en millimètres

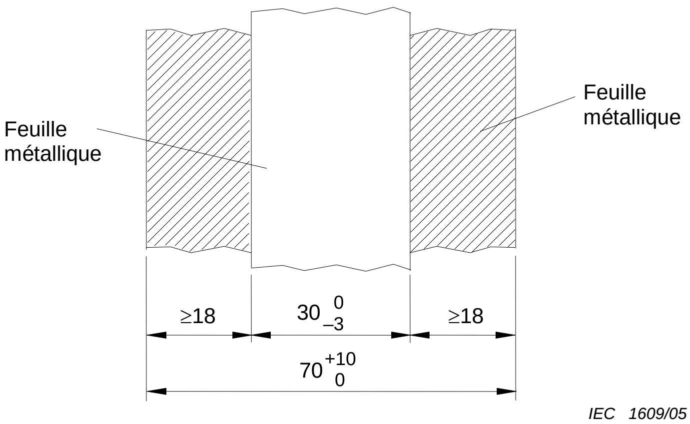


Figure AA.4 – Position de la feuille métallique sur le matériau isolant

Tandis que le mandrin est dans sa position finale, et dans les 60 s suivant le positionnement final, un essai de rigidité diélectrique est appliqué entre le mandrin et la feuille métallique, conformément à 5.2.2. La tension d'essai est égale à 150 % de U_{essai} , mais elle n'est pas inférieure à 5 kV. U_{essai} est la tension d'essai spécifiée en 5.2.2 pour l'ISOLATION RENFORCEE.

L'essai est répété sur les deux autres échantillons.

Annexe BB
(informative)

Modifications de la deuxième édition

BB.1 Tableau des modifications de numérotation

Les numéros des paragraphes, annexes, figures et tableaux suivants ont changé par rapport à la première édition de la CEI 60950-1.

Première édition	Action	Présente édition
1.2.2.3	supprimé	
	nouveau	1.2.2.3
1.2.2.4	supprimé	
1.2.2.5	supprimé	
	nouveau	1.2.5.3
1.2.5.3 à 5	renuméroté	1.2.5.4 à 6
	nouveau	1.2.8.3
1.2.8.3 à 13	renuméroté	1.2.8.4 à 14
	nouveau	1.2.9.7
1.2.9.7 à 10	renuméroté	1.2.9.8 à 11
	nouveau	1.2.10.4
	nouveau	1.2.13.15
	nouveau	1.2.13.16
	nouveau	1.2.13.17
1.5.6, 1.5.7.2	remplacé	1.5.6
1.5.7	remplacé	1.5.7
	nouveau	1.5.9
	nouveau	1.7.2.1 à 3
1.7.10	renuméroté	1.7.2.4
1.7.11	renuméroté	1.7.10
1.7.12	supprimé	
1.7.13 à 15	renuméroté	1.7.11 à 13
1.7.16	renuméroté	1.7.2.5
1.7.17	renuméroté	1.7.14
	nouveau	1.7.2.6
	nouveau	2.1.1.8
	nouveau	2.1.1.9
2.2.3.1	supprimé	
2.2.3.2	supprimé	
2.2.3.3	supprimé	
	nouveau	2.3.2.1 à 4
2.6.1 c)	combiné à 2.6.1 b)	
2.6.1 d) à g)	renuméroté	2.6.1 c) à f)
	nouveau	2.9.4
2.10	remplacé	2.10
	nouveau	3.5.4
	nouveau	4.5.1
4.5.1	renuméroté	4.5.2
4.5.2	renuméroté	4.5.5
	nouveau	4.5.3
	nouveau	4.5.4
	nouveau	4.6.4.1 à 3
	nouveau	5.1.2.1 à 3
	nouveau	5.1.7.1 à 2
	nouveau	5.3.6
5.3.6 à 5.3.8.2	renuméroté	5.3.7 à 5.3.9.2
	nouveau	7.1
7.1 à 7.2	renuméroté	7.2 à 7.3

Première édition	Action	Présente édition

Première édition	Action	Présente édition
7.3.1 à 7.3.3	renuméroté	7.4.1 à 7.4.3
	nouveau	B.6.1 à 4
	nouveau	B.7.1
B.7.1 à B.7.3	renuméroté	B.7.2 à B.7.4
	nouveau	G.1.1
G.1	renuméroté	G.1.2
	nouveau	G.2.3
	nouveau	G.2.4
G.4 a)	renuméroté	G.4.1
G.4 b)	renuméroté	G.4.2
G.4 c)	renuméroté	G.4.3
G.4 d)	renuméroté	G.4.4
	nouveau	Annexe Q
Annexe Q	changement d'intitulé	Bibliographie
	nouveau	Annexe Z
	nouveau	Annexe AA
	nouveau	Annexe BB
	nouveau	Figure 2D
	nouveau	Figure 2E.1 et Figure 2E.2
Figure 2D à Figure 2H	renuméroté	Figure 2F à Figure 2K
Figure F.12	éclaté et renuméroté	Figures 2D et F.12
	nouveau	Figure F.14 à F.18
	nouveau	Figure AA.1 à AA.4
	nouveau	Tableau 1B
	nouveau	Tableau 1C
	nouveau	Tableau 1D
	nouveau	Tableau 2E
Tableau 2E à Tableau 2G	renuméroté	Tableau 2F à Tableau 2H
	nouveau	Tableau 2J
Tableau 2H à Tableau 2L	renuméroté	Tableau 2K à Tableau 2N
	nouveau	Tableau 2P
Tableau 2M	renuméroté	Tableau 2R
Tableau 2N	renuméroté	Tableau 2Q
Tableau 4B partie 1	renuméroté	Tableau 4B
Tableau 4B partie 2	renuméroté	Tableau 4C
Tableau 4C	renuméroté	Tableau 4D
Tableau 4D	renuméroté	Tableau 4E
	nouveau	Tableau 5C
	nouveau	Tableau 5D
	nouveau	Tableau Z.1

BB.2 Modifications de cette édition

Les principales modifications de la présente édition par rapport à la première édition de la CEI 60950-1 sont les suivantes. Les modifications mineures ne sont pas mentionnées.

