

INTERNATIONAL STANDARD

NORME INTERNATIONALE



**Audio/video, information and communication technology equipment –
Part 1: Safety requirements**

**Équipements des technologies de l'audio/vidéo, de l'information et de la
communication –
Partie 1: Exigences de sécurité**



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**AUDIO/VIDEO, INFORMATION AND COMMUNICATION
TECHNOLOGY EQUIPMENT –****Part 1: Safety requirements**

FOREWORD

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International Standard IEC 62368-1 has been prepared by TC 108: Safety of electronic equipment within the field of audio/video, information technology and communication technology.

This bilingual version corresponds to the monolingual English version, published in 2010-01. It includes Corrigendum 1 (2010-06).

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

FDIS	Report on voting
108/325/FDIS	108/355/RVD

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

The French version of this standard has not been voted upon.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2. Except for text preceded by "Note", 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.

The "in some countries" notes regarding differing national practices are contained in the following subclauses:

0.2.1, 4.1.15, 5.4.2.4.3, 5.4.2.9, 5.4.5.1, 5.5.2.2, 5.5.2.7, 5.7.7, 10.3.2, 10.3.3.3, 10.3.3.4, 10.4.1, F.3.3.5, Table 15 and Table 16.

In this standard, the following print types or formats are used:

- requirements proper and normative annexes: in roman type;
- compliance statements and test specifications: *in italic type*;
- notes/explanatory matter: in smaller roman type;
- normative conditions within tables: in smaller roman type;
- terms that are defined in 3.3: **bold**.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

The contents of the corrigendum of June 2010 have been included in this copy.

NOTE 1 The attention of National Committees and National bodies who prepare national standards is drawn to the fact that equipment manufacturers and testing organizations may need a transitional period following publication of a new, amended or revised IEC publication in which to make products in accordance with the new requirements and to equip themselves for conducting new or revised tests. It is the recommendation of TC108 that the content of this publication be adopted for mandatory implementation nationally not earlier than five years from the date of publication of this standard.

NOTE 2 IEC 62368-1 is based on the principles of hazard based safety engineering, which is a different way of developing and specifying safety considerations than that of the current practice. While this standard is different from traditional IEC safety standards in its approach and while it is believed that IEC 62368-1 provides a number of advantages, its introduction and evolution is not intended to result in significant changes to the existing safety philosophy that led to the development of the safety requirements contained in IEC 60065 and IEC 60950-1. The predominant reason behind the creation of IEC 62368-1 is to simplify the problems created by the merging of the technologies of ITE and CE. The techniques used are novel so that a learning process is required and experience is needed in its application. Consequently, IEC/TC108 recommends that the first edition of this standard be considered as an alternative to IEC 60065 or IEC 60950-1 at least over the recommended transition period.

NOTE 3 Explanatory information related to IEC 62368-1 will be published as IEC/TR 62368-2. It will contain rationale together with explanatory information related to this standard.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

0 Principles of this product safety standard

0.1 Objective

This International Standard is a product safety standard that classifies energy sources, prescribes **safeguards** against those energy sources, and provides guidance on the application of, and requirements for those **safeguards**.

The prescribed **safeguards** are intended to reduce the likelihood of pain, injury and, in the case of fire, property damage.

The objective of the INTRODUCTION is to help designers to understand the underlying principles of safety in order to design safe equipment. These principles are informative and not an alternative to the detailed requirements of this standard.

0.2 Persons

0.2.1 General

This standard describes **safeguards** for the protection of three kinds of persons: the **ordinary person**, the **instructed person**, and the **skilled person**. This standard assumes that a person will not intentionally create conditions or situations that could cause pain or injury.

NOTE In Australia, the work conducted by an **instructed person** or **skilled person** may require formal licensing from regulatory authorities.

0.2.2 Ordinary person

Ordinary person is the term applied to all persons other than **instructed persons** and **skilled persons**. **Ordinary persons** include not only users of the equipment, but also all persons who may have access to the equipment or who may be in the vicinity of the equipment. Under **normal operating conditions** or **abnormal operating conditions**, **ordinary persons** should not be exposed to parts comprising energy sources capable of causing pain or injury. Under a **single fault condition**, **ordinary persons** should not be exposed to parts comprising energy sources capable of causing injury.

0.2.3 Instructed person

Instructed person is a term applied to persons who have been instructed and trained by a **skilled person**, or who are supervised by a **skilled person**, to identify energy sources that may cause pain (see Table 1) and to take precautions to avoid unintentional contact with or exposure to those energy sources. Under **normal operating conditions**, **abnormal operating conditions** or **single fault conditions**, **instructed persons** should not be exposed to parts comprising energy sources capable of causing injury.

0.2.4 Skilled person

Skilled person is a term applied to persons who have training or experience in the equipment technology, particularly in knowing the various energies and energy magnitudes employed in the equipment. A **skilled person** is expected to use their training and experience to recognize energy sources capable of causing pain or injury and to take action for protection from injury from those energies. **Skilled persons** should also be protected against unintentional contact or exposure to energy sources capable of causing injury.

0.3 Model for pain and injury

This subclause presents an engineering-based model for pain and injury and their relationship to an energy source.

An energy source that causes pain or injury does so through the transfer of some form of energy to or from a body part.

This concept is represented by a three-block model (see Figure 1).

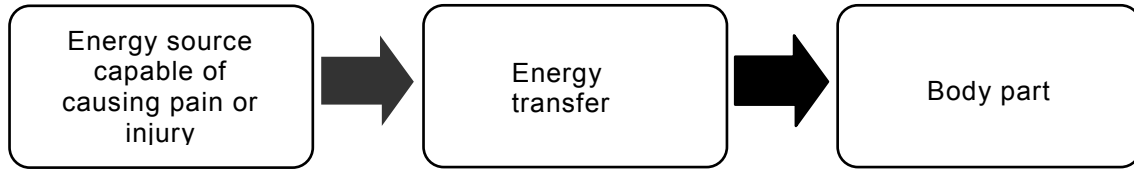


Figure 1 – Three block model for pain and injury

This safety standard specifies three classes of energy sources defined by magnitudes and durations of source parameters relative to either the body or to **combustible material** responses to those energy sources. Each energy class (see 4.2) is a function of the body part or the **combustible material** susceptibility to that energy magnitude (see Table 1).

Table 1 – Response to energy class

Energy source	Effect on the body	Effect on combustible materials
Class 1	Not painful, but may be detectable	Ignition not likely
Class 2	Painful, but not an injury	Ignition possible, but limited growth and spread of fire
Class 3	Injury	Ignition likely, rapid growth and spread of fire

The energy threshold for pain or injury is not constant throughout the population. For example, for some energy sources, the threshold is a function of body mass; the lower the mass, the lower the threshold, and vice-versa. Other body variables include age, state of health, state of emotions, effect of drugs, skin characteristics, etc. Furthermore, even where outward appearances otherwise appear equal, individuals differ in their thresholds of susceptibility to the same energy source.

The effect of duration of energy transfer is a function of the specific energy form. For example, pain or injury from thermal energy can be very short (1 s) for high skin temperature, or very long (several hours) for low skin temperature.

Furthermore, the pain or injury may occur some considerable time after the transfer of energy to a body part. For example, pain or injury from some chemical reaction may not be manifested for days, weeks, months, or years.

0.4 Energy sources

This subclause identifies the energy sources addressed by this standard, and the pain or injury that results from a transfer of that energy to the body, and the likelihood of property damage that results from fire escaping the equipment.

An electrical product is connected to an electrical energy source (for example, the **mains**), an external power supply, or a battery. An electrical product uses the electrical energy to perform its intended functions.

In the process of using electrical energy, the product transforms the electrical energy into other forms of energy, for example thermal energy, kinetic energy, optical energy, audio energy, electromagnetic energy, etc. Some energy transformations may be a deliberate part of the product function (for example, moving parts of a printer, images on a visual display unit, sound from a speaker, etc). Some energy transformations may be a by-product of the product

function (for example, heat dissipated by functional circuits, x-radiation from a cathode-ray tube, etc).

Some products may employ energy sources that are non-electrical energy sources such as batteries, moving parts, or chemicals, etc. The energy in these other sources may be transferred to or from a body part, or may be transformed into other energy forms (for example, a battery transforms chemical energy into electrical energy, or a moving body part transfers its kinetic energy to a sharp edge).

Examples of the types of energy forms and the associated injuries and property damage addressed in this standard are in Table 2.

Table 2 – Examples of body response or property damage related to energy sources

Forms of energy	Examples of body response or property damage	Clause
Electrical energy (for example, energized conductive parts)	Pain, fibrillation, cardiac arrest, respiratory arrest, skin burn, or internal organ burn	5
Thermal energy (for example, electrical ignition and spread of fire)	Electrically-caused fire leading to burn-related pain or injury, or property damage	6
Chemical reaction (for example, electrolyte, poison)	Skin damage, lung and other organ damage, or poisoning	7
Kinetic energy (for example, moving parts of equipment, or a moving body part against an equipment part)	Laceration, puncture, abrasion, contusion, crush, amputation, or loss of a limb, eye, ear, etc.	8
Thermal energy (for example, hot accessible parts)	Skin burn	9
Radiated energy (for example, electromagnetic energy, optical energy, acoustic energy)	Loss of sight, skin burn, or loss of hearing	10

0.5 Safeguards

0.5.1 General

This subclause introduces the three-block model for safety to explain the function of a **safeguard** and describes various manifestations of **safeguards**.

Many products necessarily employ energy capable of causing pain or injury. Equipment design cannot eliminate such energy use. Consequently, such products should employ a scheme that reduces the likelihood of such energy being transferred to a body part. The scheme that reduces the likelihood of energy transfer to a body part is a **safeguard** (see Figure 2).



Figure 2 – Three block model for safety

A **safeguard** is a device or scheme or system that

- is interposed between an energy source capable of causing pain or injury and a body part, and
- reduces the likelihood of transfer of energy capable of causing pain or injury to a body part.

NOTE **Safeguard** mechanisms against transfer of energy capable of causing pain or injury include

- attenuating the energy (reduces the value of the energy), or
- impeding the energy (slows the rate of energy transfer), or
- diverting the energy (changes the energy direction), or
- disconnecting, interrupting, or disabling the energy source, or
- enveloping the energy source (reduces the likelihood of the energy from escaping), or
- interposing a barrier between a body part and the energy source.

A **safeguard** can be applied to the equipment, to the local installation, to a person or can be a learned or directed behaviour (for example, resulting from an **instructional safeguard**) intended to reduce the likelihood of transfer of energy capable of causing pain or injury. A **safeguard** may be a single element or may be a set of elements.

Ideally, the order of preference for providing **safeguards** is:

- **equipment safeguards**;
- **installation safeguards**;
- **instructional safeguards** invoking **personal protective equipment**, or avoidance behaviour.

In practice, **safeguard** selection will take account of the nature of the energy source, the intended user, the functional requirements of the equipment, and similar considerations.

0.5.2 Equipment safeguard

An **equipment safeguard** may be a **basic safeguard**, a **supplementary safeguard**, a **double safeguard**, or a **reinforced safeguard**.

0.5.3 Installation safeguard

Installation safeguards are not controlled by the equipment manufacturer, although in some cases, **installation safeguards** may be specified in the equipment installation instructions.

Generally, with respect to equipment, an **installation safeguard** is a **supplementary safeguard**.

NOTE For example, the protective earthing **supplementary safeguard** is located partly in the equipment and partly in the installation. The protective earthing **supplementary safeguard** is not effective until the equipment is connected to the installation.

Requirements for **installation safeguards** are not addressed in this standard. However, this standard does assume some **installation safeguards**, such as protective earthing, are in place and are effective.

0.5.4 Instructional safeguard

An **instructional safeguard** is a visual indicator (symbols or words or both) or an audible message describing the existence and location of an energy source capable of causing pain or injury and is intended to invoke a specific behaviour on the part of a person to reduce the likelihood of transfer of energy to a body part (see Annex F).

An **instructional safeguard** may be a **basic safeguard**, or a **supplementary safeguard**.

When accessing locations where the unit needs to be energized to perform a service activity, an **instructional safeguard** may be considered acceptable protection to bypass an **equipment safeguard** such that the person is made aware of how to avoid contact with a class 2 energy source.

If **equipment safeguards** would interfere with or prohibit the equipment function, an **instructional safeguard** may be a **reinforced safeguard**.

Provision of an **instructional safeguard** does not result in an **ordinary person** becoming an **instructed person** (see 0.5.8).

0.5.5 Personal safeguard

A **personal safeguard** may be a **basic safeguard**, a **supplementary safeguard**, or a **reinforced safeguard**.

Requirements for **personal safeguards (personal protective equipment)** are not addressed in this standard. However, this standard does assume that **personal safeguards** are available for use as specified by the manufacturer.

0.5.6 Safeguards during ordinary or instructed person service conditions

During **ordinary person** or **instructed person** service conditions, **safeguards** for such persons may be necessary. Such **safeguards** can be **equipment safeguards**, **personal safeguards**, or **instructional safeguards**. Application of these **safeguards** is specified in the respective clauses.

0.5.7 Equipment safeguards during skilled person service conditions

During **skilled person** service conditions, **equipment safeguards** should be provided to protect against the effects of a body's involuntary reaction (for example, startle) that might cause unintentional contact with a class 3 energy source located outside the view of the **skilled person**.

NOTE This **safeguard** typically applies in large equipment, where the **skilled person** may need to partially or wholly enter between two or more class 3 energy source locations while servicing.

0.5.8 Precautionary safeguard

A **precautionary safeguard** is the training and experience or supervision of an **instructed person** by a **skilled person** to use precautions to protect the **instructed person** against class 2 energy sources. **Precautionary safeguards** are not specifically prescribed in this standard but are assumed to be effective when the term **instructed person** is used.

During equipment servicing, an **instructed person** may need to remove or defeat an **equipment safeguard**. In this case, an **instructed person** must then apply precaution as a **safeguard** to avoid injury.

0.5.9 Skill safeguard

A **skill safeguard** is the education, training, knowledge and experience of the **skilled person** that is employed to protect the **skilled person** against class 2 and class 3 energy sources. **Skill safeguards** are not specifically prescribed in this standard but are assumed to be effective when the term **skilled person** is used.

During equipment servicing, a **skilled person** may need to remove or defeat an **equipment safeguard**. In this case, a **skilled person** must then apply skill as a **safeguard** to avoid injury.

0.5.10 Examples of safeguard characteristics

Table 3 lists some examples of **safeguard** characteristics.

Table 3 – Examples of safeguard characteristics

Safeguard	Basic safeguard	Supplementary safeguard	Reinforced safeguard
Equipment safeguard: a physical part of an equipment	Effective under normal operating conditions	Effective in the event of failure of the basic safeguard	Effective under normal operating conditions and in the event of a single fault condition elsewhere in the equipment
	Example: basic insulation	Example: supplementary insulation	Example: reinforced insulation
	Example: normal temperatures below ignition temperatures	Example: fire enclosure	Not applicable
Installation safeguard: a physical part of a man-made installation	Effective under normal operating conditions	Effective in the event of failure of an equipment basic safeguard	Effective under normal operating conditions and in the event of a single fault condition elsewhere in the equipment
	Example: wire size	Example: overcurrent protective device	Example: socket outlet
Personal safeguard: a physical device worn on the body	In the absence of any equipment safeguard , effective under normal operating conditions	Effective in the event of failure of an equipment basic safeguard	In the absence of any equipment safeguard , effective under normal operating conditions and in the event of a single fault condition elsewhere in the equipment
	Example: glove	Example: insulating floor mat	Example: electrically-insulated glove for handling live conductors
Instructional safeguard: a voluntary or instructed behaviour intended to reduce the likelihood of transfer of energy to a body part	In the absence of any equipment safeguard , effective under normal operating conditions	Effective in the event of failure of an equipment basic safeguard	Only effective on an exceptional basis, when providing all appropriate safeguards would prevent the intended functioning of the equipment
	Example: instructional safeguard to disconnect telecommunication cable before opening the cover	Example: after opening a door, an instructional safeguard against hot parts	Example: instructional safeguard of hot parts in an office photocopier, or a continuous roll paper cutter on a commercial printer

0.6 Electrically-caused pain or injury (electric shock)

0.6.1 General

This subclause describes models for electrically-caused pain or injury and models for reducing the likelihood of transfer of electrical energy capable of causing pain or injury to a body part.

0.6.2 Models for electrically-caused pain or injury

Electrically-caused pain or injury may occur when electrical energy capable of causing pain or injury is transferred to a body part (see Figure 3).

Electrical energy transfer occurs when there are two or more electrical contacts to the body:

- the first electrical contact is between a body part and a conductive part of the equipment;
- the second electrical contact is between another body part, and
 - earth, or
 - another conductive part of the equipment.

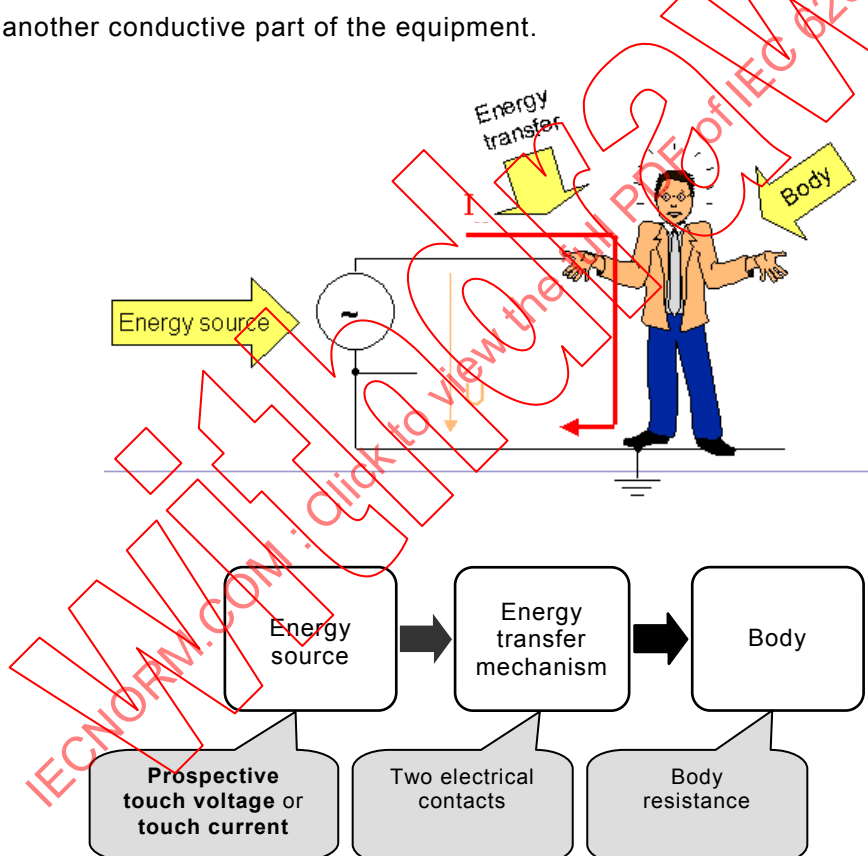


Figure 3 – Schematic and model for electrically-caused pain or injury

Depending on the magnitude, duration, wave shape, and frequency of the current, the effect to the human body varies from undetectable to detectable to painful to injurious.

0.6.3 Models for protection against electrically-caused pain or injury

Protection against electrically-caused pain or injury requires that one or more **safeguards** be interposed between an electrical energy source capable of causing pain or injury and a body part (see Figure 4).

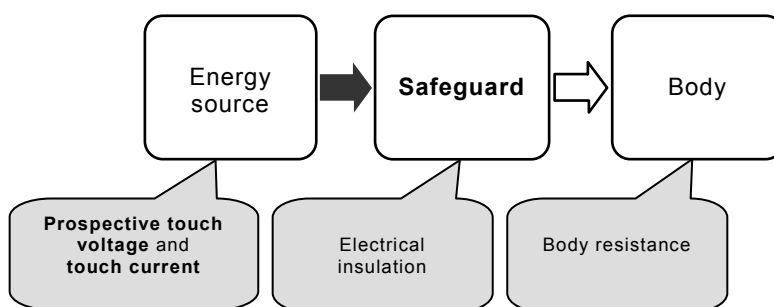


Figure 4 – Model for protection against electrically-caused pain or injury

Protection against electrically-caused pain is provided under **normal operating conditions** and **abnormal operating conditions**. Such protection requires that, under **normal operating conditions** and **abnormal operating conditions**, a **basic safeguard** be interposed between an electrical energy source capable of causing pain and an **ordinary person**.

The most common **basic safeguard** against an electrical energy source capable of causing pain is electrical insulation (also known as **basic insulation**) interposed between the energy source and a body part.

Protection against electrically-caused injury is provided under **normal operating conditions**, **abnormal operating conditions**, and **single fault conditions**. Such protection requires that, under **normal operating conditions** and **abnormal operating conditions**, both a **basic safeguard** and a **supplementary safeguard** be interposed between an electrical energy source capable of causing injury and an **ordinary person** (see 4.3.2.4), or an **instructed person** (see 4.3.3.3). In the event of a failure of either **safeguard**, the other **safeguard** becomes effective.

The **supplementary safeguard** against an electrical energy source capable of causing injury is interposed between the **basic safeguard** and a body part. A **supplementary safeguard** may be additional electrical insulation (**supplementary insulation**) or a protectively earthed conductive barrier or other construction that performs the same function.

The most common **safeguard** against an electrical energy source capable of causing injury is electrical insulation (also known as **double insulation** or **reinforced insulation**) interposed between the energy source and a body part.

Likewise, a **reinforced safeguard** may be interposed between an electrical energy source capable of causing injury and a body part.

0.7 Electrically-caused fire

0.7.1 General

This subclause describes models to reduce the likelihood of ignition (within the equipment) or to reduce the likelihood of fire (originating within the equipment) from spreading beyond the equipment.

0.7.2 Models for electrically-caused fire

Electrically-caused fire is due to conversion of electrical energy to thermal energy (see Figure 5), where the thermal energy heats a fuel material followed by ignition and combustion.

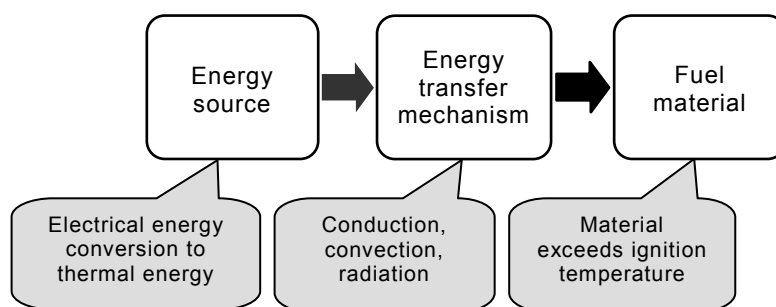


Figure 5 – Model for electrically-caused fire

Electrical energy is converted to thermal energy either in a resistance or in an arc and is transferred to a fuel material by conduction, convection, or radiation. As the fuel material heats, it chemically decomposes into gases, liquids and solids. When the gas is at its ignition temperature, the gas can be ignited by an ignition source. When the gas is at its spontaneous ignition temperature, the gas will ignite by itself. Both result in fire.

0.7.3 Models for protection against electrically-caused fire

The **basic safeguard** against electrically-caused fire (see Figure 6) is that the temperature of a material, under **normal operating conditions** and **abnormal operating conditions**, does not cause the material to ignite.

The **supplementary safeguard** against electrically-caused fire reduces the likelihood of ignition or, in the case of ignition, reduces the likelihood of spread of fire.

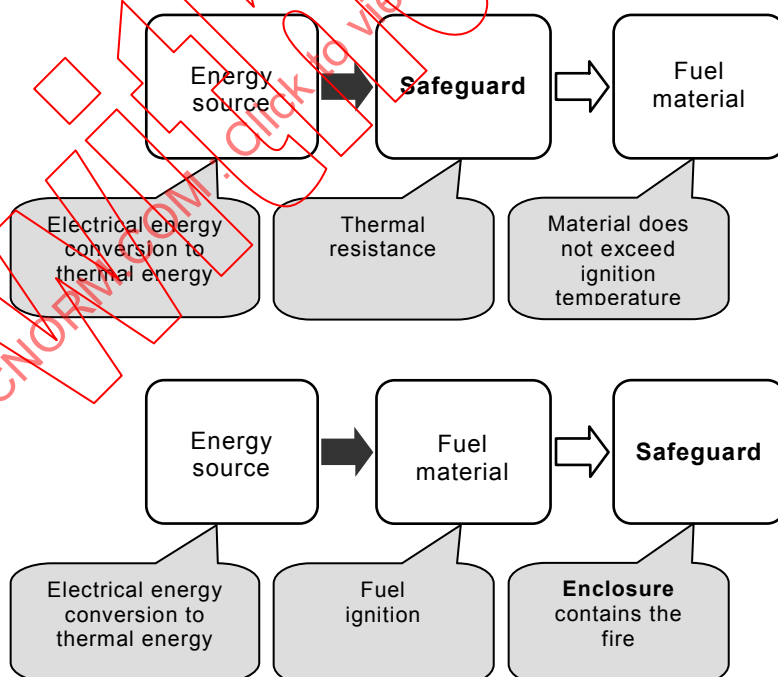


Figure 6 – Models for protection against fire

0.8 Chemically-caused injury

This subclause describes models for reducing the likelihood of injury from exposure to chemicals.

Chemically-caused injury is due to a chemical reaction with a body part. The extent of injury by a given agent depends on both the magnitude and duration of exposure and on the body part susceptibility to that agent.

The **basic safeguard** against chemically-caused injury is containment of the material.

Supplementary safeguards against chemically-caused injury may include:

- a second container or a spill-resistant container;
- containment trays;
- tamper-proof screws to prevent unauthorized access;
- **instructional safeguards**.

National and regional regulations govern the use of and exposure to chemicals used in equipment. These regulations do not enable a practical classification of chemicals in the manner in which other energy sources are classified in this standard. Therefore, energy source classifications are not applied in Clause 7.

0.9 Mechanically-caused injury

This subclause describes models for reducing the likelihood of injuries such as cuts, bruises, broken bones, etc. due to transfer of kinetic energy to a body part.

Mechanically-caused injury is due to kinetic energy transfer to a body part when a collision occurs between a body part and an equipment part. The kinetic energy is a function of the relative motion between a body part and **accessible** parts of the equipment, including parts ejected from the equipment that collide with a body part.

Examples of kinetic energy sources are:

- body motion relative to sharp edges and corners;
- part motion due to rotating or other moving parts, including pinch points;
- part motion due to loosening, exploding, or imploding parts;
- equipment motion due to instability;
- equipment motion due to wall, ceiling, or rack mounting means failure;
- equipment motion due to handle failure;
- part motion due to an exploding battery;
- equipment motion due to cart or stand instability or failure.

The **basic safeguard** against mechanically-caused injury is a function of the specific energy source. **Basic safeguards** may include:

- rounded edges and corners;
- an **enclosure** to prevent a moving part from being **accessible**;
- an **enclosure** to prevent expelling a moving part;
- a **safety interlock** to control access to an otherwise moving part;
- means to stop the motion of a moving part;
- means to stabilize the equipment;
- handles;
- mounting means;
- means to contain parts expelled during **explosion** or implosion.

The **supplementary safeguard** against mechanically-caused injury is a function of the specific energy source. **Supplementary safeguards** may include:

- **instructional safeguards**;
- instructions and training;
- additional **enclosures** or barriers;
- **safety interlocks**.

The **reinforced safeguard** against mechanically-caused injury is a function of the specific energy source. **Reinforced safeguards** may include:

- extra thick glass on the front of a CRT;
- rack slide-rails and means of support;
- **safety interlock**.

0.10 Thermally-caused injury (skin burn)

0.10.1 General

This subclause describes models for thermally-caused injury and models for reducing the likelihood of thermal energy capable of causing pain or injury being transferred to a body part.

0.10.2 Models for thermally-caused injury

Thermally-caused injury may occur when thermal energy capable of causing injury is transferred to a body part (see Figure 7).

Thermal energy transfer occurs when a body touches a hot equipment part. The extent of injury depends on the temperature difference, the thermal mass of the object, rate of thermal energy transfer to the skin, and duration of contact.

The requirements in this standard only address **safeguards** against thermal energy transfer by conduction. This standard does not address **safeguards** against thermal energy transfer by convection or radiation.

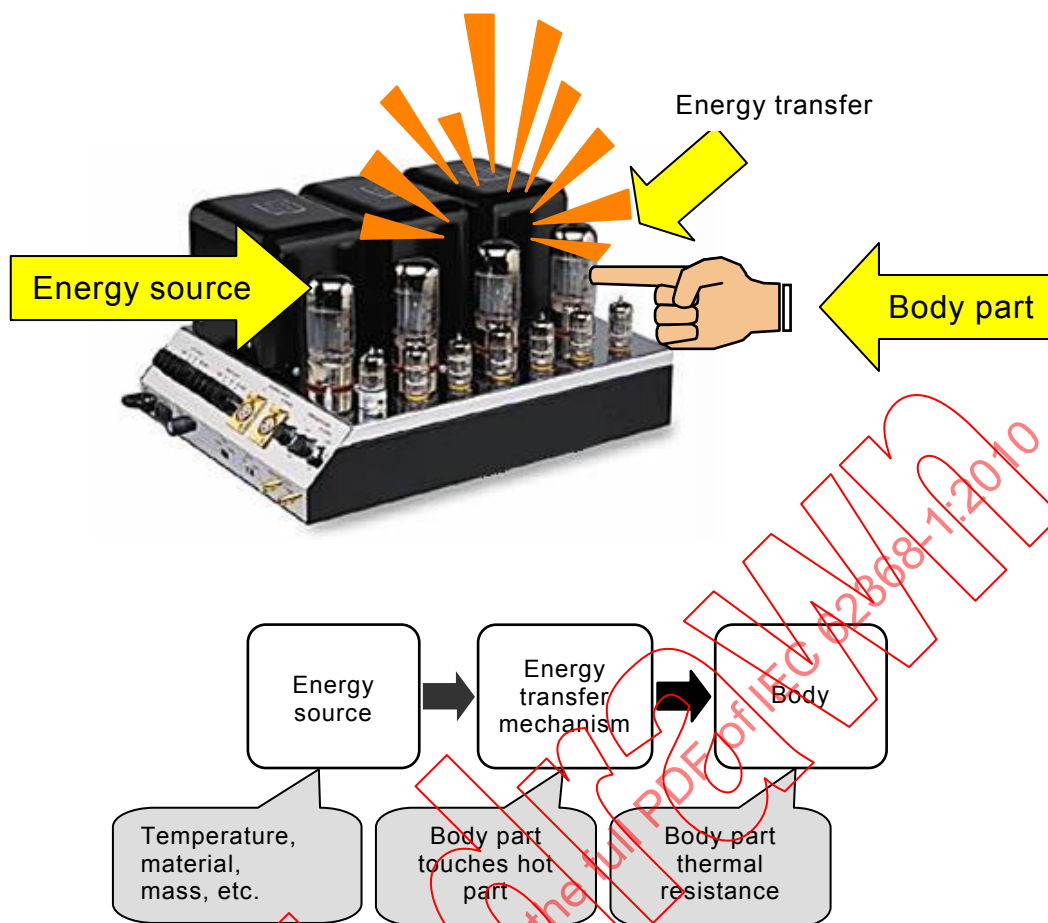


Figure 7 – Schematic and model for thermally-caused injury

Depending on the temperature, contact duration, material properties, and mass of the material, the perception of the human body varies from warmth to heat that may result in pain or injury (burn).

0.10.3 Models for protection against thermally-caused pain or injury

Protection against thermally-caused pain or injury requires that one or more **safeguards** be interposed between a thermal energy source capable of causing pain or injury and an **ordinary person** (see Figure 8).

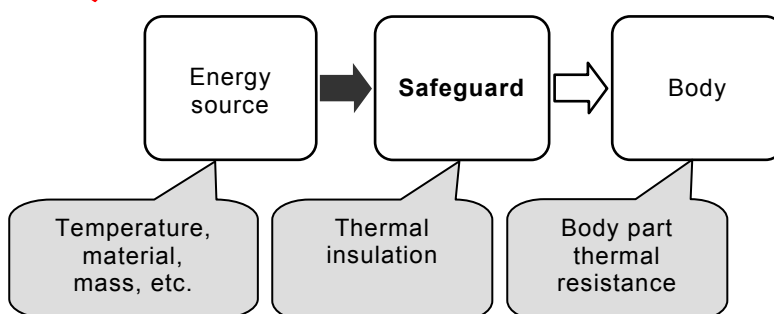


Figure 8 – Model for protection against thermally-caused injury

Protection against thermally-caused pain is required under **normal operating conditions** and **abnormal operating conditions**. Such protection requires that a **basic safeguard** be

interposed between a thermal energy source capable of causing pain and an **ordinary person**.

Protection against thermally-caused injury is required under **normal operating conditions**, **abnormal operating conditions** and **single fault conditions**. Such protection requires that a **basic safeguard** and a **supplementary safeguard** be interposed between a thermal energy source capable of causing injury and an **ordinary person**.

The **basic safeguard** against a thermal energy source capable of causing pain or injury is thermal insulation interposed between the energy source and a body part. In some cases, a **basic safeguard** against a thermal energy source capable of causing pain or injury may be an **instructional safeguard** identifying the hot parts and how to reduce the likelihood of injury. In some cases, a **basic safeguard** reduces the likelihood of a non-injurious thermal energy source from becoming a thermal energy source capable of causing pain or injury.

Examples of such **basic safeguards** are:

- control of electrical energy being converted to thermal energy (for example, a **thermostat**);
- heat sinking, etc.

The **supplementary safeguard** against a thermal energy source capable of causing injury is thermal insulation interposed between the energy source and a body part. In some cases, a **supplementary safeguard** against a thermal energy source capable of causing pain or injury may be an **instructional safeguard** identifying the hot parts and how to reduce the likelihood of injury.

0.11 Radiation-caused injury

This subclause describes models for reducing the likelihood of injury from exposure to radiated energy.

Radiation-caused injury within the scope of this standard is generally attributed to one of the following energy transfer mechanisms:

- heating of a body organ caused by exposure to non-ionising radiation, such as the highly localised energy of a laser impinging on the retina, or heating a larger volume such as the energy from a high frequency wireless, electromagnetic fields, or high frequency transmitter, or
- auditory injury caused by over stimulation of the ear by excessive peaks or sustained loud sound, leading to physical or nerve damage.

Radiated energy is transferred by impingement of wave emission upon a body part.

The **basic safeguard** against radiation-caused injury is containment of the energy within an **enclosure** that is opaque to the radiated energy.

The **basic safeguard** against auditory injury is the provision of warnings and information advising the user how to use the equipment correctly.

Examples of **basic safeguards** against auditory pain and injury are the provision of warnings and information advising the user how to use the equipment correctly. Examples of **supplementary safeguards** against auditory injury are the provision of a **safety interlock** or a soundproof **enclosure**.

There are several **supplementary safeguards** against radiation-caused injury. The **supplementary safeguards** may include **safety interlocks** to disconnect power to the generator, tamper-proof screws to prevent unauthorized access, etc.

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Withd2Mn

AUDIO/VIDEO, INFORMATION AND COMMUNICATION TECHNOLOGY EQUIPMENT –

Part 1: Safety requirements

1 Scope

This part of IEC 62368 is applicable to the safety of electrical and electronic equipment within the field of audio, video, information and communication technology, and business and office machines with a **rated voltage** not exceeding 600 V. This standard does not include requirements for performance or functional characteristics of equipment.

NOTE 1 Examples of equipment within the scope of this standard are given in Annex A.

This part of IEC 62368 is also applicable to components and subassemblies intended for incorporation in this equipment. Such components and subassemblies need not comply with every requirement of the standard, provided that the complete equipment, incorporating such components and subassemblies, does comply.

This standard specifies **safeguards** for **ordinary persons**, **instructed persons**, and **skilled persons**.

NOTE 2 In Australia, the work conducted by an **instructed person** or a **skilled person** may require formal licensing from regulatory authorities.

This standard assumes an altitude of 2 000 m unless specified otherwise by the manufacturer.

This standard does not apply to equipment to be used in wet areas. Additional requirements may apply.

This standard does not apply to equipment for outdoor installation.

NOTE 3 Information and communication technology equipment that is intended for use outdoors is covered by IEC 60950-22.

This standard does not include requirements for functional safety.

NOTE 4 For specific functional and software safety requirements of electronic safety-related systems (for example, protective electronic circuits), see IEC 61508-1.

This standard does not address:

- manufacturing processes except safety testing;
- injurious effects of gases released by thermal decomposition or combustion;
- disposal processes;
- effects of transport (other than as specified in this standard);
- effects of storage of materials, components, or the equipment itself;
- the likelihood of injury from particulate radiation such as alpha particles and beta particles;
- the likelihood of thermal injury due to radiated or convected thermal energy;
- the likelihood of injury due to flammable liquids;
- the use of the equipment in oxygen-enriched or **explosive** atmospheres;
- exposure to chemicals other than those specified in Clause 7;
- electrostatic discharge events.

2 Normative references

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.

IEC 60027-1, *Letter symbols to be used in electrical technology – Part 1: General*

IEC 60065, *Audio, video and similar electronic apparatus – Safety requirements*

IEC 60068-2-6, *Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal)*

IEC 60068-2-78, *Environmental testing – Part 2-78: Tests – Test Cab. Damp heat, steady state*

IEC 60079-10-1, *Explosive atmospheres – Part 10-1: Classification of areas – Explosive gas atmospheres*

IEC/TR 60083, *Plugs and socket-outlets for domestic and similar general use standardized in member countries of IEC*

IEC 60085, *Electrical insulation – Thermal evaluation and designation*

IEC 60086-4, *Primary batteries – Part 4: Safety of lithium batteries*

IEC 60107-1:1997, *Methods of measurement on receivers for television broadcast transmissions – Part 1: General considerations – Measurements at radio and video frequencies*

IEC 60112, *Method for the determination of the proof and the comparative tracking indices of solid insulating materials*

IEC 60127 (all parts), *Miniature fuses*

IEC 60127-1:2006, *Miniature fuses – Part 1: Definitions for miniature fuses and general requirements for miniature fuse-links*

IEC 60227-1:2007, *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V – Part 1: General requirements*

IEC 60227-7:2003, *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V – Part 7: Flexible cables screened and unscreened with two or more conductors*

IEC 60245-1:2003, *Rubber insulated cables – Rated voltages up to and including 450/750 V – Part 1: General requirements*

IEC 60309-1, *Plugs, socket-outlets and couplers for industrial purposes – Part 1: General requirements*

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 60320-1, *Appliance couplers for household and similar general purposes – Part 1: General requirements*

IEC 60320-2-2, *Appliance couplers for household and similar general purposes – Part 2-2: Interconnection couplers for household and similar equipment*

IEC 60332-1-2, *Tests on electric and optical fibre cables under fire conditions – Part 1-2: Test for vertical flame propagation for a single insulated wire or cable – Procedure for 1 kW pre-mixed flame*

IEC 60332-1-3, *Tests on electric and optical fibre cables under fire conditions – Part 1-3: Test for vertical flame propagation for a single insulated wire or cable – Procedure for determination of flaming droplets/particles*

IEC 60332-2-1, *Tests on electric and optical fibre cables under fire conditions – Part 2-1: Test for vertical flame propagation for a single small insulated wire or cable – Apparatus*

IEC 60332-2-2, *Tests on electric and optical fibre cables under fire conditions – Part 2-2: Test for vertical flame propagation for a single small insulated wire or cable – Procedure for diffusion flame*

IEC 60384-14:2005, *Fixed capacitors for use in electronic equipment – Part 14: Sectional specification: Fixed capacitors for electromagnetic interference suppression and connection to the supply mains*

IEC 60417, *Graphical symbols for use on equipment*

IEC 60505, *Evaluation and qualification of electrical insulation systems*

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

IEC 60664-1:2007, *Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests*

IEC 60664-3:2003, *Insulation coordination for equipment within low-voltage systems – Part 3: Use of coating, potting or moulding for protection against pollution*

IEC 60664-4:2005, *Insulation coordination for equipment within low-voltage systems – Part 4: Consideration of high-frequency voltage stress*

IEC 60691:2002, *Thermal-links – Requirements and application guide*

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 60695-11-5:2004, *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 60695-11-20:1999, *Fire hazard testing – Part 11-20: Test flames – 500 W flame test methods*

IEC/TS 60695-11-21, *Fire hazard testing – Part 11-21: Test flames – 500 W vertical flame test method for tubular polymeric materials*

IEC 60728-11:2005, *Cable networks for television signals, sound signals and interactive services – Part 11: Safety*

IEC 60730 (all parts), *Automatic electrical controls for household and similar use*

IEC 60730-1:1999, *Automatic electrical controls for household and similar use – Part 1: General requirements*

IEC 60738-1, *Thermistors – Directly heated positive temperature coefficient – Part 1: Generic specification*

IEC 60747-5-5:2007, *Semiconductor devices – Discrete devices – Part 5-5: Optoelectronic devices – Photocouplers*

IEC 60825 (all parts), *Safety of laser products*

IEC 60825-1:2007, *Safety of laser products – Part 1: Equipment classification and requirements*

IEC 60825-2:2004, *Safety of laser products – Part 2: Safety of optical fibre communication systems (OFCS)*

IEC 60825-12:2004, *Safety of laser products – Part 12: Safety of free space optical communication systems used for transmission of information*

IEC 60851-3:2009, *Winding wires – Test methods – Part 3: Mechanical properties*

IEC 60851-5:2008, *Winding wires – Test methods – Part 5: Electrical properties*

IEC 60851-6:1996, *Winding wires – Test methods – Part 6: Thermal properties*

IEC 60896-11, *Stationary lead-acid batteries – Part 11: Vented types – General requirements and methods of tests*

IEC 60896-21:2004, *Stationary lead-acid batteries – Part 21: Valve regulated types – Methods of test*

IEC 60896-22, *Stationary lead-acid batteries – Part 22: Valve regulated types – Requirements*

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, *Low-voltage switchgear and controlgear – Part 1: General rules*

IEC 60950-1:2005, *Information technology equipment – Safety – Part 1: General requirements*

IEC 60950-23, *Information technology equipment – Safety – Part 23: Large data storage equipment*

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 mm² up to 35 mm² (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 mm² up to 300 mm² (included)*

IEC 61051-2:1991, *Varistors for use in electronic equipment – Part 2: Sectional specification for surge suppression varistors*

IEC 61056-1, *General purpose lead-acid batteries (valve-regulated types) – Part 1: General requirements, functional characteristics – Methods of test*

IEC 61056-2, *General purpose lead-acid batteries (valve-regulated types) – Part 2: Dimensions, terminals and marking*

IEC 61058-1:2000, *Switches for appliances – Part 1: General requirements*

IEC 61140:2001, *Protection against electric shock – Common aspects for installation and equipment*

IEC/TS 61201:2007, *Use of conventional touch voltage limits – Application guide*

IEC 61204-7, *Low-voltage power supplies, d.c. output – Part 7: Safety requirements*

IEC 61293, *Marking of electrical equipment with ratings related to electrical supply – Safety requirements*

IEC 61427, *Secondary cells and batteries for photovoltaic energy systems (PVES) – General requirements and methods of test*

IEC/TS 61430, *Secondary cells and batteries – Test methods for checking the performance of devices designed for reducing explosion hazards – Lead-acid starter batteries*

IEC 61434, *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Guide to designation of current in alkaline secondary cell and battery standards*

IEC 61558-1:2005, *Safety of power transformers, power supplies, reactors and similar products – Part 1: General requirements and tests*

IEC 61558-2 (all parts), *Safety of power transformers, power supplies, reactors and similar products*

IEC 61810-1:2008, *Electromechanical elementary relays – Part 1: General requirements*

IEC 61959, *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Mechanical tests for sealed portable secondary cells and batteries*

IEC 61960, *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Secondary lithium cells and batteries for portable applications*

IEC 61965:2003, *Mechanical safety of cathode ray tubes*

IEC 61984, *Connectors - Safety requirements and tests*

IEC 62133, *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 62282-2, *Fuel cell technologies – Part 2: Fuel cell modules*

IEC/TS 62393, *Portable and hand-held multimedia equipment – Mobile computers – Battery run-time measurement*

IEC 62471:2006, *Photobiological safety of lamps and lamp systems*

IEC 62485-2, *Safety requirements for secondary batteries and battery installations – Part 2: Stationary batteries*¹

ISO 178, *Plastics – Determination of flexural properties*

ISO 179-1, *Plastics – Determination of Charpy impact properties – Part 1: Non-instrumented impact test*

ISO 180, *Plastics – Determination of Izod impact strength*

ISO 306, *Plastics – Thermoplastic materials – Determination of Vicat softening temperature (VST)*

ISO 527 (all parts), *Plastics – Determination of tensile properties*

ISO 871, *Plastics – Determination of ignition temperature using a hot-air furnace*

ISO 3864 (all parts), *Graphical symbols – Safety colours and safety signs*

ISO 3864-2, *Graphical symbols – Safety colours and safety signs – Part 2: Design principles for product safety labels*

ISO 4046-4:2002, *Paper, board, pulps and related terms – Vocabulary – Part 4: Paper and board grades and converted products*

ISO 4892-1, *Plastics – Methods of exposure to laboratory light sources – Part 1: General guidance*

ISO 4892-2:2006, *Plastics – Methods of exposure to laboratory light sources – Part 2: Xenon-arc lamps*

ISO 4892-4, *Plastics – Methods of exposure to laboratory light sources – Part 4: Open-flame carbon-arc lamps*

¹ To be published.

ISO 7000:2004, *Graphical symbols for use on equipment – Index and synopsis*

ISO 7010, *Graphical symbols – Safety colours and safety signs – Safety signs used in workplaces and public areas*

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*

3 Terms, definitions and abbreviations

3.1 General

This clause has been subdivided into “terms and abbreviations” and “definitions”. Where the words “voltage” and “current” are used, they are r.m.s. values unless otherwise specified.

3.2 Terms and abbreviations

3.2.1 Terms in alphabetical order

Term	Description	
ES	Electrical energy source	see 5.2
ES1	Electrical energy source class 1	
ES2	Electrical energy source class 2	
ES3	Electrical energy source class 3	
MS	Mechanical energy source	see 8.2
MS1	Mechanical energy source class 1	
MS2	Mechanical energy source class 2	
MS3	Mechanical energy source class 3	
PS	Power source	see 6.2
PS1	Power source class 1	
PS2	Power source class 2	
PS3	Power source class 3	
RS	Radiation energy source	see 10.2
RS1	Radiation energy source class 1	
RS2	Radiation energy source class 2	
RS3	Radiation energy source class 3	
TS	Thermal energy source	see 9.2
TS1	Thermal energy source class 1	
TS2	Thermal energy source class 2	
TS3	Thermal energy source class 3	

3.2.2 Abbreviations in alphabetical order

CD	Compact Disk
CD ROM	Compact Disc Read-Only Memory
CRT	Cathode RayTube
CTI	Comparative Tracking Index
DVD	Digital Versatile Disc
EIS	Electrical Insulation System
EUT	Equipment Under Test
IC	Integrated Circuits
LEL	Lower Explosion Limit
LFC	Liquid Filled Component
LPS	Limited Power Source
MOV	Metal Oxide Varistor
NiCd	Nickel Cadmium
PPE	Personal Protective Equipment
PTC	Positive Temperature Coefficient
Sb	Antimony
SPD	Surge Protection Devices
UPS	Uninterruptible Power Supply
VDR	Voltage Dependent Resistor
VRLA	Valve Regulated Lead Acid

3.3 Terms and definitions

For the purposes of this document the following terms and definitions apply. For the convenience of the user, the defined terms are listed below in alphabetical order by noun indicating the number of the defined term

accessible	3.3.6.1
area, restricted access	3.3.6.6
cheesecloth	3.3.6.2
chemical, hazardous	3.3.16.4
circuit, external	3.3.1.1
class, material flammability	3.3.4.2
clearance	3.3.12.1
condition, abnormal operating	3.3.7.1
condition, normal operating	3.3.7.4
condition, overload	3.3.7.5
condition, single fault	3.3.7.10
conductor, protective	3.3.11.9
conductor, protective bonding	3.3.11.8
conductor, protective earthing	3.3.11.10
construction, class II	3.3.15.2
cord, non-detachable power supply	3.3.6.4
current, protective conductor	3.3.14.6
current, maximum charging	3.3.14.3
current, rated	3.3.10.1
current, touch	3.3.6.10
cut-off, thermal	3.3.13.4
degree, pollution	3.3.6.5
device, disconnect	3.3.6.3
distance, creepage	3.3.12.2
enclosure	3.3.2.2

enclosure, electrical	3.3.2.1
enclosure, fire	3.3.2.3
enclosure, mechanical	3.3.2.4
equipment, class I	3.3.15.1
equipment, class II	3.3.15.3
equipment, class III	3.3.15.4
equipment, direct plug-in	3.3.3.1
equipment, hand-held	3.3.3.2
equipment, movable	3.3.3.3
equipment, permanently connected	3.3.3.4
equipment, personal protective (PPE)	3.3.16.5
equipment, pluggable, type A	3.3.3.5
equipment, pluggable, type B	3.3.3.6
equipment, stationary	3.3.3.7
equipment, transportable	3.3.3.8
explosion	3.3.16.2
explosive	3.3.16.3
frequency, peak response	3.3.7.6
frequency, rated	3.3.10.2
impedance, rated load	3.3.7.7
insulation, basic	3.3.5.1
insulation, double	3.3.5.2
insulation, functional	3.3.5.3
insulation, reinforced	3.3.5.4
insulation, solid	3.3.5.5
insulation, supplementary	3.3.5.6
interlock, safety	3.3.11.13
limiter, temperature	3.3.13.3
mains	3.3.1.2
material, 5VA class	3.3.4.2.1
material, 5VB class	3.3.4.2.2
material, combustible	3.3.4.1
material, consumable	3.3.16.1
material, HB40 class	3.3.4.2.3
material, HB75 class	3.3.4.2.4
material, HBF class foamed	3.3.4.2.5
material, HF-1 class foamed	3.3.4.2.6
material, HF-2 class foamed	3.3.4.2.7
material, V-0 class	3.3.4.2.8
material, V-1 class	3.3.4.2.9
material, V-2 class	3.3.4.2.10
material, VTM-0 class	3.3.4.2.11
material, VTM-1 class	3.3.4.2.12
material, VTM-2 class	3.3.4.2.13
misuse, reasonably foreseeable	3.3.7.8
operation, intermittent	3.3.7.2
operation, short-time	3.3.7.9
person, instructed	3.3.8.1
person, ordinary	3.3.8.2
person, skilled	3.3.8.3
PIS, arcing	3.3.9.2
PIS, resistive	3.3.9.3
power, non-clipped output	3.3.7.3
power, rated	3.3.10.3
range, rated voltage	3.3.10.5
rating, protective current	3.3.10.6
safeguard	3.3.11.12
safeguard, basic	3.3.11.1
safeguard, double	3.3.11.2
safeguard, equipment	3.3.11.3
safeguard, installation	3.3.11.4
safeguard, instructional	3.3.11.5

safeguard, personal	3.3.11.6
safeguard, precautionary	3.3.11.7
safeguard, reinforced	3.3.11.11
safeguard, skill	3.3.11.14
safeguard, supplementary	3.3.11.15
source, potential ignition (PIS)	3.3.9.1
temperature, highest charging	3.3.13.1
temperature, lowest charging	3.3.13.2
test, routine	3.3.6.7
test, sampling	3.3.6.8
test, type	3.3.6.11
thermostat	3.3.13.5
tissue, wrapping	3.3.6.12
tool	3.3.6.9
voltage, d.c.	3.3.14.1
voltage, mains transient	3.3.14.2
voltage, peak working	3.3.14.4
voltage, prospective touch	3.3.14.5
voltage, r.m.s. working	3.3.14.8
voltage, rated	3.3.10.4
voltage, required withstand	3.3.14.7
voltage, upper limit charging	3.3.14.9
voltage, working	3.3.14.10

3.3.1 Circuit terms

3.3.1.1

external circuit

electrical circuit that is external to the equipment and is not **mains**

NOTE An **external circuit** is classified as ES1, ES2 or ES3, and PS1, PS2, or PS3.

3.3.1.2

mains

a.c. or d.c. power distribution system (external to the equipment) that supplies operating power to the equipment and is PS3

NOTE **Mains** include public or private utilities and, unless otherwise specified in this standard, equivalent sources such as motor-driven generators and uninterruptible power supplies.

3.3.2 Enclosure terms

3.3.2.1

electrical enclosure

enclosure intended as a **safeguard** against electrically-caused injury

[IEV 195-06-13, modified]

3.3.2.2

enclosure

housing affording the type and degree of protection suitable for the intended application

[IEV 195-02-35]

NOTE The same **enclosure** may provide multiple types and degrees of protection for several intended applications such as for an **electrical enclosure**, a **fire enclosure** or a **mechanical enclosure**. Likewise, one part of an **enclosure** may provide one type and degree of protection for one intended application, and another part of the same **enclosure** may provide another type and degree of protection for another intended application.

3.3.2.3**fire enclosure**

enclosure intended as a **safeguard** against the spread of fire from within the **enclosure** to outside the **enclosure**

3.3.2.4**mechanical enclosure**

enclosure intended as a **safeguard** against mechanically-caused injury

3.3.3 Equipment terms**3.3.3.1****direct plug-in equipment**

equipment in which the **mains** plug forms an integral part of the equipment **enclosure**

3.3.3.2**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

3.3.3.3**movable equipment**

equipment that is either:

- 18 kg or less in mass and not fixed in place, or
- provided with wheels, casters, or other means to facilitate movement by an **ordinary person** as required to perform its intended use

3.3.3.4**permanently connected equipment**

equipment that can only be electrically connected to the **mains** by the use of a **tool**

3.3.3.5**pluggable equipment type A**

equipment that is intended for connection to the **mains** via a non-industrial plug and socket-outlet (IEC/TR 60083 or national equivalent) or via a non-industrial appliance coupler (IEC 60320-1), or both

3.3.3.6**pluggable equipment type B**

equipment that is intended for connection to the **mains** via an industrial plug and socket-outlet (IEC 60309-1, or national equivalent) or via an industrial appliance coupler (IEC 60320-1), or both

3.3.3.7**stationary equipment**

- fixed equipment, or
- **permanently connected equipment**, or
- equipment that, due to its physical characteristics, is normally not moved

NOTE **Stationary equipment** is neither **movable equipment** nor **transportable equipment**.

3.3.3.8**transportable equipment**

equipment that is intended to be routinely carried

NOTE Examples include notebook computers, CD players and portable accessories, including their external power supplies.

3.3.4 Flammability terms

3.3.4.1

combustible material

organic material, capable of combustion

NOTE 1 For the purpose of this standard, metal other than magnesium, or ceramic are examples of materials that are not capable of being combusted.

NOTE 2 All thermoplastic materials are considered capable of being combusted regardless of the **material flammability class**.

3.3.4.2

material flammability class

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

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

3.3.4.2.1

5VA class material

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

3.3.4.2.2

5VB class material

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

3.3.4.2.3

HB40 class material

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

3.3.4.2.4

HB75 class material

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

3.3.4.2.5

HBF class foamed material

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

3.3.4.2.6

HF-1 class foamed material

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

3.3.4.2.7

HF-2 class foamed material

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

3.3.4.2.8

V-0 class material

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

3.3.4.2.9**V-1 class material**

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

3.3.4.2.10**V-2 class material**

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

3.3.4.2.11**VTM-0 class material**

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

3.3.4.2.12**VTM-1 class material**

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

3.3.4.2.13**VTM-2 class material**

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

3.3.5 Insulation**3.3.5.1****basic insulation**

insulation to provide a **basic safeguard** against electric shock

[IEV 195-06-06, modified]

NOTE This concept does not apply to insulation used exclusively for functional purposes.