Amplificateurs audio, exigences ajoutées dans un souci de cohérence avec la CEI 60065 (2.1.1.9, 4.5.1).

Essai de pression à la bille, procédure d'essai corrigée, différente à des valeurs ambiantes élevées (4.5.5).

Piles ou batteries, exigences accrues (4.3.8).

Bibliographie déplacée dans une nouvelle section après les annexes

SYSTEMES DE DISTRIBUTION PAR CABLE, tensions d'essai clarifiées (7.4.2, 7.4.3).

Tubes cathodiques, exigences alignées avec la CEI 60065 (4.2.8).

Connecteurs, DISTANCES DANS L'AIR et LIGNES DE FUITE minimales plus faibles (2.10.3.1, 2.10.4.3, G.6).

Accès de données pour des matériels complémentaires, exigences ajoutées pour limiter la puissance de sortie (3.5.4).

Définitions ajoutées:

- ETAMINE (1.2.13.15);
- MATERIEL ENFICHABLE DIRECTEMENT (1.2.5.3);
- ISOLATION, SOLIDE (1.2.10.4);
- CARACTERISTIQUES ASSIGNEES, COURANT DE PROTECTION (1.2.13.17);
- ALIMENTATION, RESEAU (1.2.8.3);
- DUREE, REPOS ASSIGNE (1.2.2.3);
- PAPIER MOUSSELINE (1.2.13.16);
- TENSION DE SERVICE, VALEUR EFFICACE (1.2.9.7).

RESEAU D'ALIMENTATION EN COURANT CONTINU, exigences plus détaillées concernant:

- DISTANCES DANS L'AIR [2.10.3.2 b) et c), 2.10.3.7, 2.10.3.9, G.2.2, G.2.3, G.4.1 c), G.5 a)];
- danger de choc électrique (2.1.1.7, 2.1.1.8).

Distance à travers l'isolation, exigences clarifiées (2.10.5) en particulier:

- optocoupleurs, aligné avec la CEI 60747 (2.10.5.4, Figure F.17);
- matériaux en couches minces non séparables (2.10.5.8).

Mode "de protection en courant avec réarmement continuel des alimentations (2.2.3).

Isolation ayant des impulsions de démarrage, exigences ajoutées (2.10.1.7, 2.10.2.1, 2.10.3.5).

Isolation en matériaux en couches minces non séparables, aligné avec la CEI 61558-1 (2.10.5.8, 2.10.5.9, Annexe AA).

Isolation dans les composants bobinés, exigences clarifiées (2.10.5.11. 2.10.5.14, Annexe U) y compris:

- fil de bobinage (2.10.5.12);
- émail à base de solvant sur fil de bobinage (2.10.5.1, 2.10.5.13).

Langue pour le marquage, exigence concernant la langue locale supprimée (1.7.2.1 Note 3).

Sources de puissance limitée, essais clarifiés (2.5).

Résistance mécanique, essais clarifiés (4.2.5, 4.2.6).

Essai de moteur, procédure alternative ajoutée (B.6.3).

Service non continu, exigences clarifiées (1.2.2, 1.7.3, 4.5.2, 5.3.8).

Dispositifs de protection contre les surintensités à spécifier s'ils sont exigés de manière extérieure (1.7.2.3).

Catégories de surtension III et IV, exigences ajoutées ou clarifiées (2.10.3.1, 5.2.2, G.1.1, Annexe Z).

Degrés de pollution 2 et 3, DISTANCES DANS L'AIR modifiées pour alignement avec la CEI 60664-1 (Tableau G.2).

CONDUCTEURS DE LIAISON DE PROTECTION, exigences et procédure d'essai modifiées (2.6.3.3, 2.6.3.4).

Résistances, en parallèle sur l'isolation (1.5.7).

Signaux de sonnerie, procédure d'essai pour la "Partie 68" corrigée et clarifiée (M.3).

Domaine d'application clarifié, cette norme peut être utilisée:

- pour la conformité partielle des sous-ensembles de composants (1.1.1);
- pour les parties électroniques de certains autres matériels (1.1.1 Note 2).

Exigences de séparation des CIRCUITS TBTS et des CIRCUITS TRT alignées (2.3.2, 2.3.3, 2.9.4).

Isolateurs unipolaires, règles clarifiées (3.4.6).

Impulsions de démarrage, exigences ajoutées (2.10.1.7, 2.10.2.1, 2.10.3.5).

Parasurtenseurs:

- VDR dans les CIRCUITS PRIMAIRES, exigences clarifiées (1.5.9);
- plus de détails pour déterminer la valeur minimale de la tension assignée de fonctionnement (6.1.2.1).

Classes thermiques d'isolation, classes 200, 220 et 250 ajoutées en conformité avec la CEI 60085 (Tableaux 5D, B.1, B.2, C.1, U.2).

MATERIELS TRANSPORTABLES, exigences pour les ouvertures dans les ENVELOPPES (4.6.4).