3.3.5.2**double insulation**

insulation comprising both **basic insulation** and **supplementary insulation**

[IEV 195-06-08]

3.3.5.3**functional insulation**

insulation between conductive parts which is necessary only for the proper functioning of the equipment

3.3.5.4**reinforced insulation**

single insulation system that provides a degree of protection against electric shock equivalent to **double insulation**

3.3.5.5**solid insulation**

solid insulating material interposed between two conductive parts or between a conductive part and a body part

[IEC 60664-1:2007, 3.4, modified]

3.3.5.6

supplementary insulation

independent insulation applied in addition to **basic insulation** to provide a **supplementary safeguard** for fault protection against electric shock

[IEV 195-06-07 modified]

3.3.6 Miscellaneous

3.3.6.1

accessible

touchable by a body part

NOTE A body part is represented by one or more of the probes specified in Annex V.

3.3.6.2

cheesecloth

bleached cotton cloth of approximately 40 g/m²

NOTE **Cheesecloth** is a coarse, loosely woven cotton gauze, originally used for wrapping cheese.

3.3.6.3

disconnect device

means to electrically disconnect equipment from the **mains** that, in the open position complies with the requirements specified for the isolating function

3.3.6.4

non-detachable power supply cord

flexible supply cord affixed to or assembled with the equipment and that cannot be removed without the use of **tools**

3.3.6.5

pollution degree

numeral characterising the expected pollution of the micro-environment

3.3.6.6

restricted access area

area **accessible** only to **skilled persons** and **instructed persons** with the proper authorization

[IEV 195-04-04 modified]

3.3.6.7

routine test

test to which each individual device is subjected during or after manufacture to ascertain whether it complies with certain criteria

[IEC 60664-1:2007, 3.19.2]

3.3.6.8

sampling test

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

[IEC 60664-1:2007, 3.19.3]

3.3.6.9

tool

an object that can be used to operate a screw, latch or similar fixing means

NOTE Examples of **tools** include coins, tableware, screwdrivers, pliers, etc.

3.3.6.10**touch current**

electric current through a human body when a body part touches two or more **accessible** parts or one **accessible** part and earth

3.3.6.11**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

3.3.6.12**wrapping tissue**

tissue between 12 g/m² and 30 g/m²

NOTE The **wrapping tissue** is soft, thin, usually translucent paper used for wrapping delicate articles.

[ISO 4046-4:2002, definition 4.215 modified]

3.3.7 Operating and fault conditions**3.3.7.1****abnormal operating condition**

temporary operating condition that is not a **normal operating condition** and is not a **single fault condition** of the equipment itself

NOTE 1 **Abnormal operating conditions** are specified in Clause B.3.

NOTE 2 An **abnormal operating condition** may be introduced by the equipment or by a person.

NOTE 3 An **abnormal operating condition** may result in a failure of a component, a device or a **safeguard**.

3.3.7.2**intermittent operation**

operation in a series of cycles, each composed of a period of operation followed by a period with the equipment switched off or running idle

3.3.7.3**non-clipped output power**

sine wave power dissipated in the **rated load impedance**, measured at 1 000 Hz at the onset of clipping on either one or both peaks

3.3.7.4**normal operating condition**

mode of operation that represents as closely as possible the most severe conditions of normal use that can reasonably be expected

NOTE Unless otherwise stated, the most severe conditions of normal use are the most unfavourable default values as specified in Clause B.2.

3.3.7.5**overload condition**

an **abnormal operating condition** or **single fault condition** where the load stresses the equipment or circuit beyond **normal operating conditions**, but does not, immediately, result in a non-operating state

3.3.7.6**peak response frequency**

test frequency that produces the maximum output power measured at the **rated load impedance**

NOTE The frequency applied should be within the amplifier/transducer's intended operating range.

3.3.7.7

rated load impedance

impedance or resistance, specified by the manufacturer, in the user instructions or marked on the equipment, by which an output circuit should be terminated

3.3.7.8

reasonably foreseeable misuse

use of a product, process or service in a way not intended by the supplier, but which may result from readily predictable human behaviour

[ISO/IEC Guide 51, definition 3.14]

3.3.7.9

short-time operation

operation under **normal operating conditions** for a specified period, starting when the equipment is cold, the intervals after each period of operation being sufficient to allow the equipment to cool down to room temperature

3.3.7.10

single fault condition

fault under **normal operating condition** of a single **safeguard** (but not a **reinforced safeguard**) or of a single component or a device

3.3.8 Persons

3.3.8.1

instructed person

person instructed or supervised by a **skilled person** as to energy sources and who can responsibly employ equipment and **precautionary safeguards** with respect to those energy sources

[IEV 826-18-02, modified]

NOTE Supervised, as used in the definition, means having the direction and oversight of the performance of others.

3.3.8.2

ordinary person

person who is neither a **skilled person** nor an **instructed person**

[IEV 826-18-03]

3.3.8.3

skilled person

person with relevant education or experience to enable him or her to avoid dangers and to reduce the likelihood of risks that may be created by the equipment

[IEV 826-18-01, modified]

3.3.9 Potential ignition sources

3.3.9.1

potential ignition source

PIS

location where electrical energy can cause ignition

3.3.9.2

arcing PIS

location where an arc may occur due to the opening of a conductor or a contact

NOTE 1 An electronic protection circuit or additional constructional measures may be used to prevent a location from becoming an **arcing PIS**.

NOTE 2 A faulty contact or interruption in an electric connection that may occur in conductive patterns on printed boards is considered to be within the scope of this definition.

3.3.9.3

resistive PIS

location where a component may ignite due to excessive power dissipation

3.3.10 Ratings

3.3.10.1

rated current

input current of the equipment as declared by the manufacturer at **normal operating conditions**

3.3.10.2

rated frequency

supply frequency or frequency range as declared by the manufacturer

3.3.10.3

rated power

input power of the equipment as declared by the manufacturer at **normal operating conditions**

3.3.10.4

rated voltage

value of voltage assigned by the manufacturer to a component, device or equipment and to which operation and performance characteristics are referred

[IEC 60664-1, definition 3.9]

NOTE 1 Equipment may have more than one **rated voltage** value or may have a **rated voltage range**.

NOTE 2 For three-phase supply, the phase-to-phase voltage applies.

3.3.10.5

rated voltage range

supply voltage range as declared by the manufacturer expressed by its lower and upper **rated voltages**

3.3.10.6

protective current rating

rating of an overcurrent protective device that is in the building installation or in the equipment to protect a circuit

3.3.11 Safeguards

3.3.11.1

basic safeguard

safeguard that provides protection under **normal operating conditions** and under **abnormal operating conditions** whenever an energy source capable of causing pain or injury is present in the equipment

3.3.11.2

double safeguard

safeguard comprising both a **basic safeguard** and a **supplementary safeguard**

3.3.11.3

equipment safeguard

safeguard that is a physical part of the equipment

3.3.11.4

installation safeguard

safeguard that is a physical part of a man-made installation

3.3.11.5

instructional safeguard

instruction invoking specified behaviour to avoid contact with or exposure to a class 2 or class 3 energy source (see 4.2)

3.3.11.6

personal safeguard

personal protective equipment that is worn on the body

3.3.11.7

precautionary safeguard

instructed person behaviour to avoid contact with or exposure to a class 2 energy source based on supervision or instructions given by a **skilled person**

3.3.11.8

protective bonding conductor

protective 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

3.3.11.9

protective conductor

conductor provided for the purposes of safety (for example, protection against electric shock)

[IEV 195-02-09]

NOTE A **protective conductor** is either a **protective earthing conductor** or a **protective bonding conductor**.

3.3.11.10

protective earthing conductor

protective conductor connecting a main protective earthing terminal in the equipment to an earth point in the building installation for protective earthing

[IEV 195-02-11, modified]

3.3.11.11

reinforced safeguard

single **safeguard** that is operational under:

- **normal operating conditions**,
- **abnormal operating conditions**, and
- **single fault conditions**

3.3.11.12

safeguard

physical part or system or instruction specifically provided to reduce the likelihood of pain or injury, or, for fire, to reduce the likelihood of ignition or spread of fire

NOTE See 0.5 for further explanation of a **safeguard**.

3.3.11.13**safety interlock**

means to automatically change an energy source to a lower class energy source prior to the potential for transfer of the higher energy to a body part

3.3.11.14**skill safeguard**

skilled person behaviour to avoid contact with or exposure to a class 2 or class 3 energy source based on education and experience

3.3.11.15**supplementary safeguard**

safeguard applied in addition to the **basic safeguard** that is or becomes operational in the event of failure of the **basic safeguard**

3.3.12 Spacings**3.3.12.1****clearance**

shortest distance in air between two conductive parts

[IEC 60664-1:2007, definition 3.2]

3.3.12.2**creepage distance**

shortest distance along the surface of an insulating material between two conductive parts

[IEC 60664-1:2007, definition 3.3, modified]

3.3.13 Temperatures and controls**3.3.13.1****highest charging temperature**

highest allowable temperature measured at the surface of a battery during the charging operation

3.3.13.2**lowest charging temperature**

lowest allowable temperature measured at the surface of a battery during the charging operation

3.3.13.3**temperature limiter**

device for limiting the temperature of a system, either below or above a particular value, by controlling, either directly or indirectly, the flow of thermal energy into or out of the system

NOTE A **temperature limiter** may be of the automatic reset or of the manual reset type.

3.3.13.4**thermal cut-off**

device for limiting the temperature of a system, under **single fault conditions**, by controlling, either directly or indirectly, the flow of thermal energy into or out of the system

NOTE A **thermal cut-off** may be one-time operation or manual reset type.

3.3.13.5**thermostat**

device for maintaining the temperature of a system within a range by controlling, either directly or indirectly, the flow of thermal energy into or out of the system

3.3.14 Voltages and currents

3.3.14.1

d.c. 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.

3.3.14.2

mains transient voltage

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

3.3.14.3

maximum charging current

upper limit of charging current per cell while the battery is charged

NOTE The maximum charging current may be defined for each standard charging temperature range, low charging temperature range and high charging temperature range.

3.3.14.4

peak working voltage

peak value of the **working voltage**, including any d.c. component and any repetitive peak impulses generated in the equipment

3.3.14.5

prospective touch voltage

voltage between simultaneously **accessible** conductive parts when those conductive parts are not being touched

3.3.14.6

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".

3.3.14.7

required withstand voltage

peak voltage that the insulation under consideration is required to withstand

3.3.14.8

r.m.s. working voltage

the true r.m.s. value of the **working voltage**

NOTE 1 True r.m.s. measurement includes any d.c. component of the waveform.

NOTE 2 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:

$$\text{r.m.s. value} = (A^2 + B^2)^{1/2}$$

3.3.14.9

upper limit charging voltage

maximum allowed voltage per cell while the battery is being charged, as specified by the manufacturer of the cell

NOTE A different value of the charging voltage upper limit may be defined for each standard charging temperature range, low charging temperature range and high charging temperature range.

3.3.14.10

working voltage

highest voltage across any particular insulation that can occur when the equipment is supplied at **rated voltage** or any voltage in the **rated voltage range** under **normal operating conditions**

[IEC 60664-1, definition 3.5, modified]

NOTE External transients are disregarded.

3.3.15 Classes of equipment with respect to protection from electric shock

3.3.15.1

class I equipment

equipment in which protection against electric shock does not rely on **basic insulation** only, but that includes a **supplementary safeguard** in such a way that means are provided for the connection of **accessible** conductive parts to the **protective earthing conductor** in the fixed wiring of the installation in such a way that **accessible** conductive parts cannot become live in the event of a failure of the **basic insulation**

NOTE For equipment intended for use with a flexible cord or cable, this provision includes a **protective conductor** as part of the flexible cord or cable.

3.3.15.2

class II construction

part of an equipment for which protection against electric shock relies upon **double insulation** or **reinforced insulation**

[IEC 60335-1, 3.3.11, modified]

3.3.15.3

class II equipment

equipment in which protection against electric shock does not rely on **basic insulation** only, but in which a **supplementary safeguard** is provided, there being no provision for protective earthing or reliance upon installation conditions

3.3.15.4

class III equipment

equipment in which protection against electric shock relies upon supply from ES1 and in which ES3 is not generated

[IEC 60950-1, 1.2.4.3, modified]

3.3.16 Chemical terms

3.3.16.1

consumable material

material that is used by the equipment in performing its intended function, and intended to be periodically or occasionally replaced or replenished, including any material that has a life expectancy less than that of the equipment

3.3.16.2

explosion

chemical reaction of any chemical compound or mechanical mixture that, when initiated, undergoes a very rapid combustion or decomposition, releasing large volumes of highly heated gases that exert pressure on the surrounding medium

NOTE **Explosion** can also be a mechanical reaction in which failure of the container causes sudden release of pressure, and the contents, from within a pressure vessel. Depending on the rate of energy release, an **explosion** can be categorized as a deflagration, a detonation or pressure rupture.

3.3.16.3

explosive

substance or mixture of substances that can undergo a rapid chemical change with or without an outside source of oxygen, generating large quantities of energy generally accompanied by hot gases

3.3.16.4

hazardous chemical

chemical, having a risk phase or equivalent as provided in the specifications for human health aspects, that can be in the form of a solid, powder, liquid or gas

NOTE Dust and other particulate materials can also be **hazardous chemicals** depending on their composition and potential for interaction with the human body.

3.3.16.5

personal protective equipment

PPE

personal **safeguard**, typically worn on the body, that reduces the known exposure of a person to a class 3 energy source

NOTE Examples of PPE include shields, goggles, gloves, aprons, face masks or breathing apparatus.

4 General requirements

4.1 General

4.1.1 **Application of requirements and acceptance of materials, components and subassemblies**

Requirements are specified in the relevant clauses and, where referenced in those clauses, in the relevant annexes.

Where compliance of materials, components or subassemblies is demonstrated by inspection, such compliance may be by review of published data or previous test results.

Components and subassemblies that comply with IEC 60950-1 or IEC 60065 are acceptable as part of 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.

NOTE This paragraph will be deleted in a future version of the standard. It is added here to allow a smooth transition from IEC 60950-1 and IEC 60065 to this standard.

4.1.2 **Use of components**

Unless stated otherwise, where the component or a characteristic of a component is a **safeguard**, components shall comply either with the requirements of this standard or with the safety aspects of the relevant IEC component standards.

NOTE 1 An IEC component standard is considered relevant only if the component in question clearly falls within its scope.

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 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 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 2 The applicable test for compliance with a component standard is, in general, conducted separately.

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

4.1.3 Equipment design and construction

Equipment shall be so designed and constructed that, under **normal operating conditions** (see Clause B.2), **abnormal operating conditions** (see Clause B.3), and **single fault conditions** (see Clause B.4), **safeguards** are provided to reduce the likelihood of injury or, in the case of fire, property damage.

NOTE Under **normal operating conditions**, the **safeguards** specified in this standard may or may not prevent pain, depending on the person and the operating condition of the equipment.

Parts of equipment that could cause injury shall not be **accessible**, and **accessible** parts shall not cause an injury.

For an **ordinary person** or an **instructed person**, the adjustment of a control shall not defeat an **equipment safeguard**.

Compliance is checked by inspection and by the relevant tests.

4.1.4 Equipment installation

The equipment evaluation according to this standard shall take into account manufacturers' instructions with regard to installation, relocation, servicing and operation, as applicable.

4.1.5 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 **safeguards** 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.

4.1.6 Orientation during transport and use

Where it is clear that the orientation of use of equipment is likely to have a significant effect on the application of the requirements or the results of tests, all orientations of use specified in the installation or user instructions shall be taken into account. In addition, for **transportable equipment**, all orientations of transport shall be taken into account.

4.1.7 Choice of criteria

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

4.1.8 Conductive liquids

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

4.1.9 Electrical measuring instruments

Electrical measuring instruments shall have adequate bandwidth to provide accurate readings, taking into account all components (d.c., **mains** frequency, high frequency and harmonic content) of the parameter being measured.

If an r.m.s. value is measured, care shall be taken that the measuring instrument gives a true r.m.s. reading of non-sinusoidal waveforms as well as sinusoidal waveforms.

Measurements are made with a meter whose input impedance has minimum influence on the measurement.

4.1.10 Temperature measurements

Unless stated otherwise, where the result of a test is likely to depend upon the ambient temperature, the manufacturer's specified ambient temperature range of the equipment (T_{ma}) shall be taken into account. When performing the test at a specific ambient (T_{amb}), extrapolation (above and below) the results of the test may be used to consider the impact of T_{ma} on the result. Components and subassemblies may be considered separately from the equipment if the test results and extrapolation is representative of the whole equipment being so tested. Relevant test data and manufacturer's specifications may be examined in order to determine the effect of temperature variability on a component or subassembly (see B.1.7).

4.1.11 Steady state conditions

Steady state conditions are those conditions when thermal equilibrium is considered to exist (see B.1.7).

4.1.12 Hierarchy of safeguards

Safeguards that are required for **ordinary persons** are acceptable, but may not be required, for **instructed persons** and **skilled persons**. Likewise, **safeguards** that are required for **instructed persons** are acceptable, but may not be required, for **skilled persons**.

A **reinforced safeguard** may be used in place of a **basic safeguard** or a **supplementary safeguard** or a **double safeguard**. A **double safeguard** may be used in place of a **reinforced safeguard**.

Safeguards other than **equipment safeguards** may be specified in specific clauses (for example, see 8.4.1, 8.5.1 and Table 42).

4.1.13 Examples mentioned in the standard

Where examples are given in this standard, other examples, situations, and solutions are not excluded.

4.1.14 Tests on parts or samples separate from the end-product

If a test is conducted on a part or sample separate from the end-product, the test shall be conducted as if the part or sample was in the end-product.

4.1.15 Markings and instructions

Equipment that is required by this standard to

- bear markings, or
- be provided with instructions, or
- be provided with **instructional safeguards**

shall meet the relevant requirements of Annex F.

NOTE In Finland, Norway and Sweden, **class I pluggable equipment type A** intended for connection to other equipment or a network shall, if safety relies on connection to reliable earthing 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.

4.2 Energy source classifications

4.2.1 Class 1 energy source

Unless otherwise specified, a class 1 source is an energy source with levels not exceeding class 1 limits under

- **normal operating conditions** and
- **abnormal operating conditions** that do not lead to a **single fault condition**,

and not exceeding class 2 limits under **single fault conditions**.

Under **normal operating conditions** and **abnormal operating conditions**, the energy in a class 1 source, in contact with a body part, may be detectable, but is not painful nor is it likely to cause an injury. For fire, the energy in a class 1 source is not likely to cause ignition.

Under **single fault conditions**, a class 1 energy source, under contact with a body part, may be painful, but is not likely to cause injury.

4.2.2 Class 2 energy source

Unless otherwise specified, a class 2 source is an energy source with levels exceeding class 1 limits and not exceeding class 2 limits under **normal operating conditions**, **abnormal operating conditions**, or **single fault conditions**. The energy in a class 2 source, under contact with a body part, may be painful, but is not likely to cause an injury. For fire, the energy in a class 2 source can cause ignition under some conditions.

4.2.3 Class 3 energy source

A class 3 source is an energy source with levels exceeding class 2 limits under **normal operating conditions**, **abnormal operating conditions**, or **single fault conditions**, or any energy source declared to be a class 3 source. The energy in a class 3 source, under contact with a body part, is capable of causing injury. For fire, the energy in a class 3 source may cause ignition and the spread of flame where fuel is available.

4.2.4 Energy source classification by declaration

The manufacturer may declare a class 1 energy source to be either a class 2 energy source or a class 3 energy source.

The manufacturer may declare a class 2 energy source to be a class 3 energy source.

Safeguards shall be applied according to the declared class.

A neutral conductor is declared a class 3 electrical energy source.

A **protective conductor** is a class 1 electrical energy source and cannot be declared a higher class energy source.

4.3 Protection against energy sources

4.3.1 General

This subclause specifies protection requirements for **ordinary persons**, **instructed persons**, and **skilled persons**.

The terms "persons", "body", and "body parts" are represented by the accessibility probes of Annex V.

4.3.2 Safeguards for protection of an ordinary person

4.3.2.1 Safeguards between a class 1 energy source and an ordinary person

No **safeguards** need be interposed between a class 1 energy source and an **ordinary person** (see Figure 9). Consequently, a class 1 energy source may be **accessible** to an **ordinary person**.

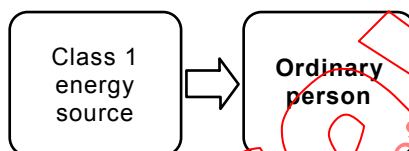


Figure 9 – Model for protection of an ordinary person against a class 1 energy source

4.3.2.2 Safeguards between a class 2 energy source and an ordinary person

During **normal operating conditions** at least one **basic safeguard** shall be interposed between a class 2 energy source and an **ordinary person** (see Figure 10).



Figure 10 – Model for protection of an ordinary person against a class 2 energy source

4.3.2.3 Safeguards between a class 2 energy source and an ordinary person during ordinary person servicing conditions

If **ordinary person** servicing conditions require a **basic safeguard** to be removed or defeated, an **instructional safeguard** as described in Clause F.5 shall be provided and located in such a way that an **ordinary person** will see the instruction prior to removing or defeating the equipment **basic safeguard** (see Figure 11).

The **instructional safeguard** (see Clause F.5) shall include all of the following:

- identify parts and locations of the class 2 energy source;
- specify actions that will protect persons from that energy source; and
- specify actions to reinstate or restore the **basic safeguard**.

If **ordinary person** servicing conditions require a **basic safeguard** to be removed or defeated, and where the equipment is intended for use in the home, an **instructional safeguard** (see Clause F.5), directed towards adults, shall warn against removing or defeating the **basic safeguard** by children.

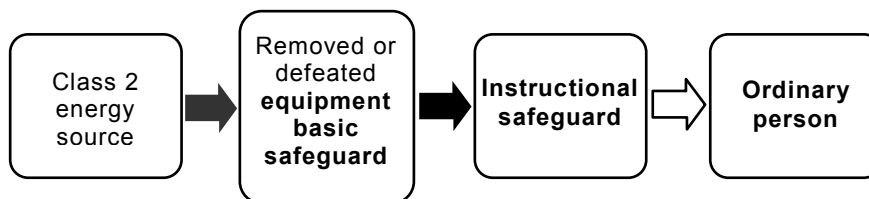


Figure 11 – Model for protection of an ordinary person against a class 2 energy source during ordinary person servicing conditions

4.3.2.4 Safeguards between a class 3 energy source and an ordinary person

An **equipment basic safeguard** and an **equipment supplementary safeguard** (double safeguard) or an **equipment reinforced safeguard** shall be interposed between a class 3 energy source and an **ordinary person** (see Figure 12).

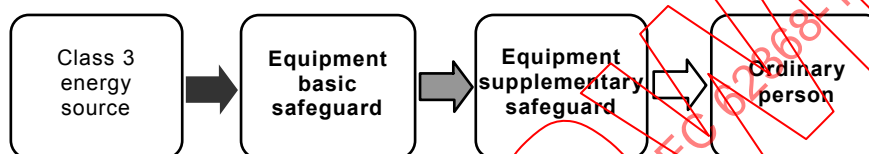


Figure 12 – Model for protection of an ordinary person against a class 3 energy source

4.3.3 Protection of an instructed person

4.3.3.1 Safeguards between a class 1 energy source and an instructed person

No **safeguards** need be interposed between a class 1 energy source and an **instructed person**. Consequently, a class 1 energy source may be **accessible** to an **instructed person** (see Figure 13).

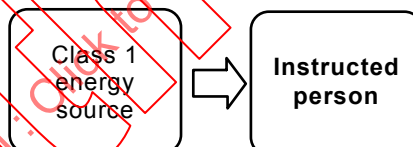


Figure 13 – Model for protection of an instructed person against a class 1 energy source

4.3.3.2 Safeguards between a class 2 energy source and an instructed person

During **instructed person** servicing, the **equipment safeguards** against a class 2 energy source may be removed or defeated. In this case, an **instructed person** is presumed to use precaution as a **safeguard** against a class 2 energy source (see Figure 14).



Figure 14 – Model for protection of an instructed person against a class 2 energy source

4.3.3.3 Safeguards between a class 3 energy source and an instructed person

An **equipment basic safeguard** and an **equipment supplementary safeguard** (double safeguard) or a **reinforced safeguard** shall be interposed between a class 3 energy source and an **instructed person** (see Figure 15).

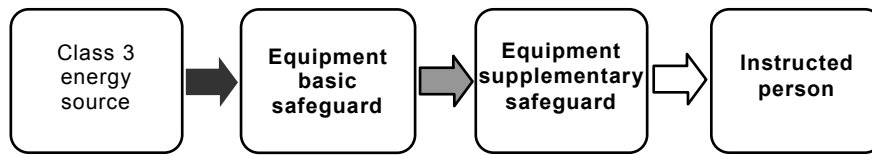


Figure 15 – Model for protection of an instructed person against a class 3 energy source

4.3.4 Protection of a skilled person

4.3.4.1 Safeguards between a class 1 energy source and a skilled person

No **safeguard** need be interposed between a class 1 energy source and a **skilled person** (see Figure 16).

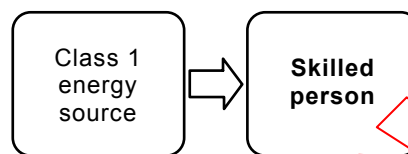


Figure 16 – Model for protection of a skilled person against a class 1 energy source

4.3.4.2 Safeguards between a class 2 energy source and a skilled person

During **skilled person** servicing, the **equipment safeguards** against a class 2 energy source may be removed or defeated. In this case, a **skilled person** is presumed to use skill as a **safeguard** against a class 2 energy source (see Figure 17).



Figure 17 – Model for protection of a skilled person against a class 2 energy source

4.3.4.3 Safeguards between a class 3 energy source and a skilled person

During **skilled person** servicing, the **equipment safeguards** against a class 3 energy source may be removed or defeated. In this case, a **skilled person** is presumed to use skill as a **safeguard** against a class 3 energy source (see Figure 18).



Figure 18 – Model for protection of a skilled person against a class 3 energy source

4.3.4.4 Safeguards between class 3 energy sources and a skilled person during equipment servicing conditions

During equipment servicing conditions on a class 3 energy source, an **equipment safeguard** intended to reduce the likelihood of injury due to an involuntary reaction shall be interposed between:

- another class 3 energy source, not undergoing service and in the same vicinity as the class 3 energy source being serviced; and
- a **skilled person** (see 0.5.7 and Figure 19).



Figure 19 – Model for protection of a skilled person against class 3 energy sources during equipment servicing conditions

4.3.5 Safeguards in a restricted access area

Certain equipment is intended for installation exclusively in **restricted access areas**. Such equipment shall have **safeguards** as required in 4.3.3 for **instructed persons** and 4.3.4 for **skilled persons**.

4.4 Safeguards

4.4.1 General

This subclause specifies composition, accessibility and robustness requirements for **safeguards**.

4.4.2 Equivalent materials or components

Where the standard specifies a particular **safeguard** parameter, such as thermal class of insulation or **material flammability class**, a **safeguard** with a better parameter may be employed.

NOTE For a hierarchy of the **material flammability classes** see Table S.1, Table S.2 and Table S.3.

4.4.3 Composition of a safeguard

A **safeguard** may be comprised of a single element, or may be comprised of two or more elements.

4.4.4 Accessible parts of a safeguard

4.4.4.1 General

Where a solid **safeguard** is **accessible** to an **ordinary person** or to an **instructed person**, only the side of the **safeguard** opposite to the energy source may be **accessible**.

Requirements for **basic safeguards** and **supplementary safeguards**, if they are elements of **double safeguards**, may be interchanged.

4.4.4.2 Accessible parts of a basic safeguard

With respect to a class 2 energy source, the side of the **basic safeguard** opposite to the energy source may be **accessible** to an **ordinary person** (see Figure 20).

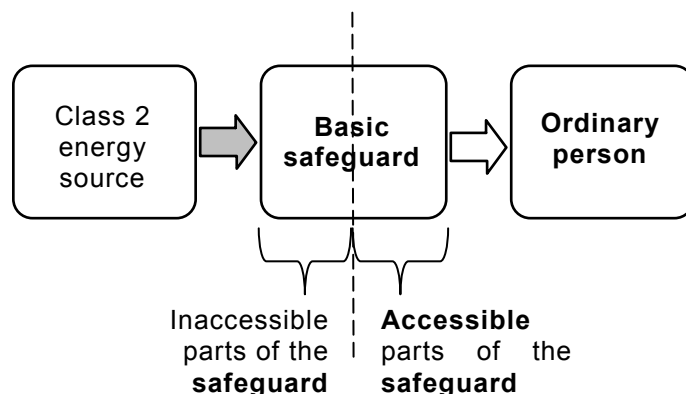


Figure 20 – Illustration of accessible and inaccessible parts of a basic safeguard

4.4.4.3 Accessible parts of supplementary and reinforced safeguards

With respect to a class 3 energy source, the side of the **supplementary safeguard** opposite to the energy source may be **accessible** to an **ordinary person** or an **instructed person**; however, the **basic safeguard** shall not be **accessible** to an **ordinary person** or to an **instructed person** (see Figure 21).

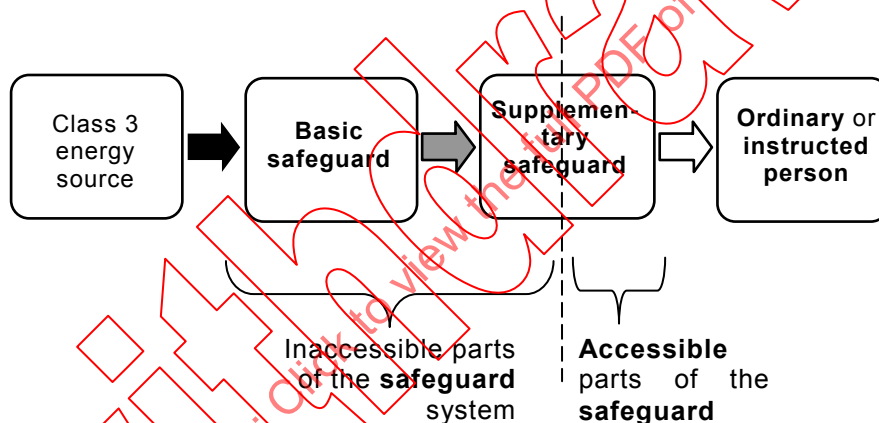


Figure 21 – Illustration of accessible and inaccessible parts of a supplementary safeguard

With respect to a class 3 energy source, the side of the **reinforced safeguard** opposite to the energy source may be **accessible** to an **ordinary person** or an **instructed person** (see Figure 22).

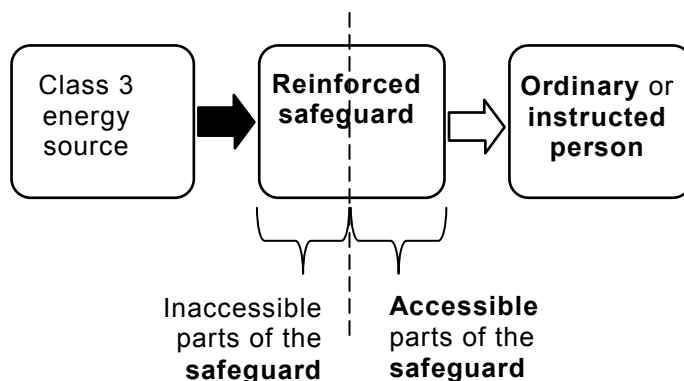


Figure 22 – Illustration of accessible and inaccessible parts of a reinforced safeguard

4.4.5 Safeguard robustness

Where a solid **safeguard** (for example, **solid insulation**, earthed metal, etc.) is **accessible** to an **ordinary person** or to an **instructed person**, the **safeguard** shall comply with the mechanical strength test specified in Annex T for that **safeguard**, as applicable.

A solid **safeguard** that has no **accessible** parts need not comply with the mechanical strength test provided that an **accessible** barrier or **enclosure** that prevents access to the **safeguard** by an **ordinary person** or by an **instructed person** complies with the mechanical strength test specified in Annex T for that **safeguard**.

If a **safeguard** is of thermoplastic material, the **safeguard** shall be so constructed that any shrinkage or distortion of the material due to release of internal stresses shall not defeat its **safeguard** function. See Clause T.8 for stress relief conditioning, and Annex V for determination of accessibility.

Other mechanical strength tests are specified in the various clauses.

4.4.6 Air comprising a safeguard

Where a **safeguard** is comprised of air (for example, a **clearance**), a barrier or **enclosure** shall prevent displacement of the air by a body part or a conductive part. The barrier shall comply with the mechanical strength test specified in Annex T, as applicable.

4.5 Explosion

4.5.1 General

Explosion can be caused by

- chemical reaction,
- mechanical deformation of a sealed container,
- rapid combustion or decomposition, producing a large volume of hot gas,
- high pressure,
- high temperature.

NOTE 1 Depending on the energy rate, **explosion** can be categorized as a deflagration, a detonation, or pressure rupture.

NOTE 2 An ultracapacitor (for example, a double layer capacitor) is a high energy source and can explode following overcharging and high temperature.

For requirements regarding **explosion** of batteries, see Annex M.

4.5.2 Requirements

During **normal operating conditions** and **abnormal operating conditions**, an **explosion** shall not occur.

During **single fault conditions**, the equipment shall comply with the relevant parts of Clause 6 and Clause 8.

4.5.3 Compliance

Compliance is checked by inspection and tests as specified in Clauses B.2, B.3 and B.4.

5 Electrically-caused injury

5.1 General

To reduce the likelihood of painful effects and injury due to electric current passing through the human body, equipment shall be provided with the **safeguards** specified in this clause.

5.2 Classification and limits of electrical energy sources

5.2.1 Electrical energy source classifications

5.2.1.1 ES1

ES1 is a class 1 electrical energy source with levels not exceeding ES1 limits under

- **normal operating conditions**, and
- **abnormal operating conditions** that do not lead to a **single fault condition**,

and not exceeding ES2 limits under **single fault conditions**.

NOTE ES1 may be **accessible** to an **ordinary person**.

5.2.1.2 ES2

ES2 is a class 2 electrical energy source with levels not exceeding ES2 limits under

- **normal operating conditions**,
- **abnormal operating conditions**, and
- **single fault conditions**,

but is not ES1.

NOTE ES2 may be **accessible** to an **instructed person**.

5.2.1.3 ES3

ES3 is a class 3 electrical energy source with levels exceeding ES2 limits under **normal operating conditions**, **abnormal operating conditions** or **single fault conditions**.

NOTE 1 The energy in ES3 may cause harmful physiological effects under contact with a body part.

NOTE 2 Parts and circuits classed ES3 may be **accessible** to a **skilled person**.

All current-carrying conductors of an a.c. **mains** circuit, including the neutral, are declared ES3.

Conductive parts may be classed ES3 without measurement or evaluation.

5.2.2 ES1, ES2 and ES3 limits

5.2.2.1 General

This subclause specifies the parameters and their magnitudes for electrical energy sources ES1, ES2 and ES3.

The limits specified in this subclause are with respect to earth or with respect to an **accessible** part.

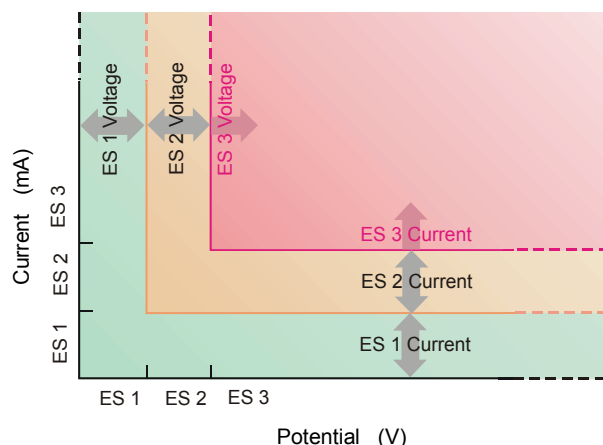


Figure 23 – Illustration that shows that ES limits depend on both voltage and current

As illustrated in Figure 23, for ES1 and ES2, for any voltage up to the limit voltage, there is no limit for the current. Likewise for any current up to the limit current, there is no limit for the voltage. However, for ES1 and ES2, in no case can both the current limit and the voltage limit be exceeded. ES2 is an energy source where both the voltage and current exceed the limits for ES1, but do not exceed the limits for ES2. ES3 is any source where both the voltage limit and current limit exceed ES2. Voltage limits in this figure do not apply to charged capacitors (see 5.2.2.3).

5.2.2.2 Steady-state voltage and current limits

An electrical energy source class is determined from both the available voltage and the available current (see Table 4, Table 5 and Table 6).

The values are the maximum that can be delivered by the source for 2 s or more. Currents are measured according to 5.7.

NOTE The current limits are derived from IEC/TS 60479-1:2005:

- d.c. limits are from Figure 22;
- a.c. limits are from Figure 20.

Table 4 – Electrical energy source limits for d.c. and low frequency a.c. currents

Energy source	ES1 limit	ES2 limit	ES3
DC	2 mA	25 mA	Greater than ES2 limit
AC up to 1 kHz	0,5 mA r.m.s. 0,707 mA peak	5 mA r.m.s. 7,07 mA peak	
Combined a.c. and d.c.	$\frac{I_{dc} \text{ mA}}{2} + \frac{I_{ac} \text{ mA r.m.s.}}{0,5} \leq 1$ $\frac{I_{dc} \text{ mA}}{2} + \frac{I_{ac} \text{ mA peak}}{0,707} \leq 1$	See Figure 24	
Peak values are to be used for non-sinusoidal current. The current limits are derived from IEC 60479-1 for dry conditions.			

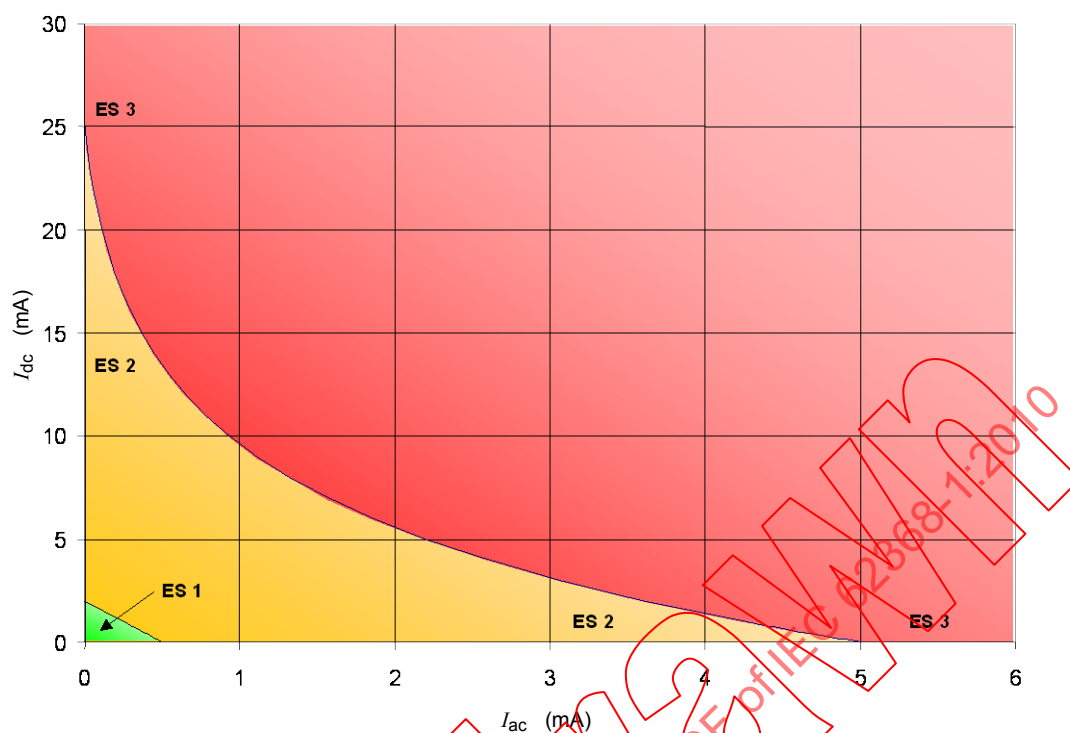


Figure 24 – Maximum values for combined a.c. current and d.c. current

The ES2 limit curve is based on the following formula:

$$5,104 \times e^{(-0,16 \times I_{dc})} - 0,097 \geq I_{ac}$$

where

I_{ac} is the measured a.c. current within the range of 0 mA to 5 mA;

I_{dc} is the measured d.c. current within the range of 0 mA to 25 mA.

Table 5 – Electrical energy source limits for d.c. and low frequency a.c. voltages

Energy source	ES1 limit	ES2 limit	ES3
DC	60 V	120 V	Greater than ES2 limit
AC up to 1 kHz	30 V r.m.s. 42,4 V peak	50 V r.m.s. 70,7 V peak	
Combined a.c. voltage and d.c. voltage	$\frac{U_{dc} \text{ V}}{60} + \frac{U_{ac} \text{ V r.m.s.}}{30} \leq 1$	See Figure 25	
Peak values are to be used for non-sinusoidal voltage. The voltage limits are derived from IEC/TS 61201:2007 for dry conditions.			

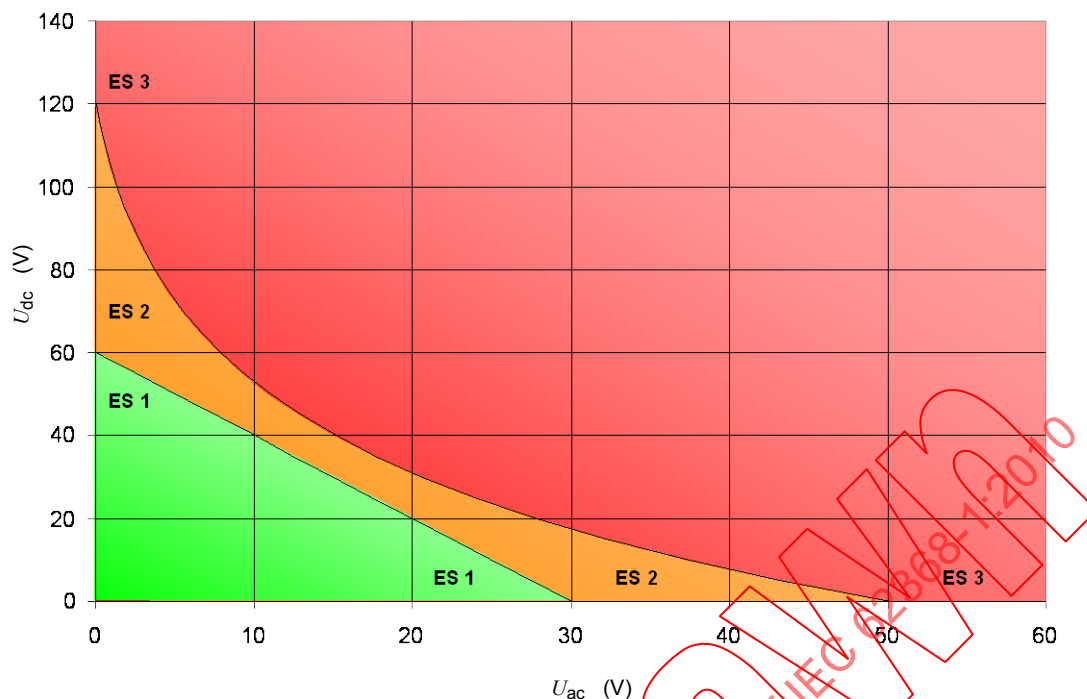


Figure 25 – Maximum values for combined a.c. voltage and d.c. voltage

The ES2 limit curve is based on the following formula:

$$51,746 \times e^{(-0,028 \times U_{dc})} - 1,746 \geq U_{ac}$$

where

U_{ac} is the measured a.c. voltage within the range of 0 V to 50 V r.m.s.

U_{dc} is the measured d.c. voltage within the range of 0 V to 120 V.

Table 6 – Electrical energy source limits for medium and high frequency voltage and current

Energy source		ES1 limit	ES2 limit	ES3
1 kHz up to 100 kHz	Voltage	$30 \text{ V r.m.s.} + 0,4 \times f$	$50 \text{ V r.m.s.} + 0,9 \times f$	Greater than ES2 limit
	Current	$0,5 \text{ mA r.m.s.} \times f$	$5 \text{ mA r.m.s.} + 0,95 \times f$	
Above 100 kHz	Voltage	70 V r.m.s.	140 V r.m.s.	
	Current	50 mA r.m.s.	100 mA r.m.s.	
For non-sinusoidal waveforms and for signals having multiple frequencies, use Figure 4 or 5 of IEC 60990:1999 as applicable to measure the value of the current.				
f is in kHz.				

5.2.2.3 Capacitance limits

Where the electrical energy source is a capacitor, the energy source is classified from both the charge voltage and the capacitance.

The capacitance is the rated value of the capacitor plus the specified tolerance.

The ES1 and ES2 limits for various capacitance values are listed in Table 7.

NOTE 1 The capacitance values for ES2 are derived from Table 2 of IEC/TS 61201:2007.

NOTE 2 The values for ES1 are calculated by dividing the values from Table 2 of IEC/TS 61201:2007, by two (2).

Table 7 – Electrical energy source limits for a charged capacitor

C nF	ES1 U_{peak} V	ES2 U_{peak} V
300 or greater	60	120
170	75	150
91	100	200
61	125	250
41	150	300
28	200	400
18	250	500
12	350	700
8,0	500	1 000
4,0	1 000	2 000
1,6	2 500	5 000
0,8	5 000	10 000
0,4	10 000	20 000
0,2	20 000	40 000
0,133 or less	25 000	50 000
Linear interpolation may be used between the nearest two points.		

5.2.2.4 Single pulse limits

Where the electrical energy source is a single pulse, the energy source is classified from both the voltage and the duration or from both the current and the duration. Values are given in Table 8 and Table 9. If the voltage exceeds the limit, then the current shall not exceed the limit. If the current exceeds the limit, the voltage shall not exceed the limit. Currents are measured according to 5.7. For repetitive pulses, see 5.2.2.5.

For pulse durations up to 10 ms, the voltage or current limit for 10 ms applies.

NOTE 1 The pulse limits are calculated from IEC/TS 60479-1:2005, Figure 22 and Table 10.

NOTE 2 These single pulses do not include transients.

NOTE 3 Pulse duration is considered to be the time duration when the voltage or current exceeds ES1 limits.

Table 8 – Voltage limits for single pulses

Pulse duration up to and including ms	Electrical energy source level	
	ES1 U_{peak} V	ES2 U_{peak} V
10	60	196
20		178
50		150
80		135
100		129
200		117
300		110
400		102
500		98
600		97
700		96
800		94
900		93
1 000		89
2 000	80	
If the time duration lies between the values in any two rows, the ES2 value of the U_{peak} in the row below shall be used or a logarithmic interpolation may be used between any two adjacent rows with the calculated value rounded down to the nearest millisecond.		

Table 9 – Current limits for single pulses

Pulse duration up to and including ms	Electrical energy source level	
	ES1 I_{peak} mA	ES2 I_{peak} mA
10	2	200
20	2	153
50	2	107
100	2	81
200	2	62
500	2	43
1 000	2	33
2 000	2	25
If the time duration lies between the values in any two rows, the ES2 value of the I_{peak} in the row below shall be used or a logarithmic interpolation may be used between any two adjacent rows with the calculated value rounded down to the nearest millisecond.		

5.2.2.5 Limits for repetitive pulses

Except for pulses covered in Annex H, a repetitive pulse electrical energy source class is determined from either the available voltage or the available current (see Table 10). If the

voltage exceeds the limit, then the current shall not exceed the limit. If the current exceeds the limit, the voltage shall not exceed the limit. Currents are measured according to 5.7.

The voltage is the maximum that can be delivered by the source into any resistive load not exceeding 1 MΩ.

The current is the maximum that can be delivered by the source for any one pulse into any resistive load.

Table 10 – Electrical energy source limits for repetitive pulses

Pulse off time		ES1	ES2	ES3
Less than 3 s	Current	0,707 mA peak	7,07mA peak	Greater than ES2 limit
	Voltage	42,4 V peak	70,7 V peak	
3 s or more	Current	2 mA peak	See Table 9	
	Voltage	60 V peak	See Table 8	

5.2.2.6 Ringing signals

Where the electrical energy source is an analogue telephone network ringing signal as defined in Annex H, the energy source class is considered ES2.

5.2.2.7 Audio signals

For electrical energy sources comprised of audio signals, see Clause E.1 f).

5.3 Protection against electrical energy sources

5.3.1 General

This subclause specifies protection requirements for parts **accessible** to **ordinary persons**, **instructed persons**, and **skilled persons**. See 5.3.6 for accessibility and Table 11 for an overview.

Table 11 – Overview on safeguard requirements (persons)

Person	Required number of equipment safeguards interposed between an electrical energy source and persons		
	ES1	ES2	ES3
Ordinary person	0	1	2
Instructed person	0	0	2
Skilled person	0	0	0 or 1 ^a
^a See 4.3.4.4.			

5.3.2 Protection of an ordinary person

5.3.2.1 Safeguards between ES1 and an ordinary person

No **safeguards** need be interposed between ES1 and an **ordinary person**.

5.3.2.2 Safeguards between ES2 and an ordinary person

At least one **safeguard** shall be interposed between ES2 and an **ordinary person** (see Figure 10 and Figure 11).

5.3.2.3 Safeguards between ES3 and an ordinary person

Unless otherwise specified, at least one **equipment basic safeguard** and one **equipment supplementary safeguard (double safeguard)** or a **reinforced safeguard** shall be interposed between ES3 and an **ordinary person** (see Figure 12).

5.3.3 Protection of an instructed person

5.3.3.1 Safeguards between ES1 or ES2 and an instructed person

No **safeguards** need to be interposed between ES1 or ES2 and an **instructed person** (see Figure 14).

5.3.3.2 Safeguards between ES3 and an instructed person

Unless otherwise specified, at least one **equipment basic safeguard** and one **equipment supplementary safeguard (double safeguard)** or a **reinforced safeguard** shall be interposed between ES3 and an **instructed person** (see Figure 15).

5.3.4 Protection of a skilled person

5.3.4.1 Safeguards between ES1 or ES2 and a skilled person

No **safeguards** need to be interposed between ES1 or ES2 and a **skilled person** (see Figure 16 and Figure 17).

5.3.4.2 Safeguards between ES3 and a skilled person

Bare conductors at ES3 shall be located or guarded so that unintentional contact with such conductors during service operations is unlikely (see Figure 18 and Figure 19).

5.3.5 Safeguards between energy sources

5.3.5.1 General

This subclause specifies **safeguards** between ES1, ES2 and ES3.

Table 12 gives an overview of the required number of **equipment safeguards** between electrical energy sources.

Table 12 – Overview of required number of equipment safeguards

Electrical energy source	Required number of interposed equipment safeguards		
	ES1	ES2	ES3
ES1	0	1	2 ^a
ES2	1	0	2 ^b
ES3	2 ^a	2 ^b	0
^a See 5.3.5.2.			
^b See 5.3.5.3.			

5.3.5.2 Safeguards between ES1, ES2 and ES3

At least one **basic safeguard** shall be interposed between ES2 and ES1 (see Figure 26, Figure 27 and Figure 28).



Figure 26 – Model for protection of ES1 against ES2

At least one **basic safeguard** and one **supplementary safeguard** shall be interposed between ES3 and ES1 (see Figure 27 and Figure 28).

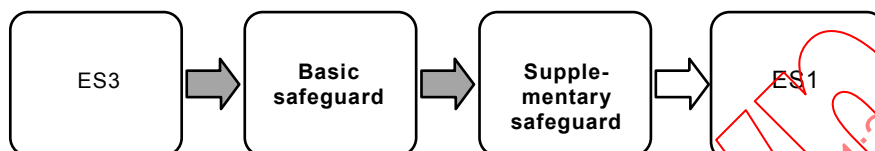


Figure 27 – Model for protection of ES1 against ES3

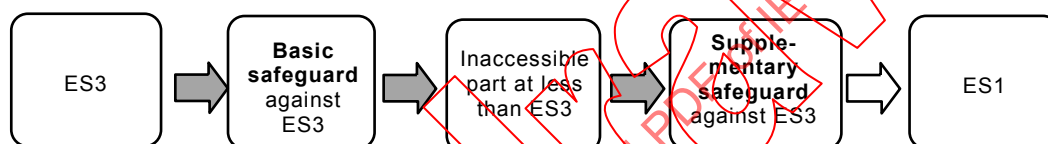


Figure 28 – Model for protection of ES1 against ES3

5.3.5.3 Protection of ES2 against ES3

At least one **basic safeguard** and one **supplementary safeguard** shall be interposed between ES3 and ES2 (see Figure 29 and Figure 30).

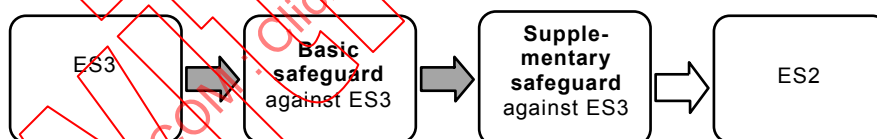


Figure 29 – Model for protection of ES2 against ES3



Figure 30 – Model for protection of ES2 against ES3

5.3.6 Accessibility to electrical energy sources and safeguards

5.3.6.1 Requirements

For **ordinary persons**, the following shall not be **accessible**:

- bare parts at ES2, except for the pins of connectors. However, such pins shall not be **accessible** under **normal operating conditions** by the blunt probe of Figure V.3; and
- bare parts at ES3; and

- an ES3 **basic safeguard**.

For **instructed persons**, the following shall not be **accessible**:

- bare parts at ES3; and
- an ES3 **basic safeguard**.

5.3.6.2 Contact requirements

For ES3 voltages up to 420 V peak, the appropriate test probe from Annex V shall not contact a bare internal conductive part.

For ES3 voltages above 420 V peak, the appropriate test probe from Annex V shall not contact a bare internal conductive part and shall have an air gap from that part (see Figure 31).

The air gap shall either:

- pass an electric strength test in accordance with 5.4.11.1 at a test voltage (d.c. or peak a.c.) that is equal to the test voltage for **basic insulation** in Table 32 corresponding to the **peak working voltage**; or
- have a minimum distance according Table 13.

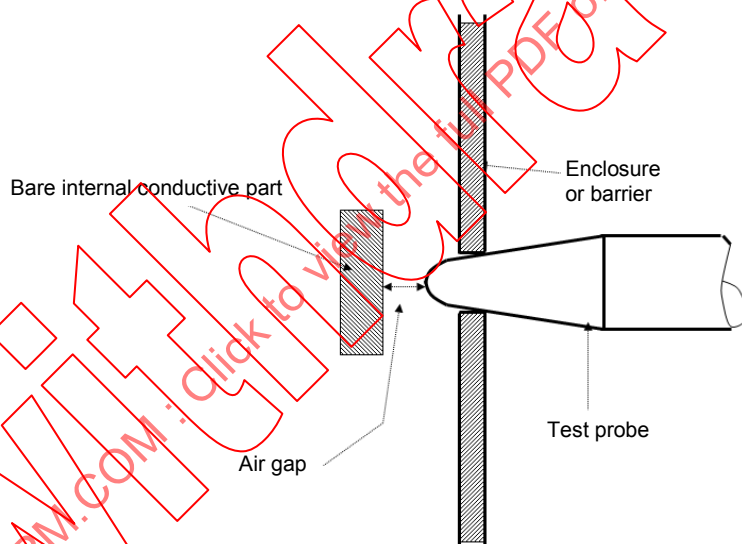


Figure 31 – Contact requirements to bare internal conductive parts

Table 13 – Minimum airgap distance

Peak working voltage	Air gap distance mm	
V peak or d.c. up to and including	Pollution degree	
	2	3
>420 and ≤ 1 000	0,2	0,8
1 200	0,25	
1 500	0,5	
2 000	1,0	
2 500	1,5	
3 000	2,0	
4 000	3,0	
5 000	4,0	
6 000	5,5	
8 000	8,0	
10 000	11	
12 000	14	
15 000	18	
20 000	25	
25 000	33	
30 000	40	
40 000	60	
50 000	75	
60 000	90	
80 000	130	
100 000	170	
Linear interpolation may be used between the nearest two points, the calculated minimum airgap distance being rounded up to the next higher 0,1 mm increment or the value in the next row below whichever is lower.		