COURANT DE CONTACT:

- procédure d'essai clarifiée pour les matériels avec raccordements multiples à l'alimentation (5.1.2, 5.1.7.2);
- exigences étendues pour MATERIELS DU TYPE A RACCORDE PAR PRISE DE COURANT (5.1.7.1).

Matériels fixés au mur, procédure d'essai modifiée (4.2.10).

Condensateurs X et Y montés en parallèle sur l'isolation, applications clarifiées, aligné avec la CEI 60384-14 (1.5.6).

Annexe CC
(normative)

Evaluation des limiteurs de courant à circuits intégrés (IC)

CC.1 Limiteurs de courant à circuits intégrés (IC)

Les limiteurs de courant à IC (utilisés pour limiter le courant de la sortie d'une source de puissance conformément aux exigences relatives à une source de puissance limitée, voir 2.5) ne sont pas court-circuités de l'entrée à la sortie s'ils répondent à tous les critères suivants:

- des DISTANCES DANS L'AIR et des LIGNES DE FUITE pour ISOLATION RENFORCEE sont fournies entre les broches d'entrée et de sortie pour la TENSION DE SERVICE applicable, à l'exception des limiteurs de courant à IC dans des CIRCUITS TBTS;
- les limiteurs de courant à IC limitent le courant à la valeur spécifiée par le fabricant (ne devant pas dépasser 5 A) dans des conditions normales d'utilisation en tenant compte de toute dérive spécifiée;
- les limiteurs de courant à IC sont totalement électroniques et n'ont aucun moyen d'actionnement manuel ou de réinitialisation;
- *les limiteurs de courant à IC doivent limiter le courant à 5 A en prenant en compte la dérive spécifiée par le fabricant, selon le cas, (un circuit ouvert est considéré comme étant un résultat acceptable) après chacun des essais de conditionnement donnés dans l'un ou l'autre des programmes d'essai spécifiés en CC.2, CC.3 ou CC.4. Le limiteur de courant à IC a seulement besoin de satisfaire à l'un des programmes d'essai.*

NOTE Il convient que la source de puissance pour les essais soit capable de fournir au minimum 250 VA, à moins que le limiteur de courant à IC ne soit soumis à essai dans le produit final.

Il est permis d'utiliser un échantillon différent pour chaque essai.

CC.2 Programme d'essai 1

Le programme d'essai 1 est constitué de ce qui suit:

- *10 000 cycles de mise sous tension et hors tension de la broche "enable" avec une résistance de 100 $\Omega \pm 5$ Ω et un condensateur de 425 μF $\pm$ 10 μF en parallèle avec la sortie;*
- *10 000 cycles de mise sous tension et hors tension de la broche "enable" avec une bobine d'inductance à noyau de ferrite d'une inductance de 0,35 mH $\pm$ 0,1 mH à 1 kHz et une résistance en courant continu ne dépassant pas 1 Ω, reliés dans le circuit de sortie;*
- *10 000 cycles de mise sous tension et hors tension de la broche "enable" avec l'entrée reliée à un condensateur d'une capacité assignée de 425 μF $\pm$ 1 μF et court-circuitant la sortie;*
- *10 000 cycles de mise sous tension et hors tension de la broche d'entrée avec un condensateur d'une capacité assignée de 425 μF $\pm$ 10 μF relié à l'alimentation d'entrée tout en maintenant active la broche "enable" et court-circuitant la sortie;*
- *10 000 cycles de mise sous tension et hors tension de la broche d'entrée ("input") avec une bobine d'inductance à noyau de ferrite d'une inductance de 0,35 mH $\pm$ 0,1 mH à 1 kHz et une résistance en courant continu ne dépassant pas 1 Ω, reliés à l'alimentation d'entrée et au point de retour, tout en maintenant active la broche "enable" et en court-circuitant la sortie ;*
- *50 cycles avec la broche "enable" maintenue active avec la sortie en circuit ouvert, chaque cycle consistant à court-circuiter la sortie puis ouvrir la sortie;*

- *50 cycles avec la broche "enable" maintenue active tout en appliquant un court-circuit à la sortie, chaque cycle consistant à fournir et couper l'alimentation électrique;*
- *50 cycles avec la broche "enable" maintenue active pendant que la puissance est appliquée, chaque cycle consistant à court-circuiter la sortie, retirer la puissance, remettre la puissance, retirer le court-circuit puis retirer la puissance.*

CC.3 Programme d'essai 2

Le programme d'essai 2 est constitué de ce qui suit:

- *50 cycles avec la broche "enable" maintenue active avec la sortie en circuit ouvert; chaque cycle consistant à court-circuiter la sortie puis ouvrir la sortie;*
- *50 cycles avec la broche "enable" maintenue active tout en appliquant un court-circuit à la sortie, chaque cycle consistant en une mise sous tension et hors tension;*
- *50 cycles avec la broche "enable" maintenue active avec la sortie chargée à la puissance maximale, chaque cycle consistant en une mise sous tension et hors tension ;*
- *50 cycles avec la broche "enable" maintenue active pendant que la puissance est appliquée, chaque cycle consistant à court-circuiter la sortie, retirer la puissance, remettre la puissance, retirer le court-circuit puis retirer la puissance;*
- *3 cycles d'exposition du dispositif (non alimenté) à 70 ^{o}C $\pm$ 2 ^{o}C pendant 24 h; suivis d'un maintien d'au moins 1 h à la température ambiante; suivi d'un maintien d'au moins 3 h à -30 ^{o}C $\pm$ 2 ^{o}C; suivi d'un maintien de 3 h à la température ambiante;*
- *10 cycles d'exposition du dispositif (alimenté) à 50 ^{o}C $\pm$ 2 ^{o}C pendant 10 min; suivis d'un maintien de 10 min à 0 ^{o}C $\pm$ 2 ^{o}C avec une période de transition de 5 min d'un état à un autre;*
- *7 jours avec la sortie mise en court-circuit et le dispositif enveloppé dans une double couche d'*ETAMINE*. Un fusible rapide de 5 A (conforme à la CEI 60127-1) maintenu en série avec la sortie ne doit pas s'ouvrir.*