5.3.6.3 Compliance

Compliance is checked by the relevant test of Annex T, followed by the tests of Annex V.

In addition, for bare ES3 parts at a voltage above 420 V peak, compliance is checked by distance measurement or by an electric strength test.

Components and subassemblies that comply with their respective IEC standards are not subjected to the finger probe of V.1.2 when such components and subassemblies are used in the final product.

5.3.6.4 Terminals for connecting stripped wire

The use of a stripped wire to make connection with a terminal intended to be used by an **ordinary person** (for example, a loudspeaker terminal of an audio amplifier) shall not result in contact with ES2 or ES3 (for audio signal voltages, see Table E.1 for values of ES2 and ES3).

Compliance is checked by the test of V.1.6.

5.4 Insulation materials and requirements

5.4.1 General

5.4.1.1 Insulation

This subclause specifies insulating materials, **clearances**, **creepage distances** and **solid insulation**, including the use of these materials in components.

Insulation providing a **safeguard** function is designated **basic insulation**, **supplementary insulation**, **double insulation**, or **reinforced insulation**.

5.4.1.2 Properties of insulating material

The choice and application of insulating material shall take into account the needs for electrical strength, mechanical strength, dimension, frequency of the **working voltage** and other properties for the working environment (temperature, pressure, humidity and pollution) as specified in this Clause 5 and Annex T.

Insulating material shall not be hygroscopic as determined by 5.4.1.3.

NOTE To protect **solid insulation** from damage due to transient voltages, the electric strength of **solid insulation** should be greater than the electric strength of the associated (parallel) **clearance**.

5.4.1.3 Compliance

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 5.4.10. The insulation is then subjected to the relevant electric strength test of 5.4.11.1 while still in the humidity chamber, or in the room in which the samples were brought to the prescribed temperature.

5.4.1.4 Frequency

For fundamental frequencies higher than 30 kHz, the **clearances**, **creepage distances** and **solid insulation** shall comply with 5.4.2, 5.4.3 and 5.4.4.9 respectively.

NOTE 1 For fundamental frequencies higher than 30 kHz, the requirements are based on IEC 60664-1 and IEC 60664-4.

If the circuit has both a **mains** frequency and a fundamental frequency exceeding 30 kHz, then the worst-case requirements for **clearances**, **creepage distances**, and **solid insulation** shall be applied.

As an alternative, for **solid insulation** and frequencies above 30 kHz, the high frequency test of 5.4.4.9 can be substituted by the electric strength test of 5.4.11.1 under the following conditions:

- the field strength is approximately uniform; and
- no voids or air gaps are present in the **solid insulation**.

NOTE 2 In this context, the electric field is considered to be approximately uniform if the deviations are less than $\pm 20\%$ from the average value of the field strength.

5.4.1.5 Maximum operating temperatures for insulating materials

5.4.1.5.1 Requirements

Under **normal operating conditions**, insulating material temperatures shall not exceed the temperature limit of the insulating material, including insulating materials of components, or the maximum temperature limit of the insulation system as given in Table 14.

For maximum temperatures below or equal to 100 °C, no classified insulation system is required.

5.4.1.5.2 Test method

Insulating material temperatures are measured in accordance with B.1.7.

*The equipment or parts of the equipment are operated under **normal operating conditions** (see Clause B.2) as follows:*

- for continuous operation, until steady state conditions are established; and*
- for **intermittent operation**, until steady state conditions are established using the rated "ON" and "OFF" periods; and*
- for **short-time operation**, for the operating time specified by the manufacturer.*

Components and other parts may be tested independent of the end product provided that the test conditions applicable to the end product are applied to the component or part.

Equipment intended for building-in or rack-mounting, or for incorporation in larger equipment, is tested under the most adverse actual or simulated conditions specified in the installation instructions.

5.4.1.5.3 Compliance

The temperature of the electrical insulation material or EIS shall not exceed the limits in Table 14.

For a single insulating material, the declared relative temperature index information from the material manufacturer can be used if it is suitable for the applicable class of insulation.

NOTE For example, a material rated for 124 °C is considered suitable for classes whose temperature is lower (class with letter codes E and A) and not for classes whose temperature is higher (class with letter codes B, F, H, N, R and C).

No tests are necessary if the thermal classification is class 105 in accordance with IEC 60085.

For thermal classifications above class 105, the EIS shall comply with IEC 60085.

Table 14 – Temperature limits for materials, components and systems

Part	Maximum temperature $T_{\max}$ °C
Insulation, including winding insulation:	
of Class 105 (A) material or EIS	100 ^a
of Class 120 (E) material or EIS	115 ^a
of Class 130 (B) material or EIS	120 ^a
of Class 155 (F) material or EIS	140 ^a
of Class 180 (H) material or EIS	165 ^a
of Class 200 (N) material or EIS	180 ^a
of Class 220 (R) material or EIS	200 ^a
of Class 250 material or EIS	225 ^a
Insulation of internal and external wiring, including power supply cords:	
– without temperature marking	70
– with temperature marking	Temperature marked on the wire or spool, or rating assigned by the manufacturer
Other thermoplastic insulation	See 5.4.1.11
Components	See also Annex G
^a If the temperature of a winding is determined by thermocouples, these values are reduced by 10 K, except in the case of a – motor, or – winding with embedded thermocouples. The classes are related to the temperature classes of electrical insulating materials and electrical insulating systems in accordance with IEC 60085. The assigned letter designations are given in parentheses. For each material, account shall be taken of the data for that material to determine the appropriate maximum temperature.	

5.4.1.6 Pollution degrees

This subclause describes different degrees of pollution of the operating environment for products covered by this standard.

Pollution degree 1

No pollution or only dry, non-conductive pollution occurs. The pollution has no influence.

NOTE 1 Within the equipment, components or subassemblies that are sealed to exclude dust and moisture are examples of **pollution degree 1**.

Pollution degree 2

Only non-conductive pollution occurs except that occasionally a temporary conductivity caused by condensation is to be expected.

NOTE 2 **Pollution degree 2** is generally appropriate for equipment covered by the scope of this standard.

Pollution degree 3

Conductive pollution occurs or dry non-conductive pollution occurs that becomes conductive due to condensation, which is to be expected.

5.4.1.7 Insulation in transformers with varying dimensions

This subclause specifies the method of determining **clearances**, **creepage distances**, and distances through insulation along the length of the winding of a transformer.

If the insulation of a transformer has different **working voltages** along the length of the winding, the **clearances**, **creepage distances** and distances through insulation may vary in a corresponding fashion.

NOTE An example of such a construction is a 30 kV winding, consisting of multiple bobbins connected in series, and earthed or connected to a common point at one end.

5.4.1.8 Insulation in circuits generating starting pulses

This subclause specifies the method of determining **clearances**, **creepage distances** and distance through insulation for circuits generating starting pulses.

For circuits generating starting pulses (for example, to ignite a discharge lamp), the requirements for **basic insulation**, **supplementary insulation** and **reinforced insulation** apply to **creepage distances** and distances through insulation. For **clearances**, see G.12.2.

NOTE For **working voltages** in the above cases, see 5.4.1.9.1, i).

5.4.1.9 Determination of working voltage

5.4.1.9.1 General

This subclause specifies various parameters and assumptions that need to be taken into account when determining **working voltage**.

In determining **working voltages**, all of the following requirements apply:

- a) unearthed **accessible** conductive parts are assumed to be earthed;
- b) if a transformer winding or other part is not connected to a circuit that establishes its potential relative to earth, the winding or other part are assumed to be earthed at a point by which the highest **working voltage** is obtained;
- c) except as specified in 5.4.1.7, for insulation between two transformer windings, the highest voltage between any two points in the two windings is the **working voltage**, taking into account the voltages to which the input windings will be connected;
- d) except as specified in 5.4.1.7, for insulation between a transformer winding and another part, the highest voltage between any point on the winding and the other part is the **working voltage**;
- e) where **double insulation** is used, the **working voltage** across the **basic insulation** is determined by imagining a short circuit across the **supplementary insulation**, and vice versa. For **double insulation** between transformer windings, the short circuit is 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 equipment shall be the **rated voltage** or the voltage within the **rated voltage range** that results in the highest measured value;
- g) the **working voltage** between
 - any point in the circuit supplied by the **mains** and any part connected to earth; and
 - any point in the circuit supplied by the **mains** and any point in a circuit isolated from the **mains**, 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 an ES1 or ES2 **external circuit**, the normal operating voltages shall be taken into account. If the operating voltages are not known, the **working voltage** shall be taken as the upper limits of ES1 or ES2 as applicable.

Short duration signals (such as telephone ringing) shall not be taken into account for determining **working voltage**;

- i) for circuits generating starting pulses (for example, discharge lamps, see Clause G.12), the **peak working voltage** is the peak value of the pulses with the lamp connected but before the lamp ignites. The **working voltage** to determine minimum **creepage distances** is the voltage measured after the ignition of the lamp;
- j) temporary overvoltages and recurring peak voltages have to be considered.

5.4.1.9.2 RMS working voltage

In determining the **r.m.s. working voltage**, short-term conditions (for example, cadenced telephone ringing signals in **external circuits**) and non-repetitive transients (for example, due to atmospheric disturbances) are not taken into account.

NOTE The **creepage distances** are determined from the **r.m.s. working voltages**.

5.4.1.9.3 Peak working voltage

For the **peak working voltage** used to determine the **required withstand voltage** for minimum **clearances** and test voltages for electric strength:

- when determining the **peak working voltage** between circuits connected to the **mains** and circuits isolated from the **mains**, the voltage of any ES2 circuit, ES1 circuit or **external circuits** (including telephone ringing signals) shall be regarded as zero;
- when determining the **peak working voltage** for an **external circuit** that does not have transients, the **peak working voltage** of repetitive signals, such as telephone ringing signals, shall be taken into account;
- non-repetitive transients (for example, due to atmospheric disturbances) shall not be taken into account.

5.4.1.10 Insulating surfaces

An **accessible** insulating surface is considered to be covered by a thin metallic foil for determining **clearances**, **creepage distances** and distance through insulation (see Figure O.13).

5.4.1.11 Thermoplastic parts on which conductive metallic parts are directly mounted

5.4.1.11.1 Requirements

Thermoplastic parts on which conductive metallic parts are directly mounted shall be sufficiently resistant to heat if softening of the plastic could result in the failure of a **safeguard**.

5.4.1.11.2 Compliance

Compliance is checked by examination of the Vicat test data from the material manufacturer. If the data is not available, compliance is checked by either the Vicat test of this subclause or the ball pressure test of 5.4.1.11.3.

*The measured temperature during **normal operating conditions**, as specified in Clause B.2, shall be at least 15 K less than the Vicat softening temperature as specified in Vicat test B50 of ISO 306.*

*The measured temperature during **abnormal operating conditions** of Clause B.3 shall be less than the Vicat softening temperature.*

*The Vicat softening temperature of a non-metallic part supporting parts in a circuit supplied from the **mains** shall be not less than 125 °C.*

5.4.1.11.3 Ball pressure test

*Compliance is checked by examination of the ball pressure test data from the manufacturer or by subjecting the part to the ball pressure test according to IEC 60695-10-2. The test is made in a heating cabinet at a temperature of $(T - T_{amb} + T_{ma} + 15 \text{ °C}) \pm 2 \text{ °C}$. However, a thermoplastic part supporting parts in a circuit supplied from the **mains** is tested at a minimum of 125 °C.*

The significances of T , T_{ma} and T_{amb} are as given in B.2.6.1.

After the test, dimension d (diameter of the indentation) shall not exceed 2 mm.

The test is not made if it is clear from examination of the physical characteristics of the material that it will meet the requirements of this test.

5.4.2 Clearances

5.4.2.1 General

This subclause specifies the required **clearances** for a given **working voltage** and the various other parameters that affect **clearances**.

Clearances shall be so dimensioned that overvoltages and transients that may enter the equipment, and peak voltages that may be generated within the equipment, do not break down the **clearance**.

The parameter, **required withstand voltage**, accounts for overvoltages and transients that may enter the equipment or that may be generated within the equipment. The dimension for a **clearance** that is affected by the transients from the **mains** or an **external circuit** is determined from the **required withstand voltage** for that **clearance**.

The **peak working voltage** (including steady state voltages and recurring peak voltages) and temporary overvoltages are taken into account to determine the **clearance**.

High frequency voltages are taken into account to determine the **clearance**.

Clearances functioning as **basic insulation**, **supplementary insulation** and **reinforced insulation** shall be not less than the minimum dimensions as determined in 5.4.2.7, or shall be determined in accordance with 5.4.2.8.

The minimum **clearances** as determined in 5.4.2.7 do not apply to the air gap between the contacts of **thermostats**, **thermal cut-offs**, 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 **safety interlocks**, see Annex K. For air gaps between contacts of **disconnect devices**, see Annex L.

The **clearance** between the outer insulating surface (see 5.4.2.2) of a connector (including an opening in the **enclosure**) and conductive parts that are connected to ES2 within the connector (or in the **enclosure**) shall comply with the requirements for **basic insulation**.

The **clearance** between the outer insulating surface (see 5.4.2.2) of a connector (including an opening in the **enclosure**) and conductive parts that are connected to ES3 within the connector (or in the **enclosure**) shall comply with the requirements for **reinforced insulation**. As an exception, the **clearance** may comply with the requirements for **basic insulation** if the connector is:

- fixed to the equipment; and
- located internally to the outer **electrical enclosure** of the equipment; and
- only **accessible** after removal of a subassembly that
 - is required to be in place during **normal operating conditions**, and
 - is provided with an **instructional safeguard** to replace the removed subassembly.

NOTE 2 The tests of 5.4 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 determined in accordance with 5.4.2.7 apply.

The above minimum **clearances** for connectors do not apply to connectors listed in Clause G.20.

5.4.2.2 Compliance

Compliance is checked by measurement taking into account the relevant clauses of Annex O and Annex T.

The following conditions apply:

- **movable parts** are placed in their most unfavourable positions;
- **clearances** from an **enclosure** of insulating material through a slot or opening are measured according to Figure O.13, point X;
- the dimensions for **clearances** functioning as **basic insulation**, **supplementary insulation** and **reinforced insulation** are measured after the tests of Annex T;
- after the tests of Annex T the electric strength test shall be applied;
- during the force tests, metal **enclosures** shall not come into contact with bare conductive parts of
 - ES2 circuits, unless the product is in a **restricted access area**, or
 - ES3 circuits;
- for the glass breakage test, see Clause T.9. Damage to the finish, small dents that do not reduce **clearances** below the specified values, surface cracks and the like are ignored. If a through crack appears, **clearances** shall not be reduced. For cracks not visible to the naked eye, an electric strength test shall be conducted.

5.4.2.3 Procedure for determining minimum clearances

5.4.2.3.1 General

To determine the minimum value for each required **clearance**, the highest value of the following three methods shall be used:

Method 1: Determine **clearances** according to 5.4.2.3.2 using the **required withstand voltages**.

Method 2: Measure the **peak working voltage** and determine the **clearance** from Table 18.

Method 3: If the fundamental frequency is higher than 30 kHz, measure the **peak working voltage** at the fundamental frequency and determine the **clearance** from Table 19.

5.4.2.3.2 Determination of the clearance using required withstand voltage

The **clearance** shall be determined using the following steps.

- a) Determine the transient voltage:
 - 1) for equipment intended for connection to the **mains**, determine the a.c. **mains transient voltage** according to 5.4.2.4.1;
 - 2) for equipment intended for connection to a **d.c. mains**, determine the transient voltage according to 5.4.2.4.2 and the nominal **d.c. voltage**;
 - 3) for equipment intended for connection to an **external circuit**, determine the **external circuit** transient voltage according to 5.4.2.4.3;
- b) Determine the **required withstand voltage** according to 5.4.2.5;
- c) Determine the minimum **clearance** according to 5.4.2.7.

The effect of transients from an **external circuit** consisting of a coaxial cable or an antenna is not taken into account when determining **clearances**.

5.4.2.4 Determination of transient voltages

5.4.2.4.1 Determination of a.c. mains transient voltages

This subclause specifies the method to determine the a.c. **mains transient voltage** that needs to be taken into account when determining the **required withstand voltage**.

For equipment to be supplied from the a.c. **mains**, the value of the **mains transient voltage** depends on the overvoltage category and the a.c. **mains** voltage. In general, **clearances** in equipment intended to be connected to the a.c. **mains**, shall be designed for overvoltage category II.

NOTE See Annex I for further guidance on the determination of overvoltage categories.

Equipment that is likely, when installed, to be subjected to transient voltages 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 a.c. **mains** voltage using Table 15.

Table 15 – Mains transient voltages

AC mains voltage ^a up to and including		Mains transient voltage ^b V peak			
V r.m.s.	V peak ^c	Overvoltage category			
		I	II	III	IV
50	71	330	500	800	1 500
100 ^d	141	500	800	1 500	2 500
150 ^e	210	800	1 500	2 500	4 000
300 ^f	420	1 500	2 500	4 000	6 000
600 ^g	840	2 500	4 000	6 000	8 000

^a For equipment designed to be connected to a three-phase 3-wire supply, where there is no neutral conductor, the a.c. **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 See 5.4.2.5.1.

^d In Japan, the value of the **mains transient voltages** for the nominal a.c. **mains** supply voltage of 100 V is determined from columns applicable to the nominal a.c. **mains** supply voltage of 150 V.

^e Including 120/208 V and 120/240 V.

^f Including 230/400 V and 277/480 V.

^g Including 400/690 V.

5.4.2.4.2 Determination of d.c. mains transient voltages

This subclause specifies the method to determine the transient voltages from d.c. power distribution systems that need to be taken into account when determining the **required withstand voltage**.

If an earthed d.c. power distribution system is entirely within a single building, the transient voltage is selected as follows:

- if the d.c. power distribution system is earthed at a single point, the transient voltage is assumed to be 500 V peak; or
- if the d.c. power distribution system is earthed at the source and the equipment, the transient voltage is assumed to be 350 V peak; or

NOTE The connection to protective earth can be at the source of the d.c. power distribution system or at the equipment location, or both (see ITU-T Recommendation K.27).

- if the cabling associated with the d.c. power distribution system is shorter than 4 m or is installed entirely in continuous metallic conduit, the transient voltage is assumed to be 150 V peak.

If a d.c. power distribution system is not earthed or is not within the same building, the transient voltage shall be assumed to be equal to the **mains transient voltage** in the **mains** from which the d.c. power is derived. If, however, the d.c. power distribution system is not within the same building, and is constructed using installation and protection techniques similar to those of **external circuits**, the transient voltage shall be determined using the relevant classification from 5.4.2.4.3.

If equipment is supplied from a dedicated battery that has no provision for charging from an external **mains** supply, the transient voltage shall be disregarded.

5.4.2.4.3 Determination of external circuit transient voltages

This subclause specifies **external circuit** transient voltages for various physical configurations of the **external circuit**.

The applicable value of the transient voltage on an **external circuit** shall be determined using Table 16. Where more than one location or condition is applicable, the highest transient applies. A ringing or other interrupted signal shall not be taken into account if the voltage of this signal is less than that of the transient.

Transient voltages from **external circuits** do not require a **safeguard**, but the transient voltages shall be taken into account when dimensioning a **safeguard** that is required between different categories of circuits (for example, ES1, ES2 and ES3).

If the **external circuit** transient voltages are known, the known value should be used.

NOTE 1 Australia has published its overvoltage limits in AS/ACIF G624:2005.

NOTE 2 It is assumed that adequate measures have been taken to reduce the likelihood that the transients presented to the equipment exceed the values specified in Table 16. In installations where transients presented to the equipment may exceed the values specified in Table 16, additional measures such as surge suppression may be necessary.

Table 16 – External circuit transient voltages

Installed wholly within the building structure ^a			
ID	Cable type	Additional conditions	Transient voltages ^a
1	Paired conductor ^d – unshielded		1 000 V 1,2/50 µs Only differential if one conductor is earthed in the equipment
2	Paired conductor ^d – unshielded	Cable is installed wholly within an Equipment Bonding Network (Mesh-BN, Mesh-IBN or star-IBN) (no connection to outside)	500 V 1,2/50 µs Only differential if one conductor is earthed in the equipment
3	Paired conductor ^d – unshielded	Cable length is less than or equal to 4 m. The cable connects equipment that is normally expected to be part of the same bonding network or powered from the same branch circuit (no connection to outside)	Not applicable
4	Paired conductor ^d – shielded ^b		Not applicable
5	Any other conductors	Interfaces with equipment that does not have an earth connection or reference	Not applicable
6	Coaxial cable ^b	Cable shield is earthed at both ends	Not applicable
7	Coaxial cable	Cable shield is not earthed at the equipment	Centre conductor to shield is disregarded 1 000 V 1,2/50 µs shield to earth
8	Integral antenna		Not applicable
9	Any conductor		Not applicable
10	Coaxial cable	Cable is connected to a socket outlet of a cable distribution system	Not applicable

Table 16 (concluded)

Some portion of the cable or the connected network is outside the building or structure ^c			
ID	Cable type	Additional conditions	Transient voltages ^a
11	Paired conductor ^d – unshielded	The building or structure may or may not have equipotential bonding	1 500 V 10/700 μ s Only differential if one conductor is earthed in the equipment
12	Paired conductor ^d – shielded		1 500 V 10/700 μ s Only differential if one conductor is earthed in the equipment
13	Paired conductor ^d – shielded	The building or structure has equipotential bonding	1 500 V 10/700 μ s Only differential if one conductor is earthed in the equipment
14	Any other conductors	The external circuit is not earthed at either end, but there is an earth reference (for example, from connection to mains)	Mains transient voltage or external circuit transient voltage of the circuit from which the circuit in question is derived whichever is higher
15	Coaxial cable	Equipment other than power-fed coaxial repeaters. Cable shield is earthed at the equipment	4 000 V 10/700 μ s Centre conductor to shield
16	Coaxial cable	Power fed coaxial repeaters (up to 4,4 mm coaxial cable). Cable shield is earthed at the equipment	5 000 V 10/700 μ s Centre conductor to shield
17	Coaxial cable	Equipment other than power-fed coaxial repeaters. Cable shield is not earthed at the equipment. Cable shield is earthed at building entrance	4 000 V 10/700 μ s Centre conductor to shield 1 500 V 1,2/50 μ s shield to earth
18	Coaxial cable	Cable connects to an outdoor antenna	10 kV from a 1 nF
19	Paired conductor ^d	Cable connects to an outdoor antenna	10 kV from a 1 nF
20	Coaxial cable	The connection of the cable coming from outside the building is made via a transfer point. The shield of the coaxial cable from outside the building and the shield of the coaxial cable of the cable within the building are connected together and are connected to earth.	Not applicable

NOTE 1 In Norway and Sweden, the cable shield on coaxial cables is normally not earthed at the building entrance. For installation conditions, see EN 60728-11.

NOTE 2 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. Such practices are application dependent and are not dealt with by this standard.

^a See ITU-T, Recommendation K.68. If power induction occurs, transient voltages of 650 V r.m.s. for 0,35 s < t < 0,5 s may be present.

^b For a shielded cable to affect a reduction in transients, the shield shall be continuous, earthed at both ends, and have a maximum transfer impedance of 20 Ω /km (for f less than 1 MHz).

^c Conductor is considered to leave the building if it terminates on equipment earthed to a different earthing network.

^d A paired conductor includes a twisted pair.

5.4.2.5 Determination of required withstand voltage

5.4.2.5.1 Mains transient voltages

Unless 5.4.2.5.2 applies, the **required withstand voltage** is determined according to a), b) or c) of this subclause.

For equipment supplied from the a.c. **mains**, a) and b) apply. For equipment supplied from the d.c. **mains**, c) applies.

The following abbreviations are used.

$U_{\text{required withstand}}$	the peak value of the a.c. mains supply voltage in the second column of Table 15 corresponding to the rated voltage or the upper limit of the rated voltage range
$U_{\text{mains transient}}$	the mains transient voltage determined in 5.4.2.4
$U_{\text{measured transient}}$	the maximum transient voltage from the a.c. mains , determined according to 5.4.2.6

a) For circuits supplied from the a.c. **mains**, either a)1) or a)2) may be used.

- 1) $U_{\text{required withstand}} = U_{\text{mains transient}}$
- 2) $U_{\text{required withstand}} = U_{\text{measured transient}}$

b) For circuits isolated from the a.c. **mains**, either b)1), b)2), or b)3) may be used.

- 1) $U_{\text{required withstand}} = U_{\text{mains transient}}$
- 2) $U_{\text{required withstand}} = U_{\text{measured transient}}$
- 3) Determine the a.c. **mains transient voltage** from 5.4.2.4 1. $U_{\text{required withstand}}$ is one overvoltage category lower in Table 15 for a given a.c. **mains voltage**.

b)3) is normally applied for the following cases:

- an isolated circuit derived from the **mains**, and that is connected to the main protective earthing terminal in accordance with 5.6.4;
- an isolated circuit, derived from the **mains** and separated from the circuit connected to the **mains** by a metal screen that is connected to the main protective earthing terminal in accordance with 5.6.4.

c) For circuits supplied from a d.c. **mains**, b)1), b)2) or b)3) shall be applied.

5.4.2.5.2 DC source transient voltages

In a circuit isolated from the **mains** supplied by a d.c. source with capacitive filtering, and connected to protective earth, the **required withstand voltage** shall be assumed to be equal to the peak value of the **d.c. voltage** of the source, or the **peak working voltage** of the circuit isolated from the **mains**, whichever is higher.

If equipment is supplied from a dedicated battery that has no provision for charging from an external **mains**, the transient voltage is disregarded.

5.4.2.5.3 External circuit transient voltages

Except as specified in 5.5.4, for transient voltages from an **external circuit**, the **required withstand voltage** is

- the **external circuit** transient voltage determined in 5.4.2.4.3, or
- the value measured in accordance with 5.4.2.6 c).

If the transient voltage is smaller than the peak voltage of the short duration signal (such as telephone ringing), this short duration signal shall be taken into account for determination of the **required withstand voltage**.

For circuits connected to coaxial cable distribution and outdoor antennas, compliance is checked by the tests of 5.5.4.

5.4.2.5.4 Combination of transient voltages

If the transient voltages described in 5.4.2.5.1, 5.4.2.5.2 and 5.4.2.5.3 affect the same **clearance**, the largest of those voltages is used when determining **required withstand voltage**. The values shall not be added together.

5.4.2.6 Measurement of transient voltage levels

This subclause specifies the method to measure the actual transient levels from any circuit (when the manufacturer has provided a transient suppression network).

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 not connected to the **mains**, external d.c. power distribution system or to any **external circuit**. Any surge suppressors internal to the equipment in circuits connected to the **mains** or the external d.c. power distribution system are disconnected. If the equipment is intended to be used with a separate power supply, it is connected to the equipment during the tests.

A voltage measuring device is connected across the **clearance** in question.

a) Transient voltages from an a.c. **mains**

To measure the transient voltage across a **clearance** due to transient voltages on a **mains** the impulse test generator circuit 2 of Table D.1 is used to generate 1,2/50 μ s impulses. U_c is equal to the **mains transient voltage** determined in 5.4.2.4.1.

At least three impulses of each polarity, with intervals of at least 1 s between impulses, are applied between each of the following points where relevant:

- line-to-line;
- all line conductors conductively joined together and neutral;
- all line conductors conductively joined together and protective earth;
- neutral and protective earth.

b) Transient voltages from a d.c. **mains**

To measure the transient voltage across a **clearance** due to transient voltages on a d.c. power distribution system, the impulse test generator circuit 2 of Table D.1 is used to generate 1,2/50 μ s impulses. U_c is equal to the transient voltage determined in 5.4.2.4.2.

At least three impulses of each polarity, with intervals of at least 1 s between impulses, are applied between each of the following points where relevant:

- the positive and negative supply connection points;
- all supply connection points joined together and protective earth.

c) Transient voltages from an **external circuit**

To measure the transient voltage across a **clearance** due to transient voltages on an **external circuit**, the appropriate test generator of Annex D is used to generate impulses as applicable and described in Table 16. U_c is equal to the **external circuit** transient voltage determined in 5.4.2.4.3.

At least three impulses of each polarity, with intervals of at least 1 s between impulses, are applied between each of the following **external circuit** 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.

5.4.2.7 Determination of the minimum clearance

Minimum **clearances** may be determined by measurement as specified in this subclause or by electric strength test in accordance with 5.4.2.8.

NOTE The homogeneous field distribution on which Table 20 is based, is in practice not achievable. Only a distribution between inhomogeneous and homogenous can be achieved.

Lower values than in Table 17, Table 18 or Table 19 can be used if an electric strength test according to 5.4.2.8 is conducted as a **type test** using the value of **required withstand voltage** determined according to 5.4.2.5.

Table 17 – Minimum clearances up to 2 000 m above sea level, inhomogeneous field distribution (when transients from mains or external circuits are present)

Required withstand voltage	Basic insulation or supplementary insulation			Reinforced insulation		
	mm			mm		
V peak or d.c. up to and including	Pollution degree			Pollution degree		
	1 ^a	2	3	1 ^a	2	3
330	0,01	0,2	0,8	0,04	0,6	1,5
400	0,02			0,07		
500	0,04			0,10		
600	0,06			0,14		
800	0,10			0,5		
1 000	0,15			0,6		
1 200	0,25			0,9		
1 500	0,5			1,5		
2 000	1,0			2,2		
2 500	1,5			3,0		
3 000	2,0			3,8		
4 000	3,0			5,5		
5 000	4,0			8,0		
6 000	5,5			8,0		
8 000	8,0			14		
10 000	11			19,4		
12 000	14			24		
15 000	18			31,4		
20 000	25			44		
25 000	33			60		
30 000	40			72		
40 000	60			98		
50 000	75			130		
60 000	90			162		
80 000	130			226		
100 000	170			290		

Linear interpolation may be used between the nearest two points, the calculated minimum **clearances** being rounded up to the next higher 0,1 mm increment or the value in the next row below whichever is lower.

^a The values for **pollution degree** 1 may be used if a sample complies with the tests of 5.4.8.

Table 18 – Minimum clearances up to 2 000 m above sea level, inhomogeneous field distribution (for steady-state voltages, temporary overvoltages and recurring peak voltages)

Peak working voltage	Basic insulation or supplementary insulation			Reinforced insulation		
	mm			mm		
V peak or d.c. up to and including	Pollution degree			Pollution degree		
	1 ^a	2	3	1 ^a	2	3
330	0,01	0,2	0,8	0,04	0,6	1,5
400	0,02			0,074		
500	0,04			0,13		
600	0,06			0,234		
800	0,13					
1 000	0,26	0,26		0,76	0,76	
1 200	0,42			1,19		
1 500	0,76			1,8		1,8
2 000	1,27			2,8		
2 500	1,8			3,8		
3 000	2,4			6,2		
4 000	3,8			7,9		
5 000	6,7			11		
6 000	7,9			11		
8 000	11,0			19		
10 000	15,2			26,8		
12 000	19			32,56		
15 000	25			42		
20 000	34			59,4		
25 000	44			77		
30 000	55			95,4		
40 000	77			131		
50 000	100			175		
60 000	120			219		
80 000	175			307		
100 000	230			395		

The values in the above table are derived from IEC 60664-1:2007, Table F.7a.

Linear interpolation may be used between the nearest two points, the calculated minimum **clearances** being rounded up to the next higher 0,1 mm increment or the value in the next row below whichever is lower.

^a The values for **Pollution degree** 1 may be used if a sample complies with the tests of 5.4.8.

Table 19 – Minimum clearances up to 2 000 m above sea level, inhomogeneous field distribution (for steady-state voltages, temporary overvoltages and recurring peak voltages for frequencies above 30 kHz)

Peak working voltage up to and including V peak	Basic insulation or supplementary insulation mm	Reinforced insulation mm
600	0,06	0,12
800	0,18	0,36
1 000	0,5	1,0
1 200	1,4	2,8
1 400	2,35	4,7
1 600	4,0	8,0
1 800	6,7	13,4
2 000	11	22,0
Linear interpolation may be used between the nearest two points, the calculated minimum clearances being rounded up to the next higher 0,1 mm increment.		

5.4.2.8 Minimum clearances based on electric strength test

Clearances for basic insulation, supplementary insulation, and reinforced insulation shall withstand an electric strength test in addition to compliance with the minimum clearance values of Table 21. The test may be conducted using an impulse voltage or a.c. voltage or a **d.c. voltage**. The impulse withstand voltage test is carried out with a voltage having an appropriate waveform (see Annex D) with the values specified in Table 21. The a.c. voltage test is conducted using a sinusoidal voltage with r.m.s. value as specified in Table 21.

The **d.c. voltage** test is conducted using a **d.c. voltage** with average **d.c. voltage** value as specified in Table 21. The **required withstand voltage** is determined as given in 5.4.2.5. The test is carried out as follows:

- by applying five impulses of each polarity with an interval of at least 1 s between pulses; or
- by applying an a.c. r.m.s. voltage for 5 s; or
- by applying a **d.c. voltage** for 5 s in one polarity and then for 5 s in reverse polarity.

NOTE When verifying clearances within equipment by an electric strength test (for example, an impulse voltage), ensure that the specified electric test voltage appears at the **clearance** under test.

Table 20 – Minimum clearances based on electric strength test

Required withstand voltage	Basic insulation or supplementary insulation			Reinforced insulation		
	mm			mm		
V peak or d.c. up to and including	Pollution degree			Pollution degree		
	1 ^a	2	3	1 ^a	2	3
330	0,01	0,2	0,8	0,04	0,43	1,45
400	0,02			0,07		
500	0,04			0,10		
600	0,06			0,14		
800	0,10			0,3		
1 000	0,15			0,33		
1 200	0,2			0,43		
1 500	0,3			0,6		
2 000	0,45		0,88			
2 500	0,6		1,2			
3 000	0,8		1,45			
4 000	1,2		2,0			
5 000	1,5		3,0			
6 000	2,0		3,0			
8 000	3,0		4,5			
10 000	3,5		6,0			
12 000	4,5		7,5			
15 000	5,5		9,6			
20 000	8,0		13,4			
25 000	10		17			
30 000	12,5		21			
40 000	17		28,6			
50 000	22		35			
60 000	27		43			
80 000	35		59			
100 000	45		75			

Linear interpolation may be used between the nearest two points, the calculated minimum clearances being rounded up to the next higher 0,1 mm increment or the value in the next row below whichever is lower.

This table is based on the data for homogeneous fields.

^a The values for pollution degree 1 may be used if a sample complies with the tests of 5.4.8.

Table 21 – Test voltages for verifying clearances up to 2 000 m above sea level

Required withstand voltage up to and including kV peak	Test voltage for electric strength for clearances for basic insulation or supplementary insulation		
	kV peak 1,2/50 μ s impulse	kV r.m.s.	kV d.c.
0,33	0,35	0,23	0,35
0,5	0,55	0,4	0,55
0,8	0,91	0,52	0,74
1,5	1,75	0,95	1,35
2,5	2,95	1,89	2,67
4,0	4,8	2,61	3,69
6,0	7,3	3,97	5,61
8,0	9,8	5,34	7,55
12,0	14,8	8,08	11,43
U^a	$1,23 \times U$	$0,68 \times U$	$0,95 \times U$
Linear interpolation may be used between the nearest two points, the calculated minimum test voltage being rounded up to the next higher 0,01 kV increment. For reinforced insulation , the test voltage for electric strength is 160 % of the value for the basic insulation . For routine tests , the test voltage is reduced by 20 % and the duration is reduced to 1 s. If the EUT fails the r.m.s. or d.c. test, the impulse test shall be used.			
^a U is any required withstand voltage higher than 12,0 kV.			

5.4.2.9 Multiplication factors for altitudes higher than 2 000 m above sea level

For equipment intended to be used 2 000 m above sea level, the minimum **clearances** in Table 17, Table 18, Table 19 and Table 20 and the electric strength test voltages in Table 21 are multiplied by the applicable multiplication factor for the desired altitude according to Table 22 (tests conducted at sea level).

NOTE 1 It is acceptable to use a vacuum chamber to simulate higher altitudes.

NOTE 2 In China, special requirements in choosing multiplication factors for altitudes above 2 000 m exist.

Table 22 – Multiplication factors for clearances and test voltages

Altitude m	Normal barometric pressure kPa	Multiplication factor for clearances	Multiplication factor for electric strength test voltages			
			$\geq 0,01$ mm to $< 0,0625$ mm	$\geq 0,0625$ mm to < 1 mm	≥ 1 mm to < 10 mm	≥ 10 mm to < 100 mm
2 000	80,0	1,00	1,00	1,00	1,00	1,00
3 000	70,0	1,14	1,05	1,05	1,07	1,10
4 000	62,0	1,29	1,10	1,10	1,15	1,20
5 000	54,0	1,48	1,17	1,16	1,24	1,33
Linear interpolation may be used between the nearest two points, the calculated minimum multiplication factor being rounded up to the next higher 0,01 increment.						

5.4.3 Creepage distances**5.4.3.1 General**

Creepage distances for frequencies up to 30 kHz shall be so dimensioned that, for a given **r.m.s. working voltage**, **pollution degree** and material group, no flashover or breakdown of insulation (for example, due to tracking) will occur.

Creepage distances for frequencies higher than 30 kHz are under consideration. The **creepage distance** requirements for frequencies up to 30 kHz can be used for frequencies over 30 kHz until additional data is available.

The **creepage distance** between the outer insulating surface (see 5.4.3.2) of a connector (including an opening in the **enclosure**) and conductive parts that are connected to ES2 within the connector (or in the **enclosure**) shall comply with the requirements for **basic insulation**.

The **creepage distance** between the outer insulating surface (see 5.4.3.2) of a connector (including an opening in the **enclosure**) and conductive parts that are connected to ES3 within the connector (or in the **enclosure**) shall comply with the requirements for **reinforced insulation**.

As an exception, the **creepage distance** may comply with the requirements for **basic insulation** if the connector is:

- fixed to the equipment; and
- located internally to the outer **electrical enclosure** of the equipment; and
- only **accessible** after removal of a subassembly that
 - is required to be in place during normal operating conditions, and
 - is provided with an instructional safeguard to replace the removed subassembly.

NOTE 1 The tests of 5.4 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 determined in accordance with this subclause apply.

The above minimum **creepage distances** for connectors do not apply to connectors listed in Clause G.20.

NOTE 2 For **creepage distances** below 2 mm, additional information is available in IEC 60664-5.

5.4.3.2 Test method

5.4.3.2.1 Test conditions

*This subclause specifies physical conditions that need to be taken into account when determining **creepage distances**.*

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 Clause G.9, and also without conductors;*
- *when measuring **creepage distances** from the outer 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** insulated surface shall be considered to be conductive as if it were covered by a metal foil during the test of V.1.2, applied without appreciable force (see Figure O.13, point X);*
- *the dimensions for **creepage distances** functioning as **basic insulation**, **supplementary insulation** and **reinforced insulation** are measured after the tests of Annex T;*
- *for the glass breakage test, see Clause T.9. Damage to the finish, small dents that do not reduce **creepage distances** below the specified values, surface cracks and the like are ignored. If a through crack appears, **creepage distances** shall not be reduced.*

Compliance is checked by measurement, taking into account Annex O, Annex T, and Annex V.

5.4.3.2.2 Material group and CTI

Material groups are based on the CTI and are classified as follows:

Material Group I	$600 \leq \text{CTI}$
Material Group II	$400 \leq \text{CTI} < 600$
Material Group IIIa	$175 \leq \text{CTI} < 400$
Material Group IIIb	$100 \leq \text{CTI} < 175$

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.

5.4.3.3 Compliance

Creepage distances for basic insulation and supplementary insulation shall be not less than the minimum values specified in Table 23, taking into account the value of the r.m.s. working voltage, the pollution degree and the material group.

For reinforced insulation, the values for creepage distances are twice the values for basic insulation in Table 23.

If the minimum creepage distance derived from Table 23 is less than the minimum clearance, then the 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, the value of minimum clearance may be applied as the minimum creepage distance.

**Table 23 – Minimum creepage distances for basic insulation
and supplementary insulation in mm**

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	0,95	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			

Table 23 (concluded)

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
32 000	125	160	220	320			
40 000	160	200	280	400			
50 000	200	250	360	500			
63 000	250	320	450	600			
NOTE Material group IIIb is not recommended for applications in pollution degree 3 with an r.m.s. working voltage above 630 V.							
Linear interpolation may be used between the nearest two points, the calculated minimum creepage distance being rounded to the next higher 0,1 mm increment or the value in the next row below whichever is lower.							
For reinforced insulation , the rounding to the next higher 0,1 mm increment or to double the value in the next row is done after doubling the calculated value for basic insulation .							
^a The values for pollution degree 1 may be used if a sample complies with the tests of 5.4.8.							

Table 24 – Minimum values of creepage distances for frequencies higher than 30 kHz

Peak working voltage kV	Creepage distances mm						
	30 kHz < f ≤ 100 kHz	100 kHz < f ≤ 200 kHz	200 kHz < f ≤ 400 kHz	400 kHz < f ≤ 700 kHz	700 kHz < f ≤ 1 MHz	1 MHz < f ≤ 2 MHz	2 MHz < f ≤ 3 MHz
NOTE Requirements for creepages distances at frequencies above 30 kHz are under consideration.							

5.4.4 Solid insulation

5.4.4.1 General requirements

This subclause specifies general requirements for **solid insulation**.

The requirements of this subclause also apply to compounds and gel materials used as insulation. They do not apply to thin sheet materials.

Solid insulation shall not break down:

- due to overvoltages, including transients, that enter the equipment, and peak voltages that may be generated within the equipment; and
- due to pinholes in thin layers of insulation.

Solvent-based enamel coatings shall not be used for **basic insulation**, **supplementary insulation** or **reinforced insulation** except as given in G.11.1.2.

Except for printed boards, **solid insulation** shall either:

- comply with minimum distances through insulation in accordance with 5.4.4.2; or
- meet the requirements and pass the tests in 5.4.4.3 to 5.4.4.7, as applicable.

Glass used as **solid insulation** shall comply with the glass breakage test as specified in Clause T.9. Damage to the finish, small dents that do not reduce **clearances** below the

specified values, surface cracks and the like are ignored. If a through crack appears, **clearances** shall not be reduced below the specified values.

For printed boards, see Clause G.18. For antenna terminals, see 5.4.5. For **solid insulation** on internal wiring, see 5.4.6.

5.4.4.2 Minimum distance through insulation

Except where another subclause of Clause 5 applies, distances through insulation shall be dimensioned according to the application of the insulation and as follows (see Figure O.15 and Figure O.16):

- if the **working voltage** does not exceed ES2 voltage limits, there is no requirement for distance through insulation;
- if the **working voltage** exceeds ES2 voltage limits, the following rules apply:
 - for **basic insulation**, there is no minimum distance through insulation specified;
 - for **supplementary insulation** or **reinforced insulation** comprised of a single layer, the minimum distance through insulation shall be 0,4 mm;
 - for **supplementary insulation** or **reinforced insulation** comprised of multiple layers, the minimum distance through insulation shall comply with 5.4.4.6.

5.4.4.3 Insulating compound forming solid insulation

There is no minimum internal **clearance** or **creepage distance** if the insulating compound completely fills the casing of a component or subassembly, including a semiconductor device (for example, an optocoupler) provided that (see Figure O.15):

- the component or subassembly meets the minimum distances through insulation of 5.4.4.2; and
- a single sample passes the tests of 5.4.8.

NOTE 1 Alternative requirements for semiconductor devices are given in 5.4.4.4, and in Clause G.16.

For printed boards, see Clause G.18 and for wound components, see 5.4.4.7.

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 5.4.4.5 also applies.

5.4.4.4 Solid insulation in semiconductor devices

There is no minimum internal **clearance** or **creepage distance**, and 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) provided that the component satisfies one of the following a) or b) (see Figure O.15):

- a) passes the **type tests** and inspection criteria of 5.4.9; and passes **routine tests** for electric strength during manufacturing, using the appropriate test in 5.4.11.1; or
- b) complies with Clause G.16.

As an alternative to a) and b) above, a semiconductor may be evaluated according to 5.4.4.3, if applicable.

NOTE Such constructions may contain cemented joints in which case 5.4.4.5 also applies.

5.4.4.5 Insulating compound forming cemented joints

This subclause specifies requirements when an insulating compound forms a cemented joint between two non-conductive parts or between another non-conductive part and itself.

Where the path between conductive parts is filled with insulating compound, and the insulating compound forms a cemented joint between two non-conductive parts or between a non-conductive part and itself (see Figure O.14, Figure O.15 and Figure O.16), one of the following a), b) or c) applies.

- a) The distance along the path between the two conductive parts shall be not less than the minimum **clearances** and **creepage distances** for **pollution degree** 2. The requirements for distance through insulation of 5.4.4.2 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 5.4.8. The requirements for distance through insulation in 5.4.4.2 do not apply along the joint.
- c) The requirements for distance through insulation of 5.4.4.2 apply between the conductive parts along the joint. Additionally, three samples shall pass the test of 5.4.9.

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 5.4.8 and 5.4.9 are not applied to the inner layers of a printed board made using pre-preg if the temperature of the printed board measured during the heating test of 5.4.1.5 does not exceed 90 °C.

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:

- two non-conductive parts cemented together (for example, two layers of a multilayer board, see Figure O.14) or the split bobbin of a transformer where the centre limb is secured by adhesive (see Figure O.16);
- spirally wrapped insulation on a winding wire sealed by adhesive insulating compound, is an example of PD1;
- the joint between a non-conductive part (the casing) and the insulating compound itself in an optocoupler (see Figure O.15).

5.4.4.6 Thin sheet material

5.4.4.6.1 General requirements

There is no dimensional or constructional requirement for insulation in thin sheet material used as **basic insulation**.

NOTE An instrument to carry out the electric strength test on thin sheets of insulating material is described in Figure 36.

Insulation in thin sheet materials may be used for **supplementary insulation** and **reinforced insulation**, irrespective of the distance through insulation, provided that

- two or more layers are used;
- the insulation is within the equipment **enclosure**;
- the insulation is not subject to handling or abrasion during **ordinary person** or **instructed person** servicing; and
- the requirements and tests of 5.4.4.6.2 (for separable layers) or 5.4.4.6.3 (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.

For insulation in three or more layers of non-separable thin sheet materials:

- minimum distances through insulation are not required; and
- each layer of insulation does not have to be of the same material.

5.4.4.6.2 Separable thin sheet material

In addition to the requirements of 5.4.4.6.1, for:

- **supplementary insulation** consisting of two layers of material, each layer shall pass the electric strength test for **supplementary insulation**; or
- **supplementary insulation** consisting of three layers of material, any combination of two layers shall pass the electric strength test for **supplementary insulation**; or
- **reinforced insulation** consisting of two layers of material, each layer shall pass the electric strength test for **reinforced insulation**; or
- **reinforced insulation** consisting of three layers of material, any combination of two layers shall pass the electric strength test for **reinforced insulation**.

If more than three layers are used, layers may be divided into two or three groups of layers. Each group of layers shall pass the electric strength test for the appropriate insulation.

A test on a layer or group of layers is not repeated on an identical layer or group.

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

5.4.4.6.3 Non-separable thin sheet material

For insulation consisting of non-separable thin sheet materials, in addition to the requirements of 5.4.4.6.1, the test procedures in Table 25 are applied. There is no requirement for all layers of insulation to be of the same material and thickness.

Compliance is checked by inspection and by the tests specified in Table 25.

Table 25 – Tests for insulation in non-separable layers

Number of layers	Test procedure
Supplementary insulation	
Two or more layers:	The test procedure of 5.4.4.6.4 is applied
Reinforced insulation	
Two layers:	The test procedure of 5.4.4.6.4 is applied
Three or more layers:	The test procedures of 5.4.4.6.4 and 5.4.4.6.5 ^a are applied
NOTE The purpose of the tests in 5.4.4.6.5 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 5.4.4.6.5 are not applied to supplementary insulation .	
^a Where the insulation is integral to winding wire, the test does not apply.	

5.4.4.6.4 Standard test procedure for non-separable thin sheet material

For non-separable layers, electric strength tests are applied in accordance with 5.4.11.1 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 highest of the test voltages specified in Table 31, Table 32 or Table 33 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.

5.4.4.6.5 Mandrel test

This subclause specifies the test requirements for **reinforced insulation** made of three or more thin insulating sheets of material that are inseparable.

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 is fixed to the mandrel of the test fixture (Figure 32) as shown in Figure 33.

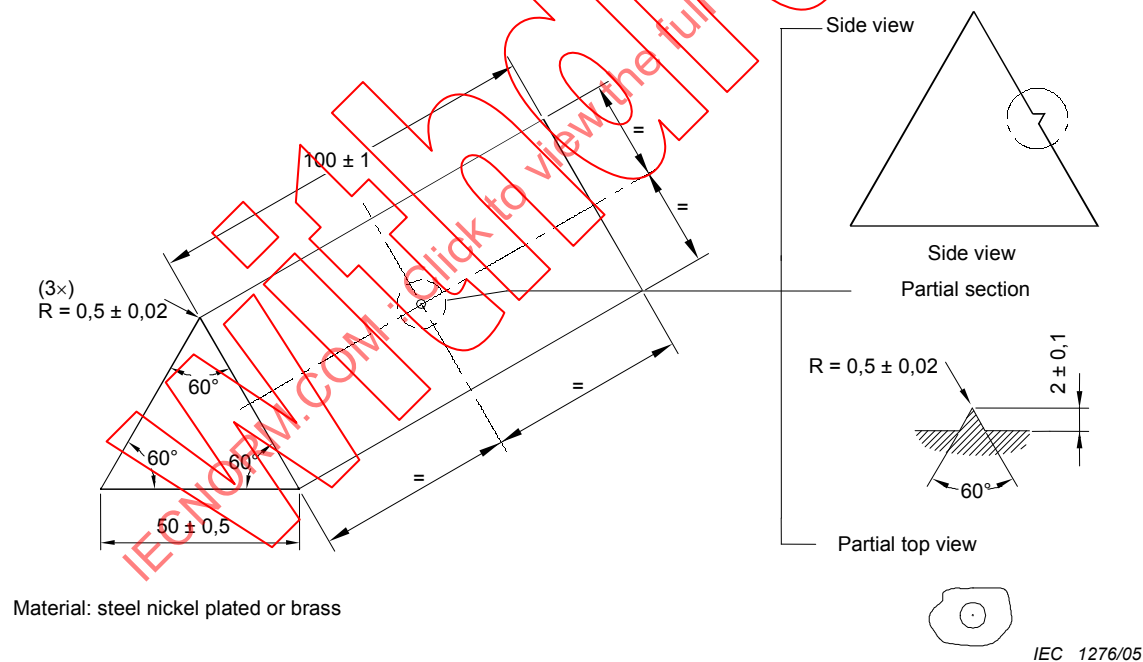
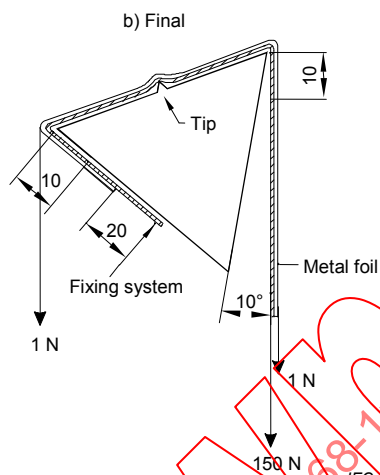
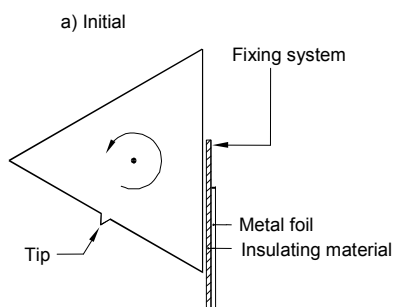


Figure 32 – Mandrel



The final position of the mandrel is rotated $230^\circ \pm 5^\circ$ from the initial position.

Figure 33 – Initial position of mandrel

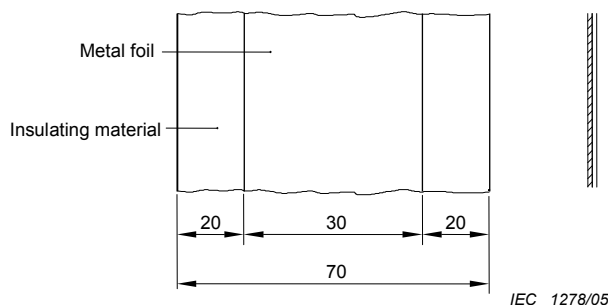
Figure 34 – Final position of mandrel

A pull is applied to the free end of the sample, using an appropriate clamping device. The mandrel is rotated:

- from the initial position (Figure 33) to the final position (Figure 34) 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, $0,035 \text{ mm} \pm 0,005 \text{ mm}$ thick, at least 200 mm long, is placed along the surface of the sample, hanging down on each side of the mandrel (see Figure 34). 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 20 mm from the edges of the sample (see Figure 35). The foil is then tightened by two equal weights, one at each end, using appropriate clamping devices.



Dimensions in millimetres

Figure 35 – 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 5.4.11.1. The test voltage is 150 % of U_{test} , but not less than 5 kV r.m.s. U_{test} is the highest of the test voltages specified in Table 31, Table 32 or Table 33 for **reinforced insulation** as appropriate.

The test is repeated on the other two samples.

5.4.4.7 Solid insulation in wound components

Planar transformers are not considered to be wound components.

NOTE 1 Planar transformers are subject to the requirements of Clause G.18.

Basic insulation, supplementary insulation or reinforced insulation in a wound component may be provided by

- the insulation on winding wire or other wire (see G.11.1); or
- other insulation (see G.11.2); or
- a combination of the two.

NOTE 2 Wound components may contain cemented joints in which case 5.4.4.5 also applies.

For **double insulation** between the conductor of a wire and another conductive part, **basic insulation** may be provided by insulation complying with G.11.1 on the wire or wires and **supplementary insulation** by additional insulation complying with G.11.2, or vice versa.

Basic insulation, supplementary insulation and reinforced insulation in the finished wound component shall pass **routine tests** for electric strength in accordance with 5.4.11.1.

5.4.4.8 Compliance

Compliance with the requirements of 5.4.4.2 to 5.4.4.7 for the adequacy of **solid insulation** is verified by inspection and measurement, taking into account Annex O, by the electric strength tests of 5.4.11.1 and the additional tests required in 5.4.4.2 to 5.4.4.7, as applicable.

5.4.4.9 Solid insulation requirements at frequencies higher than 30 kHz

The suitability of the **solid insulation** shall be determined as follows.

- Determine the value of the breakdown electric field strength of the insulation material or each individual foil at power frequency E_P in kV/mm for the insulating material. Selected materials are listed in Table 26.
- Determine the reduction factor K_R for the breakdown electric field strength of the insulating material or each individual foil at the applicable frequency from Table 27 or Table 28. If the material is not one listed in Table 27 or Table 28, use the average reduction factor in the last row of Table 27 or Table 28 as applicable.
- Determine the value of the breakdown electric field strength at the applicable frequency E_F by multiplying the value E_P with the reduction factor K_R .

$$E_F = E_P \times K_R$$

- Determine the actual electric strength V_W of the insulating material by multiplying the value E_F with the total thickness (d in mm) of the insulating material.

$$V_W = E_F \times d$$

- For **basic insulation** or **supplementary insulation**, V_W shall exceed the measured high frequency **peak working voltage** V_{PW} by 20 %.

$$V_W > 1,2 \times V_{PW}$$

- For **reinforced insulation**, V_W shall exceed twice the measured high frequency **peak working voltage** V_{PW} by 20 %.

$$V_W > 1,2 \times 2 \times V_{PW}$$

Table 26 – Electric field strength E_p for some commonly used materials

Material	Breakdown electric field strength E_p				
	kV/mm				
	Thickness of the material mm				
	0,75	0,08	0,06	0,05	0,03
Porcelain	9,2	-	-	-	-
Silicon-glass	14	-	-	-	-
Phenolic	17	-	-	-	-
Ceramic	19	-	-	-	-
Teflon	27	-	-	-	-
Melamine-glass	27	-	-	-	-
Mica	29	-	-	-	-
Paper phenolic	38	-	-	-	-
Polyethylene	50	-	-	52	-
Polystyrene	55	65	-	-	-
Glass	60	-	-	-	-
Polyethylene	49	-	-	-	-
Kapton	303	-	-	-	-
TIW	70	-	-	-	-
FR530L	33	-	-	-	-
Mica-filled phenolic	28	-	-	-	-
Glass-silicone laminate	18	-	-	-	-
Cellulose-acetobutyrate	-	-	120	-	210
Polycarbonate	-	-	160	-	270
Cellulose-triacetate	-	-	120	-	210
NOTE 1 It is assumed that materials are equal to or thicker than 0,75 mm where no thickness has been mentioned. Such materials that do not have E_p information at very small thickness actually have a better E_p value at the small thickness than the E_p value at 0,75 mm thickness.					
NOTE 2 Missing values are under investigation.					