CC.4 Programme d'essai 3

Le programme d'essai 3 est constitué de ce qui suit:

- *H.17.1.4.2 de la CEI 60730-1:1999;*
- *10 000 cycles de mise sous tension et hors tension de la broche "enable" avec une résistance de 100 Ω et un condensateur de 425 μF en parallèle avec la sortie;*
- *10 000 cycles de mise sous tension et hors tension de la broche "enable" avec une bobine d'inductance à noyau de ferrite d'une inductance de 0,35 mH $\pm$ 0,1 mH à 1 kHz et une résistance en courant continu ne dépassant pas 1 Ω, reliés dans le circuit de sortie;*
- *10 000 cycles de mise sous tension et hors tension de la broche "enable", alors que l'entrée est reliée à un condensateur d'une capacité assignée de 425 μF et court-circuitant la sortie;*
- *10 000 cycles de mise sous tension et hors tension de la broche d'entrée ("input"), alors qu'un condensateur d'une capacité assignée de 425 μF relié à l'alimentation d'entrée maintient active la broche "enable" et met en court-circuit la sortie;*
- *10 000 cycles de mise sous tension et hors tension de la broche d'entrée ("input") avec une bobine d'inductance à noyau de ferrite d'une inductance de 0,35 mH à 1 kHz et une résistance en courant continu ne dépassant pas 1 Ω, reliés à l'alimentation d'entrée maintenant active la broche "enable" et court-circuitant la sortie;*
- *50 cycles avec la broche "enable" maintenue active et appliquant un court-circuit à la sortie avec établissement et coupure de l'alimentation électrique;*

- *50 cycles avec la broche "enable" maintenue active et la sortie chargée à la puissance maximale avec établissement et coupure de l'alimentation électrique;*
- *50 cycles avec la broche "enable" maintenue active et appliquant la puissance, appliquer un court-circuit à la sortie; retirer la puissance, appliquer la puissance, retirer le court-circuit, retirer la puissance;*
- *3 cycles d'exposition du dispositif (non alimenté en énergie) à 70 °C pendant 24 h; suivis d'un maintien d'au moins 1 h à la température ambiante; suivi d'un maintien d'au moins 3 h à −30 °C; suivi d'un maintien de 3 h à la température ambiante;*
- *10 cycles d'exposition du dispositif (alimenté en énergie) à 49 °C pendant 10 min; suivis de 10 min à 0 °C avec une période de transition de 5 min d'un état vers l'autre.*

CC.5 Conformité

Après chaque essai selon CC.2, CC.3 et CC.4, le dispositif doit limiter le courant conformément à sa spécification, selon le cas, ou alors le dispositif doit devenir un circuit ouvert. Un dispositif en circuit ouvert est remplacé par un nouvel échantillon et les essais sont poursuivis selon ce qui est applicable.

Annexe DD
(normative)

Exigences pour les moyens de montage des matériels montés dans des baies

DD.1 Généralités

Ces exigences s'appliquent aux moyens de montage des matériels de masse supérieure à 7 kg installés dans une baie qui peuvent être allongés à distance de la baie en vue d'installation, de maintenance ou opération analogue. Cette exigence ne s'applique pas aux matériels fixés en place et pourvus de sous-ensembles de matériels ou de baies ayant une position supérieure d'installation située à une hauteur de moins de 1 m de la surface d'appui.

Pour les besoins de ces exigences, les moyens de montage mécaniques pour de tels matériels seront appelés rails de glissement. Ces exigences visent à réduire la probabilité de blessure en maintenant le matériel en position sûre et en ne permettant pas aux rails de glissement de se tordre, aux moyens de fixation de rompre ou au matériel de glisser au-delà de l'extrémité des rails de glissement.

NOTE 1 Les rails de glissement comprennent les coulisses à paliers, les glissières à frottement ou autres moyens de montage équivalents.

NOTE 2 Les constructions de rails de glissement de parties/unités intégrées du produit final (par exemple plateaux de papier extractibles dans les photocopieuses/imprimantes) ne sont pas considérées comme des matériels montés dans des baies.

Les rails de glissement ont des butées d'extrémité qui empêchent les matériels de glisser intempestivement hors des moyens de montage.

DD.2 Essai de résistance mécanique, variable *N*

Les rails de glissement doivent être installés dans une baie avec le matériel, ou montage équivalent, conformément aux instructions du fabricant. Le matériel étant dans sa position en extension, une force vers le bas passant par le centre de gravité doit être appliquée pendant 1 min, en plus du poids du matériel, à l'aide d'un appareil d'essai approprié assurant le contact sur une surface plane circulaire de 30 mm de diamètre. Si le fait d'appliquer la force est susceptible d'endommager le matériel, il est permis de placer une plaque métallique ou d'autres moyens sous l'appareil d'essai. La force totale doit être calculée en fonction de la masse du matériel plus une masse supplémentaire telle que déterminée ci-dessous.