Table 27 – Reduction factors for the value of breakdown electric field strength E_p at higher frequencies

Material ^a	Frequency kHz										
	30	100	200	300	400	500	1 000	2 000	3 000	5 000	10 000
	Reduction factor K_R										
Porcelain	0,52	0,42	0,40	0,39	0,38	0,37	0,36	0,35	0,35	0,34	0,30
Silicon-glass	0,79	0,65	0,57	0,53	0,49	0,46	0,39	0,33	0,31	0,29	0,26
Phenolic	0,82	0,71	0,53	0,42	0,36	0,34	0,24	0,16	0,14	0,13	0,12
Ceramic	0,78	0,64	0,62	0,56	0,54	0,51	0,46	0,42	0,37	0,35	0,29
Teflon	0,57	0,54	0,52	0,51	0,48	0,46	0,45	0,44	0,41	0,37	0,22
Melamine-glass	0,48	0,41	0,31	0,27	0,24	0,22	0,16	0,12	0,10	0,09	0,06
Mica	0,69	0,55	0,48	0,45	0,41	0,38	0,34	0,28	0,26	0,24	0,20
Paper phenolic	0,58	0,47	0,40	0,32	0,26	0,23	0,16	0,11	0,08	0,06	0,05
Polyethylene	0,36	0,28	0,22	0,21	0,20	0,19	0,16	0,13	0,12	0,12	0,11
Polystyrene	0,35	0,22	0,15	0,13	0,13	0,11	0,08	0,06	0,06	0,06	0,06
Glass	0,37	0,21	0,15	0,13	0,11	0,10	0,08	0,06	0,05	0,05	0,04
Other materials	0,43	0,35	0,30	0,27	0,25	0,24	0,20	0,17	0,16	0,14	0,12

^a This data is for materials that are 0,75 mm thick.

Table 28 – Breakdown electric field strength reduction values at a.c. frequency for thin foils

Thin foil material	Frequency kHz										
	30	100	200	300	400	500	1 000	2 000	3 000	5 000	10 000
	Reduction factor K_R										
Cellulose-acetobutyrate (0,03 mm)	0,67	0,43	0,32	0,27	0,24	0,20	0,15	0,11	0,09	0,07	0,06
Cellulose-acetobutyrate (0,06 mm)	0,69	0,49	0,36	0,30	0,26	0,23	0,17	0,13	0,11	0,08	0,06
Polycarbonate (0,03 mm)	0,61	0,39	0,31	0,25	0,23	0,20	0,14	0,10	0,08	0,06	0,05
Polycarbonate (0,06 mm)	0,70	0,49	0,39	0,33	0,28	0,25	0,19	0,13	0,11	0,08	0,06
Cellulose-triacetate (0,03 mm)	0,67	0,43	0,31	0,26	0,23	0,20	0,14	0,10	0,09	0,07	0,06
Cellulose-triacetate (0,06 mm)	0,72	0,50	0,36	0,31	0,27	0,23	0,17	0,13	0,10	0,10	0,06
Other thin foil materials	0,68	0,46	0,34	0,29	0,25	0,22	0,16	0,12	0,10	0,08	0,06

5.4.5 Antenna terminal insulation

5.4.5.1 General

This subclause specifies the tests for insulation

- between antenna terminals and **mains**, and
- between antenna terminals and ES1 circuits or ES2 circuits
 - isolated from the antenna circuits, and
 - having terminals for connection to **external circuits**.

The insulation shall withstand surges due to overvoltages at the antenna terminals.

This test does not apply to equipment where one antenna terminal on the equipment is connected to earth in accordance with 5.6.8.2.

NOTE In China, connection of the CATV to the main protective earthing terminal of equipment is not permitted.

If a **mains**-connected equipment provides non-**mains** supply voltages to other equipment having antenna terminals, the test shall apply between **mains** terminals and the non-**mains** supply voltage terminals.

5.4.5.2 Test method

*The insulation shall be tested as described in G.14.3.2. The equipment shall be placed on an insulating surface. The impulse test generator output shall be connected to the antenna terminals connected together and to the **mains** terminals connected together. The equipment is not energized during this test.*

*If the equipment has ES1 circuits or ES2 circuits that are isolated from the antenna circuits and that have terminals for connection to **external circuits**, the test is repeated with the generator connected to the antenna terminals connected together and the **external circuit** terminals connected together.*

NOTE Test personnel are cautioned not to touch the equipment during this test.

5.4.5.3 Compliance

Compliance is checked by measuring the insulation resistance with 500 V d.c.

The apparatus is deemed to comply with the requirement, if the insulation resistance measured after 1 min is not less than the values given in Table 29.

Table 29 – Values for insulation resistance

Insulation requirements between parts	Insulation resistance MΩ
Between parts separated by basic insulation or by supplementary insulation	2
Between parts separated by double insulation or reinforced insulation	4

5.4.6 Insulation of internal wire as a part of a supplementary safeguard

The requirements of this subclause apply where the insulation of an internal wire, alone, meets the requirements for **basic insulation**, but does not meet the requirements for **supplementary insulation**.

An example of such internal wiring is the wiring in a circuit isolated from the **mains** at a voltage level not exceeding ES1 voltage level.

These requirements apply to a wire that is located in a circuit isolated from the **mains** at a voltage level not exceeding ES1 voltage level that is isolated from ES3 by a **basic safeguard** only.

Where wire insulation is employed as part of a **supplementary insulation** system and the wire insulation is **accessible** to an **ordinary person**:

- the wire insulation does not need to be handled by the **ordinary person**;

- the wire is placed such that the **ordinary person** is unlikely to pull on it, or the wire shall be so fixed that the connecting points are relieved from strain;
- the wire is routed and fixed such as not to touch unearthed **accessible** conductive parts;
- the wire insulation passes the electric strength test of 5.4.11.1 for **supplementary insulation**;
- the distance through the wire insulation shall be at least as given in Table 30.

Table 30 – 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
>71 ≤ 350	>50 ≤ 250	0,17
>350	>250	0,31

Compliance is checked by inspection and measurement, and by the test of 5.4.11.1.

5.4.7 Thermal cycling test procedure

A sample of a component or subassembly is subjected to the following sequence of tests. The sample is subjected 10 times to the following sequence of thermal cycling:

68 h	at	$T_1 \pm 2\text{ °C}$;
1 h	at	$25\text{ °C} \pm 2\text{ °C}$;
2 h	at	$0\text{ °C} \pm 2\text{ °C}$;
≥1 h	at	$25\text{ °C} \pm 2\text{ °C}$.

$T_1 = T_2 + T_{ma} - T_{amb} + 10\text{ K}$, measured in accordance with B.1.7, or 85 °C , whichever is 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 5.4.1.5.

The significance of T_{ma} and T_{amb} are as given in B.2.6.1.

The period of time taken for the transition from one temperature to another is not specified, but the transition may be gradual.

5.4.8 Test for pollution degree 1 environment and for an insulating compound

This test is conducted when it is required to verify a **pollution degree 1** environment and when required by 5.4.4.3.

A sample is subjected to the thermal cycling sequence of 5.4.7.

It is allowed to cool to room temperature and is then subjected to the humidity conditioning of 5.4.10, followed immediately by the electric strength tests of 5.4.11.1.

Compliance is checked by inspection and measurement. There shall be no visible cracks in the insulating material. For compliance with 5.4.4.3, the sample is also sectioned, and there shall be no visible voids in the insulating material.

5.4.9 Tests for semiconductor components and for cemented joints

Three samples are subjected to the thermal cycling sequence of 5.4.7. 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 electric strength test of 5.4.11.1, immediately after the last period at $T_1 \pm 2^\circ\text{C}$ 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 5.4.11.1 after the humidity conditioning of 5.4.10, except that the test voltage is multiplied by 1,6.

Compliance is checked by inspection of the cross-sectional area and measurement. There shall be no visible voids, gaps or cracks in the insulating material. In the case of multilayer printed boards, there shall be no delamination.

5.4.10 Humidity conditioning

Humidity conditioning is carried out for 48 h in a cabinet or room containing air with a relative humidity of $93\% \pm 3\%$. The temperature of the air, at all places where samples can be located, is maintained within 2°C of any value t between 20°C and 30°C so that condensation does not occur. During this conditioning, the component or subassembly is not energized.

For tropical conditions the time duration shall be 120 h at a temperature of $40^\circ\text{C} \pm 2^\circ\text{C}$ and a relative humidity of $93\% \pm 3\%$.

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

5.4.11 Electric strength test

5.4.11.1 Test procedure for a solid insulation type test

Unless otherwise specified, compliance is checked either

- immediately following the temperature test in 5.4.1.5, or
- 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 5.4.1.5 (for example, by placing it in an oven) prior to performing the electric strength test.

Alternatively, thin sheet material for **supplementary insulation** or **reinforced insulation** may be tested at room temperature.

Unless otherwise specified elsewhere in this standard, the test voltage for the electric strength of **basic insulation**, **supplementary insulation** or **reinforced insulation** is the highest value of the following three methods:

Method 1: Determine the test voltage according to Table 31 using the **required withstand voltage** (based on transient voltages from the a.c. **mains** or d.c. **mains** or from **external circuits**).

Method 2: Determine the test voltage according to Table 32 using the **peak working voltage**.

Method 3: Determine the test voltage according to Table 33 using the nominal **mains** voltage (to cover temporary overvoltages).

The insulation is subjected to the highest test voltage as follows:

- by applying an a.c. voltage of substantially sine-wave form having a frequency of 50 Hz or 60 Hz; or
- by applying a **d.c. voltage** in one polarity and then in reverse polarity.

The voltage applied to the insulation under test is gradually raised from zero to the prescribed voltage and maintained at that value for 60 s (for **routine tests** see 5.4.11.2).

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 insulations that are not involved in the test, ICs, or the like, may be disconnected and equipotential bonding may be used. An MOV complying with Clause G.10 may be removed during the test.

For equipment incorporating **basic insulation** and **supplementary insulation** in parallel with **reinforced insulation**, care is taken that the voltage applied to the **reinforced insulation** does not overstress **basic insulation** or **supplementary insulation**.

NOTE 1 Where capacitors are in parallel with the insulation under test (for example, radio-frequency filter capacitors), d.c. test voltages should be used.

NOTE 2 Components providing a d.c. path in parallel with the insulation to be tested, such as discharge resistors for filter capacitors and voltage limiting devices, should be disconnected.

Where insulation of a transformer winding varies along the length of the winding in accordance with 5.4.1.7, an electric strength test method is used that stresses the insulation accordingly.

NOTE 3 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 required test voltage.

Table 31 – Test voltages for electric strength tests based on transient voltages

Required withstand voltage up to and including kV peak	Test voltage for basic insulation or supplementary insulation	Test voltage for reinforced insulation
	kV peak a.c. or d.c.	
0,33	0,33	0,5
0,5	0,5	0,8
0,8	0,8	1,5
1,5	1,5	2,5
2,5	2,5	4
4,0	4	6
6,0	6	8
8,0	8	12
12	12	18
U_R^a	U_R^a	$1,5 \times U_R^a$
Linear interpolation may be used between the nearest two points.		
^a U_R is any required withstand voltage higher than 12,0 kV.		

Table 32 – Test voltages for electric strength tests based on peak working voltages

Peak working voltage up to and including	Test voltage for basic insulation or supplementary insulation	Test voltage for reinforced insulation
kV peak	kV peak or d.c.	
0,33	0,43	0,53
0,5	0,65	0,80
0,8	1,04	1,28
1,5	1,95	2,4
2,5	3,25	4,0
4,0	5,20	6,40
6,0	7,80	9,60
8,0	10,40	12,8
12,0	15,60	19,2
U_P^a	$1,3 \times U_P^a$	$1,6 \times U_P^a$
^a U_P is any peak working voltage higher than 12,0 kV.		

Table 33 – Test voltages for electric strength tests based on temporary overvoltages

Nominal mains system voltage	Test voltage for basic insulation or supplementary insulation	Test voltage for reinforced insulation
V r.m.s.	V peak or d.c.	
Up to and including 250	2 000	4 000
Over 250 up to and including 600	2 500	5 000

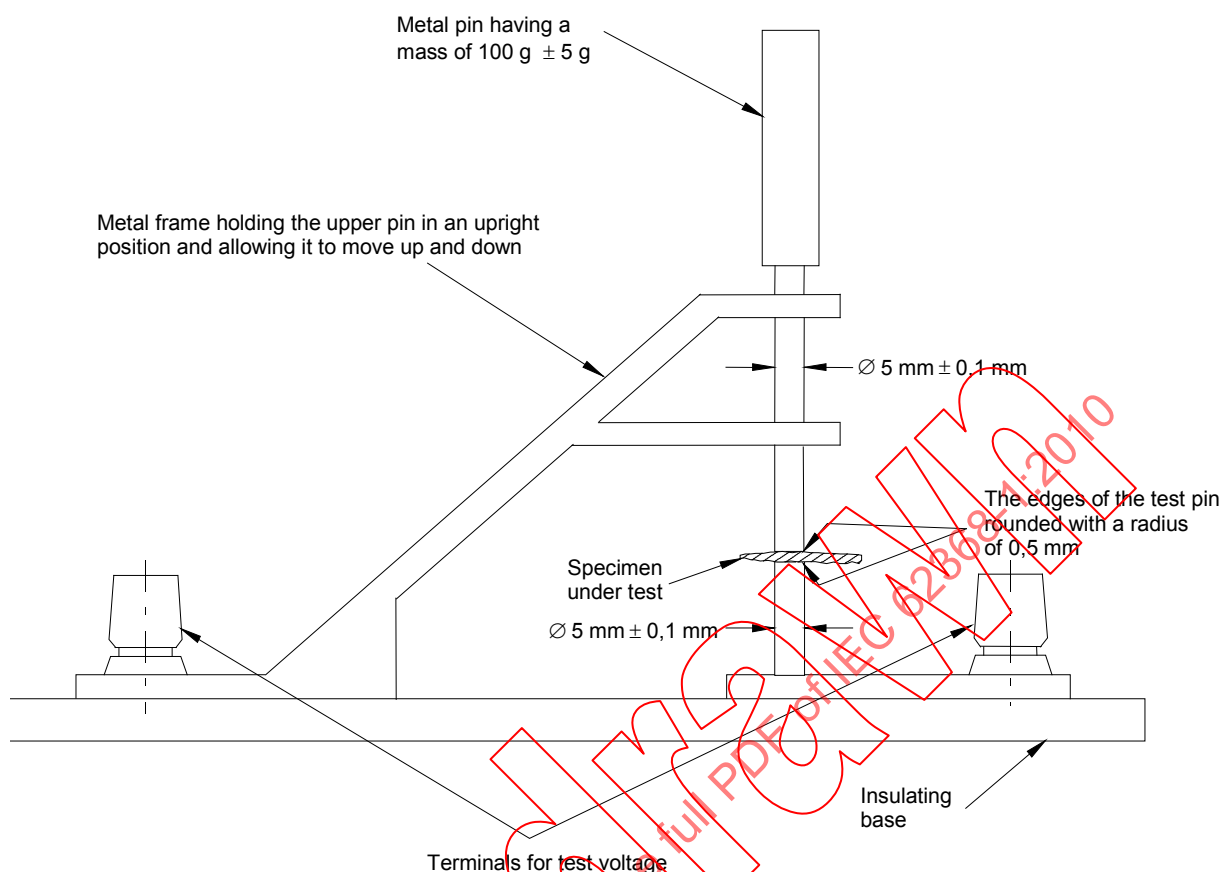


Figure 36 – Example of electric strength test instrument for solid insulation

NOTE 4 The instrument of Figure 36 may be used for testing specimens of thin sheet insulation.

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.

5.4.11.2 Test procedure for routine tests

Routine tests are performed according to 5.4.11.1, except for the following:

- the test may be performed at room temperature; and
- the duration of the electric strength test shall be between 1 s to 4 s; and
- the test voltages in Table 31, Table 32 and Table 33 may be reduced by 10 %.

NOTE The above test condition is also applicable to **routine tests** in production of the equipment or subassemblies.

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.

5.4.12 Protection against transient voltages from external circuits

5.4.12.1 Requirements

Equipment with **external circuits** as indicated in Table 16, ID numbers 11, 12, 13, 14, 15, 16, and 17 shall provide adequate electrical separation between an **external circuit** and:

- unearthed conductive parts; or
- non-conductive parts of the equipment expected to be held or otherwise maintained in continuous contact with the body during normal use (for example, a telephone handset or head set or the palm rest surface of a laptop or notebook computer); or
- another ES1 or ES2 part separated from the **external circuit**; or
- **accessible** parts and circuitry, except for the pins of connectors. However, such pins shall not be **accessible** under **normal operating conditions** by the blunt probe of Figure V.3.

5.4.12.2 Compliance and test method

*Compliance is checked by electric strength test for **basic insulation** in accordance with 5.4.11.1 applied across the electrical separation. For the tests, all conductors, including shield of coaxial cable, intended to be connected to the **external circuit** are connected together, including any conductors that may be connected to earth in the **external circuit**. Similarly, all conductors intended to be connected to other **external circuits** are connected together.*

Non-conductive parts are tested with metal foil in contact with the surface.

*The test voltage shall be selected from the highest of Table 31, Table 32 and Table 33. For parts expected to be held or touched during **normal operating conditions**, the test voltage shall be for **reinforced insulation**.*

5.4.13 Separation between external circuits and earth

5.4.13.1 General

These requirements apply only to **external circuits** indicated in Table 16, ID numbers 11, 12, 13 and 14.

These requirements do not apply to **external circuits** of:

- **permanently connected equipment**, or
- **pluggable equipment type B**; or
- **stationary pluggable equipment type A**, that is intended to be used in a location having equipotential bonding (such as a telecommunication centre, a dedicated computer room or a **restricted access area**) and has installation instructions that require verification of the **protective earthing connection** of the socket-outlet by a **skilled person**; or
- **stationary pluggable equipment type A**, that has provision for a permanently connected **protective earthing conductor**, including instructions for the installation of that conductor to building earth by a **skilled person**.

NOTE In Norway and Sweden, the exclusions are applicable for **permanently connected equipment**, **pluggable equipment type B** and equipment intended to be used in a **restricted access area** 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 **skilled person**.

5.4.13.2 Requirements

There shall be insulation between circuitry intended to be connected to **external circuits** mentioned above and any parts or circuitry that will be earthed in some applications, either within the EUT or via other equipment.

SPDs that bridge the insulation between ES1 or ES2 **external circuits** and earth 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 a.c. **mains** 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 SPD production. If this is not specified by the SPD manufacturer, ΔU_{sp} shall be taken as 10 % of the rated operating voltage of the SPD.

ΔU_{sa} is the maximum increase of the rated operating voltage due to the SPD ageing over the expected life of the equipment. If this is not specified by the SPD manufacturer, ΔU_{sa} shall be taken as 10 % of the rated operating voltage of the SPD.

NOTE ($\Delta U_{sp} + \Delta U_{sa}$) may be a single value provided by the component manufacturer.

5.4.13.3 Compliance and test method

Compliance is checked by inspection and by the electric strength test of 5.4.11.1.

Components that bridge the insulation, other than capacitors, may be removed during electric strength testing. Components that are left in place during the test shall not be damaged.

If components are removed, the following additional test with a test circuit according to Figure 37 is performed with all components in place.

*For equipment powered from a.c. **mains**, 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 d.c. **mains**, the test is performed with a voltage equal to the highest nominal voltage of the a.c. **mains** 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 37 shall not exceed 10 mA.

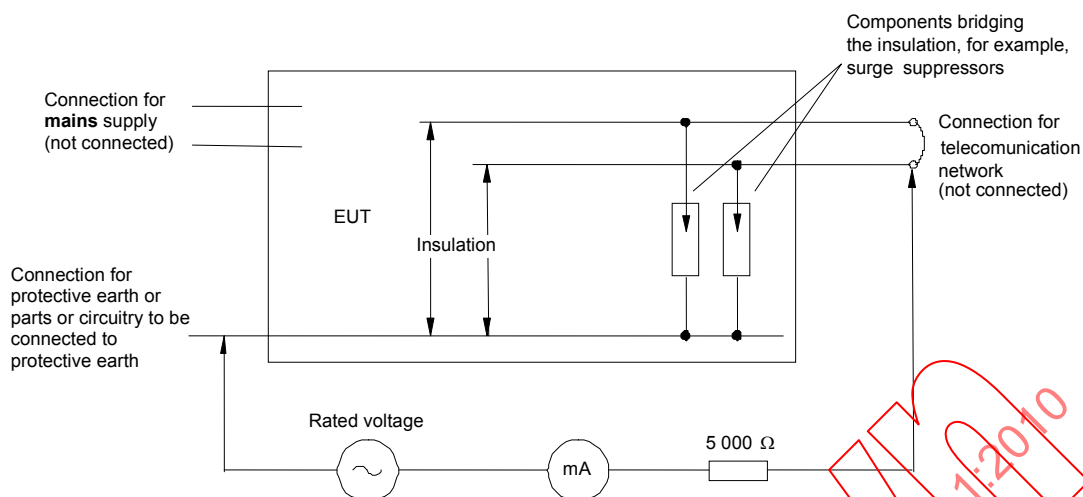


Figure 37 – Test for separation between a telecommunication network and earth

5.5 Components as safeguards

5.5.1 General

This subclause specifies applications of components that serve as (electrical) **safeguards** or that bridge **safeguards**.

NOTE See Annex G for the qualification of safety components.

If a component bridges a **safeguard**, then it shall also comply with all the requirements for that **safeguard** as applicable.

5.5.2 Components as basic safeguard and supplementary safeguard

5.5.2.1 General requirements

For components used as a **basic safeguard**, the insulation shall comply with **basic insulation**.

For components used as a **supplementary safeguard**, the insulation shall comply with **supplementary insulation**.

Components may be used as a **basic safeguard** or **supplementary safeguard**, but only if used within their ratings.

5.5.2.2 Capacitors and RC units as a basic safeguard and a supplementary safeguard

Capacitors and RC units may be used as **basic safeguards**. If capacitors and RC units are used as **basic safeguards** then they shall comply with the requirements for **basic insulation** between their terminations for the total **working voltage** across the insulation and shall comply with the requirements as specified in Clause G.15.

NOTE 1 RC units may consist of discrete components.

The requirements of Clause G.15 do not apply to the **basic insulation** provided between:

- ES3 isolated from the **mains** and protective earth; and
- ES2 and protective earth; and

- ES2 and ES1.

The test of 5.4.11.1 still applies to the above capacitors.

Capacitors and RC units may be used as a **supplementary safeguard**. If capacitors and RC units are used as a **supplementary safeguard** then they shall comply with the requirements for **supplementary insulation** between their terminations for the total **working voltage** across the insulation and shall comply with the safety requirements as specified in Clause G.15.

For a capacitor used as a **basic safeguard** or as a **supplementary safeguard**, the peak impulse test voltage of the capacitor shall be at least equal to the **required withstand voltage**.

If a **basic safeguard** or a **supplementary safeguard** consists of more than one capacitor, all of the following applies:

- under **single fault conditions**, the voltage on each of the remaining individual capacitors shall not exceed the voltage rating of the relevant individual capacitors;
- the sum of the peak impulse test voltages of all capacitors shall be not less than the **required withstand voltage**;
- the sum of the r.m.s. test voltages of all capacitors shall be not less than the highest of the required test voltage of Table 31, Table 32 and Table 33.

NOTE 2 It is common practice to have the same rated capacitance value and same rated voltage for all capacitors in series.

NOTE 3 In Norway, due to the IT power system used, capacitors are required to be rated for the applicable line-to-line voltage (230 V).

Class X capacitors may be used as **basic safeguards** in circuits isolated from the **mains** but shall not be used as:

- a **basic safeguard** in circuits connected to the **mains**; or
- a **supplementary safeguard**.

5.5.2.3 Safeguards against capacitor discharge

For an **ordinary person**, where a capacitor voltage is **accessible**, or becomes **accessible** upon disconnection of a connector (for example, the **mains** connector), either

- the combination of capacitance and voltage shall comply with ES1 limits of Table 7, or
- the circuit shall be provided with a means for discharging the capacitor to ES1 limits of Table 7 within 2 s.

For an **instructed person**, where a capacitor voltage is **accessible**, or becomes **accessible** upon disconnection of a connector (for example, the **mains** connector), either

- the combination of capacitance and voltage shall comply with ES2 limits of Table 7 or
- the circuit shall be provided with a means for discharging the capacitor to ES2 limits of Table 7 within 2 s.

NOTE The limits apply both to the capacitor itself and to the circuit that charges it.

5.5.2.4 Transformers as a basic safeguard and a supplementary safeguard

Insulation of transformers used as a **basic safeguard** shall comply with **basic insulation** requirements or with the safety requirements of the relevant IEC standard described in Clause G.7. Insulation of transformers used as a **supplementary safeguard** shall comply with

supplementary insulation requirements and Clause G.7 or with the safety requirements of the relevant IEC standard described in Clause G.7.

5.5.2.5 Optocouplers as basic safeguard and supplementary safeguard

Insulation of optocouplers used as a **basic safeguard** shall comply with **basic insulation** requirements or with the safety requirements of the IEC standard (see Clause G.16). Insulation of optocouplers used as a **supplementary safeguard**, shall comply with **supplementary insulation** requirements or with the safety requirements of the IEC standard (see Clause G.16).

5.5.2.6 Relays as a basic safeguard and a supplementary safeguard

Insulation of relays used as a **basic safeguard** shall comply with **basic insulation** requirements or with the safety requirements of the IEC standard as described in Clause G.17.

Insulation of relays used as a **supplementary safeguard** shall comply with **supplementary insulation** requirements or with the safety requirements of the IEC standard as described in Clause G.17.

5.5.2.7 Resistors as a basic safeguard and a supplementary safeguard

Resistors may be used as a **basic safeguard**. If resistors are used as a **basic safeguard**, then they shall comply with the **clearance** and **creepage distance** requirements for **basic insulation** between its terminations for the total **working voltage** across the insulation.

Resistors may be used as a **supplementary safeguard**. If resistors are used as a **supplementary safeguard**, they shall comply with the **clearance** and **creepage distance** requirements for **supplementary insulation** between their terminations for the total **working voltage** across the insulation.

Basic insulation or **supplementary insulation** may be bridged by one resistor or by a group of two or more resistors in series under the following conditions.

The resistor or group of resistors shall comply with the minimum **clearances** of 5.4.2 and the minimum **creepage distances** of 5.4.3 for **basic insulation** or **supplementary insulation** as applicable for the total **working voltage** across the resistor or group. For a group of resistors, see Figure O.4.

If a single resistor is used, it shall pass the resistor test of G.14.2.

If a group of resistors is used, the **clearance** and **creepage distance** are assessed as if each resistor were short-circuited in turn, unless the group passes the resistor test of G.14.2.

5.5.2.8 SPD as a basic safeguard

An SPD may be used as a **basic safeguard** provided that one side of the SPD is earthed according to 5.6.8.2.

A MOV used as a **basic safeguard** shall comply with the requirements of Clause G.10.

5.5.2.9 Other components as a basic safeguard between ES1 and ES2

Any type of component may be used as a **basic safeguard** provided that:

- two components are in series if a separation is required; or
- two components are in parallel if bonding (connection) is required.