NOTE Cette force supplémentaire vise à prendre en compte d'autres objets ou dispositifs qui peuvent être empilés sur le dessus du matériel à montage sur baie installé pendant qu'il est dans la position d'extension au cours de l'installation d'autres matériels.

Pour le matériel monté sur rails de glissement, lorsque les rails de glissement sont montés horizontalement de chaque côté du matériel, la force totale appliquée aux rails de glissement doit être égale à la plus grande des deux valeurs ci-après:

- *150 % de la masse du matériel plus 330 N,*
- *150 % de la masse du matériel, plus une masse supplémentaire, laquelle est égale à la masse du matériel ou à 530 N, la plus petite de ces deux valeurs étant retenue.*

Pour les matériels montés sur rails de glissement où les rails de glissement sont montés verticalement sur le dessus et le fond du matériel dans la baie, la force totale appliquée aux rails de glissement doit représenter 150 % de la masse du matériel, avec une force minimale de 250 N et une force maximale de 530 N.

Si la surface d'appui est prévue être une étagère, la répartition de la force sur une plaque métallique sous l'appareil d'essai ne s'applique pas. Le fabricant doit spécifier la charge maximale destinée à être placée sur l'étagère afin de déterminer la force qu'il est nécessaire d'appliquer à cette étagère. Un marquage doit être fourni sur l'étagère pour indiquer le poids maximal qui peut être ajouté à cette étagère. L'essai de force doit être effectué à 125 % du poids maximal indiqué par le fabricant. La force doit être appliquée directement à l'aide de l'appareillage d'essai assurant le contact sur une surface plane circulaire de 30 mm de diamètre.

DD.3 Essai de résistance mécanique, 250 N, y compris les butées d'extrémité

Le matériel monté sur rails de glissement est installé dans une baie conformément aux instructions du fabricant. Une force statique de 250 N est appliquée pendant 1 min au matériel monté sur rails de glissement, dans chaque direction sauf vers le haut afin d'inclure la position la plus défavorable du matériel monté sur rails de glissement. La force est appliquée au matériel monté sur rails de glissement dans sa position (de maintenance) en extension totale ainsi que dans sa position (de fonctionnement) en rétraction normale à l'aide d'un instrument d'essai assurant le contact sur une surface plane circulaire de 30 mm de diamètre. La force est appliquée avec la totalité de la surface plane de l'instrument d'essai et en contact avec le matériel. Il n'est pas nécessaire que l'instrument d'essai soit entièrement en contact avec des surfaces irrégulières (par exemple des surfaces ondulées ou courbes).

NOTE Des exigences supplémentaires relatives à un essai de force dynamique sur les butées d'extrémité sont à l'étude.

DD.4 Conformité

La conformité est vérifiée par examen et à partir des données du fabricant. Si les données ne sont pas disponibles, les essais conformément aux Articles DD.2 et DD.3 sont réalisés.

Pendant les essais, le matériel et ses rails de glissement associés ne doivent pas se dissocier. Un cycle complet de déplacement de l'appareil sur les rails de glissement doit être effectué après l'achèvement de chaque essai. Si le moyen de montage ne peut pas effectuer un cycle complet sans liaison, une force de 100 N doit être appliquée au point central à l'avant du matériel dans l'intention de rétracter complètement le matériel dans la baie. Si le matériel ne se rétracte pas complètement, les moyens de montage ne doivent ni fléchir ni se déformer au point d'occasionner une blessure. Des butées d'extrémité doivent retenir le matériel dans une position sûre et ne doivent pas permettre au matériel de glisser au-delà de l'extrémité des rails de glissement.

Annexe EE
(normative)

Déchiqueteuses de documents/supports à usage domestique et de bureau/maison

EE.1 Généralités

Les DECHIQUETEUSES DE DOCUMENTS/SUPPORTS A USAGE DOMESTIQUE ET DE BUREAU/MAISON doivent en plus se conformer aux exigences de la présente annexe.

EE.2 Marquages et instructions

Pour les DECHIQUETEUSES DE DOCUMENTS/SUPPORTS A USAGE DOMESTIQUE ET DE BUREAU/MAISON, les marquages ou symboles alertant l'UTILISATEUR sur les considérations suivantes doivent être fournis à proximité de l'ouverture d'alimentation de documents/supports:

- ce matériel n'est pas destiné à être utilisé par des enfants (le produit n'est pas un jouet);
- éviter de toucher l'ouverture d'alimentation de documents/supports avec les mains;
- éviter tout contact des vêtements avec l'ouverture d'alimentation de documents/supports;
- éviter tout contact des cheveux avec l'ouverture d'alimentation de documents/supports; et
- éloigner les produits en aérosol [pour le matériel comportant un moteur (à balais) universel uniquement].

De plus, le symbole  (ISO 7000-0434) et le symbole  (ISO 7000-1641) (ou une combinaison des deux) doivent être marqués à proximité de l'ouverture d'alimentation de documents/supports pour alerter l'UTILISATEUR sur la présence d'importantes instructions d'utilisation, de maintenance et/ou d'entretien dans les instructions de l'UTILISATEUR accompagnant le produit et ces symboles requis ci-dessus doivent être expliqués dans les instructions.

Les marquages doivent être permanents et facilement discernables sur l'équipement lorsqu'il est prêt à l'utilisation.

EE.3 Retour imprévu du danger

Avec la DECHIQUETEUSE DE DOCUMENTS/SUPPORTS A USAGE DOMESTIQUE ET DE BUREAU/MAISON maintenue dans n'importe quelle position, y compris lorsqu'elle est retirée d'un bac à déchets éventuel, il doit être impossible de neutraliser tout VERROUILLAGE DE SECURITE ou interrupteur qui assure la protection contre l'activation du mécanisme déchiqueteur à l'aide du doigt d'épreuve de la Figure 2A.

NOTE Au Canada, au Japon et aux Etats-Unis, on utilise un doigt d'épreuve différent pour déterminer la conformité aux Articles EE.3 et EE.5.

La conformité est vérifiée par examen et, lorsque cela est nécessaire, par un essai avec le doigt d'épreuve de la Figure 2A.

EE.4 Déconnexion de l'alimentation des parties mobiles dangereuses

Un interrupteur sectionneur conforme à 3.4.2 doit être prévu pour déconnecter l'alimentation électrique des parties mobiles dangereuses. Cet interrupteur peut être un interrupteur (à but unique) à deux positions ou un interrupteur (multifonction) à plusieurs positions (par exemple, un interrupteur à coulisse). Cet interrupteur doit être placé en un endroit où il est facilement accessible à un UTILISATEUR dont une partie du corps ou les vêtements peuvent être pris dans l'ouverture d'alimentation.

Les positions « FERMETURE» et « OUVERTURE » d'un interrupteur à deux positions doivent être marquées conformément à 1.7.8.

Pour un interrupteur à plusieurs positions, sa position « OUVERTURE » doit être marquée conformément à 1.7.8, et ses autres positions doivent être marquées avec les libellés ou symboles appropriés. Si des symboles sont utilisés, ils doivent être expliqués dans les instructions de l'UTILISATEUR.

La conformité est vérifiée par examen.

EE.5 Protection contre les parties mobiles dangereuses

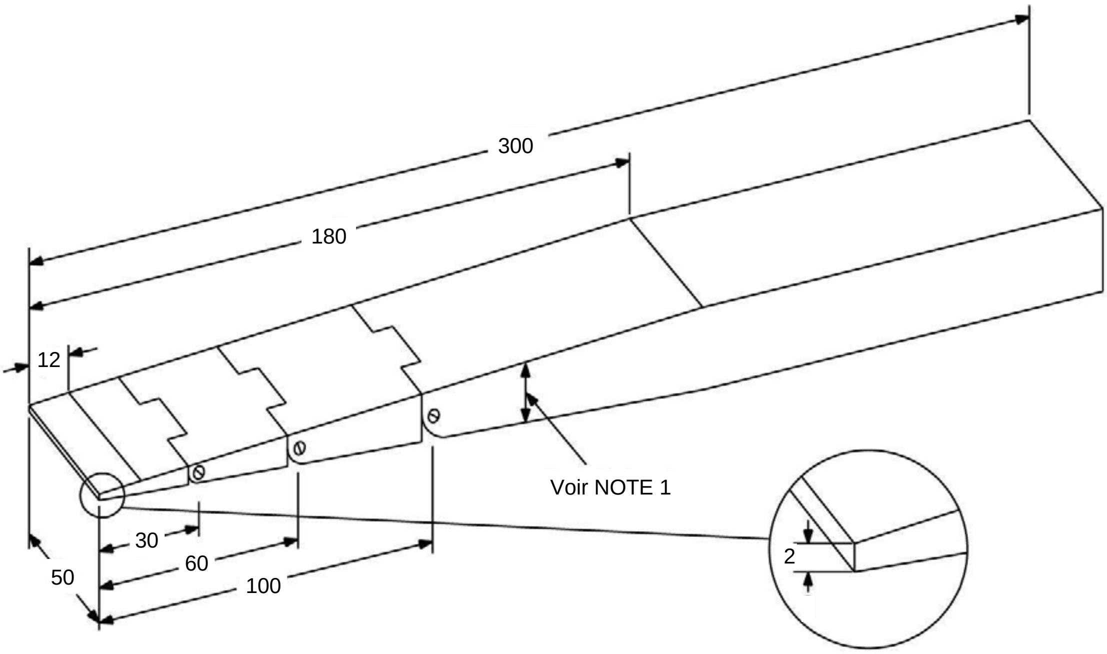
Pour les DECHIQUETEUSES DE DOCUMENTS/SUPPORTS A USAGE DOMESTIQUE ET DE BUREAU/MAISON, tout contact avec des parties mobiles dangereuses doit être évité. Une déclaration d'avertissement ne doit pas être utilisée à la place de caractéristiques de construction qui empêchent l'accès à des parties mobiles dangereuses.

La conformité est vérifiée comme suit:

Le doigt d'épreuve de la Figure 2A doit être inséré dans chaque ouverture dans l'ENVELOPPE MECANIQUE sans force appréciable. Le doigt d'épreuve ne doit pas toucher les parties mobiles dangereuses. Cette considération s'applique à tous les côtés de l'ENVELOPPE MECANIQUE lorsque la DECHIQUETEUSE DE DOCUMENTS/SUPPORTS A USAGE DOMESTIQUE ET DE BUREAU/MAISON est montée comme prévu conformément aux instructions d'utilisation du fabricant. Dans certain cas, il peut être nécessaire de faire fonctionner le matériel pour déterminer l'accessibilité (par exemple lorsqu'une protection ou couvercle ne s'ouvre que si le matériel est mis sous tension et prêt à être utilisé) lorsqu'on applique à la fois le doigt d'épreuve et la sonde à coin.

La sonde à coin, illustrée à la Figure EE.1 et à la Figure EE.2, doit être insérée dans chaque ouverture d'alimentation dans l'ENVELOPPE MECANIQUE. Une force ne dépassant pas 45 N pour les DECHIQUETEUSES DE DOCUMENTS/SUPPORTS A USAGE DOMESTIQUE ET DE BUREAU/MAISON à coupe en bandes et ne dépassant pas 90 N pour les DECHIQUETEUSES DE DOCUMENTS/SUPPORTS A USAGE DOMESTIQUE ET DE BUREAU/MAISON à coupe croisée doit être appliquée à la sonde à coin dans une direction quelconque par rapport à l'ouverture. La masse de la sonde à coin doit être prise comme facteur dans la force appliquée globale. Avant d'appliquer la sonde à coin, toutes les éventuelles ENVELOPPES MECANIQUES ou protections qui sont amovibles sans utiliser d'OUTIL doivent être retirées. La sonde à coin ne doit pas toucher les parties mobiles dangereuses, y compris les mécanismes/rouleaux déchiqueteurs.

Dimensions en millimètres



NOTE 1 L'épaisseur de la sonde varie linéairement, avec des changements de pente aux points suivants le long de la sonde:

Distance à l'extrémité de la sonde, mm	**Epaisseur de la sonde, mm**
0	2
12	4
180	24

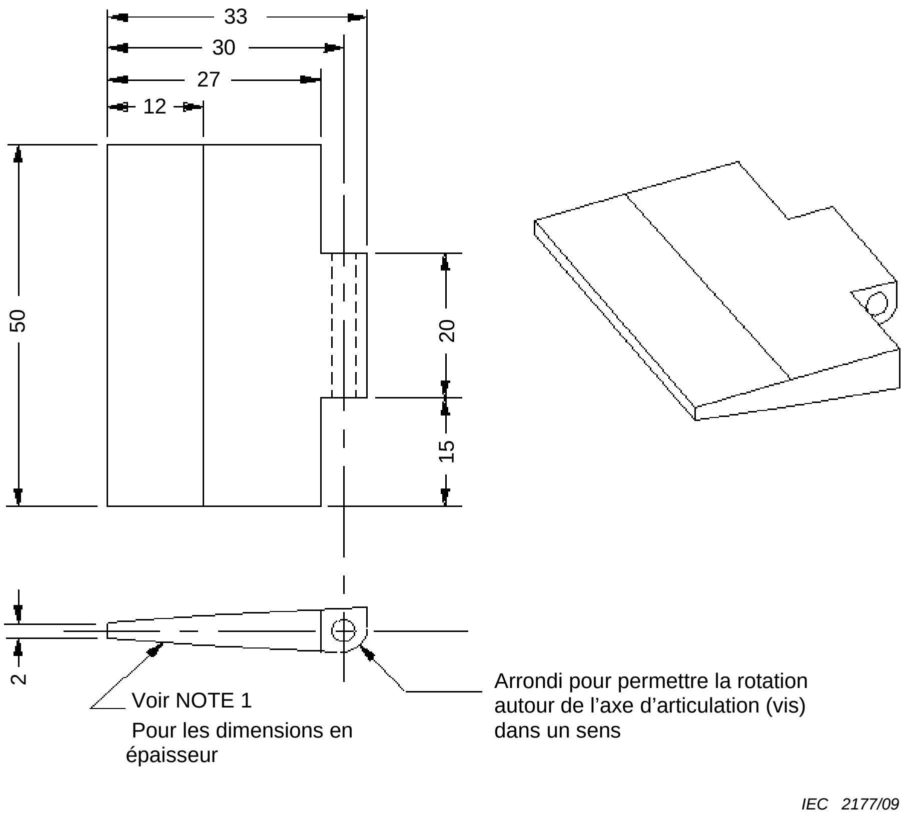
NOTE 2 Tolérances sur les dimensions linéaires sans tolérances spécifiques:

≤ 25 mm ± 0,13 mm

> 25 mm ± 0,3 mm

Figure EE.1 – Sonde à coin (vue d'ensemble)

Dimensions en millimètres



NOTE 1 L'épaisseur de la sonde varie linéairement, avec des changements de pente aux points suivants le long de la sonde:

Distance à l'extrémité de la sonde, mm	**Epaisseur de la sonde, mm**
0	2
12	4
180	24

NOTE 2 Tolérances sur les dimensions linéaires sans tolérances spécifiques:

≤ 25 mm ± 0,13 mm ;

> 25 mm ± 0,3 mm.

Figure EE.2 – Sonde à coin (détail de l'extrémité)

Bibliographie

Cette bibliographie contient des informations concernant les documents indiqués en référence dans les notes et les annexes informatives de la présente norme. Des informations supplémentaires sur les documents indiqués, y compris sur la manière de les obtenir, peuvent être trouvées sur les sites internet suivants:

http:/www.bsonline.techindex.co.uk
http:/www.cas.org
http://www.cenelec.org
http://www.cie.co.at
http://www.icrp.org et (pour les copies: http://www.elsevier.nl/locate/icrp)
http://www.iec.ch
http://www.iso.org
http://www.itu.int
http:/www.standards.com.au
http://wireless.fcc.gov/rules.htm (pour CFR 47 Part 68)

Pour les passages de la présente norme dans lesquels ces documents sont mentionnés, voir l'index.

CEI 60050-212:1990, *Vocabulaire Electrotechnique International – Chapitre 212: Isolants solides, liquides et gazeux*

CEI 60127 (toutes les parties), *Coupe-circuit miniatures*

CEI 60269-2-1, *Fusibles basse tension – Partie 2-1: Règles supplémentaires pour les fusibles destinés à être utilisés par des personnes habilitées (fusibles pour usages essentiellement industriels) – Sections I à VI: Exemples de types de fusibles normalisés*

CEI 60364-4-41, *Installations électriques des bâtiments – Partie 4-41: Protection pour assurer la sécurité – Protection contre les chocs électriques*

CEI 60410: *Plans et règles d'échantillonnage pour les contrôles par attributs*

CEI 60529, *Degrés de protection procurés par les enveloppes (code IP)*

CEI 60664-4, *Coordination de l'isolement des matériels dans les systèmes (réseaux) à basse tension – Partie 4: Considérations sur les contraintes de tension à hautes fréquences*

CEI 60728-11, *Cable networks for television signals, sound signals and interactive services – Part 11: Safety* (disponible en anglais seulement)

CEI 60896-21, *Batteries stationnaires au plomb – Partie 21: Types étanches à soupapes – Méthodes d'essai*

CEI 60896-22, *Batteries stationnaires au plomb – Partie 22: Types étanches à soupapes – Exigences*

CEI 60908, *Enregistrement audio – Système audionumérique à disque compact*

CEI 61032:1997, *Protection des personnes et des matériels par les enveloppes – Calibres d'essai pour la vérification*

CEI 61140, *Protection contre les chocs électriques – Aspects communs aux installations et aux matériels*

CEI 61558-1, *Sécurité des transformateurs, blocs d'alimentation et analogues – Partie 1: Règles générales et essais*

CEI 61643-21, *Parafoudres basse tension – Partie 21: Parafoudres connectés aux réseaux de signaux et de télécommunications – Prescriptions de fonctionnement et méthodes d'essais*

CEI 61643-311, *Composants pour parafoudres basse tension – Partie 311: Spécifications pour les tubes à décharge dans un gaz (TDG)*

CEI 61643-321, *Composants pour parafoudres basse tension – Partie 321: Spécifications pour les diodes à avalanche (ABD)*

CEI 61643-331, *Composants pour parafoudres basse tension – Partie 331: Spécifications pour les varistances à oxyde métallique (MOV)*

CEI 61965, *Sécurité mécanique des tubes cathodiques*

Guide CEI 112*, Guide pour la sécurité des matériels multimédias*

ISO 2859-1, *Règles d'échantillonnage pour les contrôles par attributs – Partie 1: Procédures d'échantillonnage pour les contrôles lot par lot, indexés d'après le niveau de qualité acceptable (NQA)*

ISO 4046-4 *Papier, carton, pâtes et termes connexes – Vocabulaire – Partie 4: Catégories et produits transformés de papiers et de carton*

ISO 4892 (toutes les parties)*, Plastiques – Méthodes d'exposition à des sources lumineuses de laboratoire*

UIT-T Recommandation K.11, *Principes de la protection contre les surtensions et les surintensités*

UIT-T Recommandation K.20, *Immunité des équipements de télécommunication des centres de télécommunication aux surtensions et aux surinten*sités

UIT-T Recommandation K.21, *Immunité des équipements de télécommunication installés dans les locaux d'abonné, aux surtensions et aux surintensités*

UIT-T Recommandation K.27, *Configurations équipotentielles et mise à la terre dans les bâtiments de télécommunication*

UIT-T Recommandation K.45 *Immunité des équipements de télécommunication installés dans les réseaux d'accès et de jonction aux surtensions et aux surintensités*

AS/NZS 3112, *Approval and test specification – Plugs and socket-outlets*

BS 1363 (toutes les parties), *13 A plugs, socket-outlets and adaptors*

CAS#110-54-3, American Chemical Society definition

CFR 47, Part 68: *Code of Federal Regulations (USA) Part 68: Connection of terminal equipment to the telephone network (commonly referred to as "FCC Rules, part 68")*

CIE Publication 63*, Mesures spectroradiométriques des sources de lumière*

ECMA-267, *120 mm DVD – Read-Only Disk*

EN 50272-2, *Règles de sécurité pour les batteries et les installations de batteries – Partie 2: batteries stationnaires*

EN 60950-1, *Technologies de l'information – Sécurité – Partie 1: Exigences générales*

ICRP 60, Recommendations of the International Commission on Radiological Protection

INDEX

Cet index n'a qu'une vocation informative et il n'est pas destiné à constituer un guide complet d'utilisation de cette norme. L'ajout ou l'omission de certains éléments dans cet index ne doit pas être pris comme le signe d'une importance particulière donnée ou refusée à tel ou tel aspect.

Les références des passages correspondent aux articles et paragraphes et aux lettres des annexes.

Dans cette norme, les numéros des tableaux et des figures sont liés à l'article ou à l'annexe dans lequel ils se trouvent,

Par exemple:

– Le tableau 2A est le premier tableau de l'article 2;
– La figure F.2 est la deuxième figure de l'annexe F.

Les références principales sont indiquées **en gras**.

Lorsqu'un terme est défini au paragraphe 1.2 de cette norme, sa définition est indiquée dans l'index par un astérisque,

– Par exemple: TENSION ASSIGNEE 1.2.1.1*.

Cet index est également utilisé pour expliquer certaines abréviations,

– Par exemple: EUT dispositif en essai (Equipment Under Test).

Les notes par pays sont indiquées mais leur contenu n'a pas été indexé.

«Bib» est une abréviation pour «Bibliographie», qui précède cet Index.

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