Each component shall be used within its rating.

Components bridging **basic insulation** serving as a **basic safeguard** between ES1 and ES2 shall meet the applicable electric strength test in accordance with 5.4.11.1.

5.5.3 Components as a reinforced safeguard

5.5.3.1 General requirements

For components used as a **reinforced safeguard**, the insulation shall comply with **reinforced insulation**.

A component used as a **reinforced safeguard** shall be used within its rating.

5.5.3.2 Capacitors and RC units

Capacitors and RC units may be used as a **reinforced safeguard** provided they comply with the requirements for **reinforced insulation** between their terminations for the total **working voltage** across the insulation. The capacitors and RC units shall comply with IEC 60384-14 as given in Clause G.15.

Class X capacitors shall not be used as a **reinforced safeguard**.

If a **reinforced safeguard** consists of more than one capacitor, all of the following applies:

- under **single fault conditions**, the voltage on each of the remaining individual capacitors shall not exceed the voltage rating of the relevant individual capacitors;
- the sum of the peak impulse test voltages of all capacitors shall be not less than twice the **required withstand voltage**;
- the sum of the r.m.s. test voltages of all capacitors shall be not less than the highest of the required test voltage of Table 31, Table 32 and Table 33.

5.5.3.3 Transformers

Transformers used as a **reinforced safeguard** shall comply with the requirements of **reinforced insulation** and Clause G.7.

5.5.3.4 Optocouplers

Insulation of optocouplers used as a **reinforced safeguard** or **double safeguard** shall comply with **reinforced insulation** requirements or with the safety requirements of the IEC standard described in Clause G.16.

5.5.3.5 Relays

Insulation of relays used as a **reinforced safeguard** or **double safeguard** shall comply with **reinforced insulation** requirements or with the safety requirements of the IEC standard as described in Clause G.17.

5.5.3.6 Resistors

Resistors may be used as a **reinforced safeguard** provided they comply with the **clearance** and **creepage distance** requirements for **reinforced insulation** between their terminations for the total **working voltage** across the insulation.

Double insulation or **reinforced insulation** may be provided by one resistor or by a group of two or more resistors in series, under the following conditions:

- the resistor or group of resistors shall comply with the minimum **clearances** of 5.4.2; and

- the minimum **creepage distances** of 5.4.3 for **reinforced insulation**, as applicable for the total **working voltage** across the resistor or group. For a group of resistors, see Figure O.4.

If a single resistor is used, it shall pass the resistor test of G.14.2.

If a group of resistors is used, the **clearance** and **creepage distance** are assessed as if each resistor were short-circuited in turn, unless the group passes the resistor test of G.14.2.

5.5.4 Insulation between the mains and an external circuit consisting of a coaxial cable

Except as specified below, the insulation between the **mains** and the terminal or lead provided for the connection to a coaxial cable including the resistor bridging this insulation, if any, shall pass either:

- the voltage surge test of G.14.3.2 for equipment intended to be connected to a coaxial cable connected to an outdoor antenna; or
- the impulse test of G.14.3.3 for equipment intended to be connected to another coaxial cable.

If the insulation and the bridging resistor are subject to overvoltages from both an outdoor antenna and another coaxial cable, they shall pass the tests of G.14.3.2 and G.14.3.3.

The above requirement does not apply to the insulation and to the resistor bridging the insulation, if any, in any of the following equipment:

- indoor use equipment, provided with a built-in (integral) antenna and not provided with a connection to a coaxial cable; or
- equipment connected to a reliable earth in accordance with 5.6.8.3.

Compliance is checked by inspection and, if necessary, by the voltage surge test of G.14.3.2 or impulse test of G.14.3.3 as referenced in G.14.3.

NOTE **Clearances** are determined by the requirements of 5.4.2. It may be necessary to increase the **clearances** between **mains** and circuits isolated from the **mains** intended for connection to an antenna or a coaxial cable.

5.5.5 Components and parts that may bridge insulation

5.5.5.1 Requirement

Where a component or part could bridge insulation where failure of that insulation would result in class 2 energy sources or class 3 energy sources becoming **accessible**, the component or part shall withstand the test of Clause T.2.

5.5.5.2 Compliance

*During the test, no short-circuit shall occur. After the test, no **equipment safeguards** shall be defeated.*

5.6 Protective conductor

5.6.1 General requirements

This subclause specifies the general, performance and size requirements for **protective conductors** that serve as a **basic safeguard** or a **supplementary safeguard** or a **reinforced safeguard**.

Protective conductors and their terminations shall not have excessive resistance (see 5.6.6.4).

The current-carrying capacity of **protective conductors** shall be adequate for the duration of the fault current under **single fault conditions**.

Protective conductors shall not contain switches or overcurrent protective devices.

Protective bonding conductors shall be such that disconnection (for example, for servicing) of a **protective conductor** at one point in a unit or a system does not break the protective bonding connection to other parts or units in a system, unless the disconnection also breaks the supply to that part or unit at the same time.

Protective conductors shall make contact earlier and disconnect later than the supply connections in each of the following:

- a connector (on a cable) or a connector attached to a part or a subassembly that can be removed by other than a **skilled person**;
- a plug on a power supply cord;
- an appliance coupler.

NOTE It is recommended that this construction also be applied when it is expected that the **skilled person** will replace powered parts and assemblies while the equipment is operational.

For low current-carrying **protective conductors**, only the requirements of 5.6.3 and the test of 5.6.4 are required.

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

5.6.2 Corrosion

Conductive parts in contact at the main protective earthing terminal, protective bonding terminals and connections shall be selected in accordance with Annex N so that the potential difference between any two different metals is 0,6 V or less.

Compliance is checked by inspection.

5.6.3 Colour of insulation

The insulation of the **protective earthing conductor** 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, if provided, may be transparent;
- a **protective bonding conductor** in assemblies such as ribbon cables, bus bars, printed wiring, etc., may be of any colour provided that no misinterpretation of the use of the conductor is likely to arise.

Compliance is checked by inspection.

5.6.4 Test for low current-carrying protective conductors

*For a part receiving its power from an **external circuit**, the test current is 1,5 times the maximum current available from the **external circuit**, for a duration of 120 s.*

*For parts connected to the **protective bonding conductor** to limit the transients or to limit touch current to an **external circuit** and that do not exceed an ES2 level during **single fault conditions**, the test is conducted in accordance with 5.6.6.4.2. The relevant test method and criteria of either a), b), c) or d) shall be applied based on the power source assumed.*

Compliance is checked by measuring the voltage drop or resistance as applicable between the main protective earthing terminal and the point in the equipment that is required to be earthed.

5.6.5 Protective conductors used as a basic safeguard between ES1 and ES2

5.6.5.1 General

This subclause specifies the general, performance and size requirements for **protective conductors** that serve as a **basic safeguard** between ES1 and ES2.

5.6.5.2 Fault current-carrying protective conductors

5.6.5.2.1 General

This subclause specifies the application of **protective conductors** that serve as a **basic safeguard** but may have to carry fault currents.

5.6.5.2.2 Requirements

Protective conductors may serve as **basic safeguards** between ES1 and ES2:

- for **accessible** conductive parts not exceeding an ES2 level during **single fault conditions**;
- to maintain the integrity of parts at ES1 level during **normal operating conditions** provided that parts do not exceed an ES2 level during **single fault conditions**;
- to maintain the integrity of parts at an ES2 level during **normal operating conditions** provided that parts do not exceed an ES2 level during **single fault conditions**.

The size of the **protective earthing conductors** shall comply with 5.6.6.2 and for **protective bonding conductors** with 5.6.6.3.

5.6.5.2.3 Compliance

*Compliance is checked by inspection and measurement of **protective earthing conductor** and **protective bonding conductor** sizes in accordance with 5.6.6.2 or 5.6.6.3 as applicable.*

5.6.6 Protective conductors used as a supplementary safeguard

5.6.6.1 General

Protective conductors may serve as a **supplementary safeguard**:

- for parts that might otherwise assume an ES3 level during **single fault conditions** (if a **supplementary safeguard** was not provided), or
- to limit transient voltages that might affect **basic insulation** for parts that could not exceed an ES2 level during **single fault conditions**, or
- to limit **touch current** to an **external circuit**.

5.6.6.2 Size of protective earthing conductors and terminals

Protective earthing conductors shall comply with the minimum conductor sizes in Table 34.

Terminals that are used in a connection of a **protective earthing conductor** shall comply with the minimum terminal sizes in Table 36.

*Compliance is checked by inspection and measurement of **protective bonding conductor** sizes in accordance with Table 34 and terminal sizes in Table 36, as applicable.*

Table 34 – Sizes of conductors

Rated current of equipment A up to and including	Minimum conductor sizes	
	Nominal cross-sectional area mm ²	AWG [cross-sectional area in mm ²] see NOTE 2
6	0,75 ^a	18 [0,8]
10	1,00 (0,75) ^b	16 [1,3]
16	1,50 (1,0) ^c	14 [2]
25	2,5	12 [3]
32	4	10 [5]
40	6	8 [8]
63	10	6 [13]
80	16	4 [21]
100	25	2 [33]
125	35	1 [42]
160	50	0 [53]
190	70	000 [85]
230	95	0000 [107]
		kcmil [cross-sectional area in mm ²] see NOTE 2
260	120	250 [126]
300	150	300 [152]
340	185	400 [202]
400	240	500 [253]
460	300	600 [304]
NOTE 1 IEC 60320-1 specifies acceptable combinations of appliance couplers and flexible cords, including those covered by items a, b and c. However, a number of countries have indicated that they do not accept all of the values listed in Table 34, particularly those covered by items a, b and c. 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 "smil" refers to circular mils where one circular mil is equal to the area of a circle having a diameter of one mil (one thousandth of an inch). These terms are commonly used to designate wire sizes in North America. NOTE 3 For higher currents see the IEC 60364 series.		
^a For rated current up to 3 A, a nominal cross-sectional area of 0,5 mm² may be used 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 60320-1 (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 60320-1 (types C19, C21 and C23) provided that the length of the cord does not exceed 2 m.		

5.6.6.3 Size of protective bonding conductors and terminals

Protective bonding conductors and their terminals shall comply with one of the following:

- the minimum conductor sizes in Table 34 and terminal sizes in Table 36; or
- the requirements of 5.6.6.4 and also, if the **protective current rating** of the circuit is more than 16 A, with the minimum conductor sizes in Table 35 and terminal sizes that are not more than one size smaller than in Table 36; or

- the requirements of 5.6.6.4 and also, if the **protective current rating** of the circuit does not exceed 16 A; either
 - with the minimum conductor sizes in Table 35 and terminal sizes that are not more than one size smaller than in Table 36; or
 - with the limited short-circuit test of Annex R;
- for components only, be not smaller than the conductors supplying power to the component.

NOTE 1 The value of **protective current rating** (above) is used in Table 35 and in the test of 5.4.5.2.

Where the source is the **mains** supply, the **protective current rating** of the circuit is the rating of the overcurrent protective device provided in, or as part of the equipment. Where the overcurrent protective device is so provided, then:

- 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 2 In most countries, 16 A is considered to be suitable as the **protective current rating** of the circuit.

NOTE 3 In Canada and the USA, the **protective current rating** of the circuit is taken as 20 A.

NOTE 4 In the UK and Ireland the **protective current rating** is taken to be 13 A, this being the largest rating of fuse used in the **mains** plug.

- for **pluggable equipment type B**, and **permanently connected equipment** 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.

Where the source is an external supply having the maximum current inherently limited by the internal source impedance (such as an impedance protected transformer) the **protective current rating** of the circuit is the highest current available from that supply into any load. Where the maximum current from the external supply source is limited by electronic components in the source, the **protective current rating** shall be taken as the maximum output current with any resistive load including a short circuit measured 60 s after the application of the load if the current is limited by impedance or the current limiting device is a fuse, a circuit breaker or a PTC device, or 5 s in other cases.

The current limiting device or the overcurrent protective device (fuse, a circuit breaker or a PTC device) shall not be connected in parallel with any other component that could fail to a low-resistance state.

Where the source is a circuit within the equipment, the **protective current rating** of the circuit is:

- the rating of the overcurrent protective device if the current is limited by an overcurrent protective device; or
- the maximum output current, if the current is limited by the source impedance of the supply. The output current is measured with any resistive load including a short circuit measured 60 s after the application of the load if current is limited by impedance or the current limiting device is a fuse, a circuit breaker or a PTC device, or 5 s in other cases.

The current limiting device or the overcurrent protective device (fuse, a circuit breaker or a PTC device) shall not be connected in parallel with any other component that could fail to a low-resistance state.

Table 35 – Minimum protective bonding conductor size of copper conductors

Protective current rating of the circuit under consideration A up to and including	Minimum conductor sizes	
	Cross-sectional area mm ²	AWG or kcmil [cross-sectional area in mm ²]
6	0,5	20 [0,519]
10	0,75	18 [0,8]
13	1,0	16 [1,3]
16	1,25	16 [1,3]
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]
		kcmil [cross-sectional area in mm²]
300	120	250 [126]
340	150	300 [152]
400	185	400 [202]
460	240	500 [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 one circular mil is equal to (diameter in mils) ² . These terms are commonly used to designate wire sizes in North America.		

Compliance is checked by inspection and measurement of **protective bonding conductor** sizes and terminal sizes.

5.6.6.4 Resistance of protective conductors and their terminations

5.6.6.4.1 Requirements

Protective conductors and their terminations shall not have excessive resistance. **Protective conductors** that meet the minimum conductor sizes in Table 34 throughout their length and whose terminals all meet the minimum sizes in Table 36 are considered to comply without test.

Table 36 – Sizes of terminals for protective conductors

Rated current A up to and including	Conductor size mm ² (from Table 34)	Minimum nominal thread diameter mm		Area of cross section mm ²	
		Pillar type or stud type	Screw type ^a	Pillar type or stud type	Screw type ^a
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	6,0	6,0	28	28
80	16	7,9	7,9	49	49

^a "Screw type" refers to a terminal that clamps the conductor under the head of a screw, with or without a washer.

For **rated currents** above 80 A, the **protective earthing conductor** shall 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 34 or Table 35 as applicable.

The terminals shall comply with IEC 60998-1 and IEC 60999-1 or IEC 60999-2.

5.6.6.4.2 Compliance and test method

This subclause specifies the test requirements for **protective bonding conductors** that do not comply with the size requirements of Table 34 and Table 36.

Compliance is checked by inspection, measurement and, for **protective bonding conductors** that do not meet the minimum conductor sizes in Table 34 throughout their length or whose terminals do not all meet the minimum sizes in Table 36, 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 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, the conductor may be included 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 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 may only be used if the cable is protected by a suitably rated protective device that takes into account the size of the conductor.

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 the **mains**, if the **protective current rating** of the circuit under test 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 the **mains**, if the **protective current rating** of the circuit under test exceeds 16 A, the test current is 200 % of the **protective current rating** or 500 A, whichever is less, and the duration of the test is as shown in Table 37.

Table 37 – Test duration, mains connected equipment

Protective current rating of the circuit A up to and including	Duration of the test min
30	2
60	4
100	6
200	8
over 200	10

The voltage drop in the **protective bonding conductor** for test currents up to 500 A shall not exceed 2,5 V. For equipment requiring branch circuit fusing over 250 A, the measured potential voltage drop multiplied by the required fusing and divided by 250 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 may be 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 d.c. supply system, 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.

5.6.7 Protective earthing conductors serving as a double or reinforced safeguard

5.6.7.1 General

This subclause specifies requirements for enhanced **protective earthing conductors** and their terminations (for example, when the **touch current** exceeds the ES2 limits in Table 4, see also 5.7.6).

Protective conductors serving as a **double safeguard** or **reinforced safeguard** shall comply with the applicable requirements of 5.6.1, 5.6.3 and 5.6.6.

5.6.7.2 Requirements for protective earthing conductors serving as a reinforced safeguard

A **reinforced safeguard protective earthing conductor** may be employed on **pluggable equipment type B** or on **permanently connected equipment** only and shall:

- be included in and protected by a sheathed supply cord not lighter than heavy duty:
 - PVC sheathed flexible cord according to IEC 60227-1 (designations 60227; IEC 52 or IEC 53) or
 - rubber-sheathed flexible cord according to IEC 60245-1 (designations 60245; IEC 53, IEC 57 or IEC 58);
- or
- have a minimum conductor size not less than 10 mm² (to resist mechanical damage); or
- be protected by a conduit and have a minimum size in accordance with Table 38.

NOTE For **mains** supply cords, see also Clause G.9.

Table 38 – Protective earthing conductor sizes for reinforced safeguards for permanently connected equipment

Protection provided by	Minimum protective earthing conductor size mm ²
Non-metallic flexible conduit	4 ^a
Metallic flexible conduit	2,5 ^a
Non-flexible metal conduit	1,5 ^a
^a The protective earthing conductor is installed by a skilled person .	

5.6.7.3 Requirements for terminations

The terminations shall have reliable securement and shall comply with Table 36.

5.6.7.4 Compliance

Compliance is checked by inspection and measurement.

5.6.8 Reliable earthing

5.6.8.1 General

This subclause specifies situations where the equipment connection to earth is considered reliable (for example, when a SPD is provided in accordance with 5.5.2.8).

5.6.8.2 Reliable earthing for protection

For **mains** connected equipment connected to **external circuits** indicated in Table 16, ID numbers 11, 12, 13, 14, 15, 16 and 17, earthing is considered reliable for the following:

- **permanently connected equipment**; or
- **pluggable equipment type B**; or
- **stationary pluggable equipment type A**, that is intended to be used in a location having equipotential bonding (such as a telecommunication centre, a dedicated computer room or a **restricted access area**) and has installation instructions that require verification of the **protective earthing connection** of the socket-outlet by a **skilled person**; or

- **stationary pluggable equipment type A** that has provision for a permanently connected **protective earthing conductor**, including instructions for the installation of that conductor to building earth by a **skilled person**.

5.6.8.3 Reliable earthing when the basic safeguard between ES1 and ES2 is provided by earthing ES1

For equipment connected to an **external circuit**, such as a indicated in Table 16, ID numbers 11, 12, 13, 14, 15, 16 and 17, earthing is considered reliable for the following:

- **permanently connected equipment**; or
- **pluggable equipment type A** and **pluggable equipment type B**, that have provision for a permanently connected **protective earthing conductor**, including instructions for the installation of that conductor to building earth by a **skilled person**.

5.7 Prospective touch voltage, touch current and protective conductor current

5.7.1 General

This subclause specifies the equipment test environment, the equipment configuration, the equipment earthing, the equipment supply system connections, and the measurement processes for measurement of **prospective touch voltage**, **touch current**, and **protective conductor current**.

5.7.2 Measuring devices and networks

For measurements of **touch current**, the instrument used for measuring U_2 and U_3 specified in Figures 4 and 5 respectively in IEC 60990:1999 shall indicate peak voltage. If the **touch current** waveform is sinusoidal, an r.m.s. indicating instrument may be used.

NOTE 1 The effect of the instrument impedance on the measured voltage should be negligible.

NOTE 2 Many commercial **touch current** instruments provide a direct reading of the r.m.s. value of weighted current, thereby not requiring a calculation from voltage to current. Some commercial **touch current** instruments also provide a direct reading of the peak value of weighted current.

5.7.3 Equipment set-up, supply connections and earth connections

The equipment set-up, equipment supply connections and equipment earthing shall be in accordance with Clause 4 and 5.3 and 5.4 of IEC 60990:1999.

Equipment provided with a connection to earth separate from the **protective conductor** shall be tested with that connection disconnected.

Systems of interconnected equipment with separate connections to the **mains** shall have each equipment tested separately.

Systems of interconnected equipment with one connection to the **mains** shall be tested as a single equipment.

NOTE Systems of interconnected equipment are specified in more detail in Annex A of IEC 60990:1999.

Equipment that is designed for multiple connections to the **mains**, where only one connection is required at a time, shall have each connection tested while the other connections are disconnected.

Equipment that is designed for multiple connections to the **mains**, where more than one connection is required, shall have each connection tested while the other connections are connected, with the **protective earthing conductors** connected together. If the **touch current** exceeds the limit in 5.2.2.2, the **touch current** shall be measured individually.

5.7.4 Unearthed conductive accessible parts

5.7.4.1 Unearthed conductive parts accessible to ordinary persons

All unearthed conductive parts **accessible** to **ordinary persons** shall be tested first for **prospective touch voltage** with respect to earth and with respect to other unearthed conductive parts **accessible** to **ordinary persons**.

If the **prospective touch voltage** exceeds the ES1 limits in 5.2.2.2, such parts shall be tested for **touch current** in accordance with 5.1.1 and 6.2.1 of IEC 60990:1999. The **touch current** shall not exceed the ES1 limits in 5.2.2.2.

If the **prospective touch voltage** or **touch current** do not exceed the ES1 limits in 5.2.2.2, then the part shall be additionally tested for **prospective touch voltage**

- following simulated or actual fault of the applicable **basic safeguard**, and
- following simulated or actual fault of the applicable **supplementary safeguard**.

Safeguard faults are introduced one at a time; the **basic safeguard** and the **supplementary safeguard** are not faulted at the same time.

If the **prospective touch voltage** does not exceed the ES2 limits in 5.2.2.2, the test is concluded.

If the **prospective touch voltage** exceeds the ES2 limits in 5.2.2.2, such parts shall be tested for **touch current** in accordance with 6.2.2 of IEC 60990:1999, except 6.2.2.7. The **touch current** shall not exceed the ES2 limits in 5.2.2.2.

NOTE 1 For parts connected to a common point, only one such part need be tested.

NOTE 2 If the unearthed **accessible** parts are isolated from the **mains** so that the fault conditions specified in 6.2.2 of IEC 60990:1999 do not alter the **prospective touch voltage** or **touch current**, then the fault condition tests need not be performed.

5.7.4.2 Unearthed conductive parts accessible only to instructed persons

All unearthed conductive parts **accessible** only to **instructed persons** shall be tested first for **prospective touch voltage** with respect to earth and with respect to other unearthed conductive parts **accessible** to **instructed persons**.

If the **prospective touch voltage** does not exceed the ES2 limits in 5.2.2.2, the test is concluded.

If the **prospective touch voltage** exceeds the ES2 limits in 5.2.2.2, such parts shall be tested for **touch current** in accordance with 5.1.2 and 6.2.2 of IEC 60990:1999, except 6.2.2.7. The **touch current** shall not exceed the ES2 limits in 5.2.2.2.

NOTE For parts connected to a common point, only one such part need be tested.

5.7.5 Earthed accessible conductive parts

At least one earthed **accessible** conductive part shall be tested for **touch current** following supply connection faults in accordance with 6.1 and 6.2.2 of IEC 60990:1999, except 6.2.2.7. Except as permitted in 5.7.6, the **touch current** shall not exceed the ES2 limits in 5.2.2.2.

Subclause 6.2.2.2 of IEC 60990:1999 does not apply to equipment with a switch or other **disconnect device** that disconnects all poles of the supply.

NOTE An appliance coupler is an example of a **disconnect device**.

5.7.6 Protective conductor current

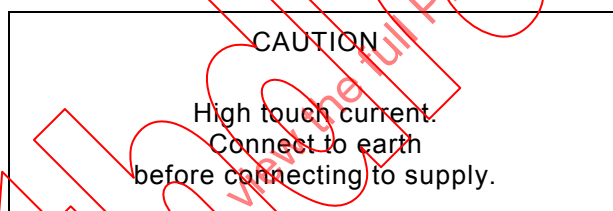
The **protective conductor current** shall be measured in accordance with Clause 8 of IEC 60990:1999.

Except as specified below, the **protective conductor current** shall not exceed the ES2 limits in 5.2.2.2.

If the **protective conductor current** exceeds the ES2 limits in 5.2.2.2, the current shall not exceed 5 % of the measured input current, and the construction of the **protective conductor** circuit and its connections shall comprise a **reinforced safeguard** (see 5.6.7.2).

The input current is measured under the same conditions as the **touch current**.

Where the **protective conductor current** exceeds the ES2 limits of Table 4, an **instructional safeguard** shall be affixed to the equipment adjacent to the equipment supply connection in accordance with Clause F.5. The **instructional safeguard** shall indicate high **touch current**, and shall require connection of the **protective conductor** prior to connection of the supply voltage with the following or equivalent wording:



5.7.7 Prospective touch voltage and touch current due to external circuits

For **external circuits** connected to a coaxial cable, the manufacturer shall provide instructions to connect the shield of the coaxial cable to building earth in accordance with 6.2 g) and 6.2 l) of IEC 60728-11:2005.

NOTE For Norway and Sweden, see NOTE 1 to Table 16.

5.7.8 Summation of touch currents from external circuits

This subclause determines when a permanently connected **protective earthing conductor** is required for **pluggable equipment type A** or **pluggable equipment type B**, should the **mains** connection be disconnected.

This subclause only applies to equipment with **external circuits** such as described in Table 16, ID numbers 11, 12, 13, 14, 15, 16, and 17.

NOTE These types of **external circuits** are typically telecommunication networks.

The summation of **touch currents** from equipment that provides multiple **external circuits**, shall not exceed the limits for ES2 (see Table 4).

In this subclause, the following abbreviations are used:

- I_1 : **touch current** received from other equipment via a network at an **external circuit** of the equipment;

- $S(I_1)$: summation of **touch current** received from other equipment at all such **external circuit** of the equipment;
- I_2 : **touch current** due to the **mains** of the equipment.

It shall be assumed that each **external circuit** 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) Equipment with earthed **external circuit**

For equipment in which each **external circuit** is connected to a terminal for the **protective earthing conductor** of the equipment, the following items 1), and 2) shall be considered:

- 1) If $S(I_1)$ (not including I_2) exceeds ES2 limits of Table 4:
 - 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 type 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 mm², if mechanically protected, or otherwise 4,0 mm²; and
 - provide a marking in accordance with 5.7.6 and Clause F.3.
- 2) Such equipment shall comply with 5.7.6. The value of I_2 shall be used to calculate the 5 % input current limit per phase specified in 5.7.6.

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 5.7.

***Touch current** tests, if necessary, are made using the relevant measuring instrument described in IEC 60990:1999, Figure 4, or any other instrument giving the same results. A capacitively coupled a.c. source of the same line frequency and phase as the a.c. **mains** is applied to each **external circuit** so that 0,25 mA, or the actual current from other equipment if known to be lower, is available to flow into that **external circuit**. The current flowing in the earthing conductor is then measured.*

b) Equipment whose **external circuit** have no reference to protective earth

If each **external circuit** does not have a common connection, the **touch current** for each **external circuit** shall not exceed ES2 limits of Table 4.

If all **external circuits** or any groups of such ports have a common connection, the total **touch current** from each common connection shall not exceed ES2 limits of Table 4.

Compliance with item b) is checked by inspection and if there are common connection points, by the following test.

*A capacitively coupled a.c. source of the same frequency and phase as the a.c. **mains** is applied to each **external circuit** so that 0,25 mA, or the actual current from the other equipment if known to be lower, is available to flow into that **external circuit**. Common connection points are tested in accordance with 5.7.3, whether or not the points are accessible.*

6 Electrically-caused fire

6.1 General

This subclause specifies **safeguards** to reduce the likelihood of injury or property damage arising from an electrically-caused fire originating from within the equipment.

6.2 Classification of power sources (PS) and potential ignition sources (PIS)

6.2.1 General

This subclause describes how to classify the different power sources and the **PIS** that may exist in the equipment.

Electrical sources of heating can be classified into available power levels PS1, PS2 and PS3 (see 6.2.2.4, 6.2.2.5 and 6.2.2.6) that may cause resistive heating of both components and connections. These power sources are based on available energy to a circuit.

Within a power source, a **PIS** may arise due to arcing of either broken connections or opening of contacts (**arcing PIS**) or from components dissipating more than 15 W (**resistive PIS**).

Depending on the power source classification of each circuit, one or more **safeguards** are required either to reduce the likelihood of ignition or to reduce the likelihood of spread of fire beyond the equipment.

6.2.2 Power source circuit classifications

6.2.2.1 General

An electric circuit is classified PS1, PS2, or PS3 based on the electrical power available to the circuit from the power source.

NOTE A power source may be an identifiable power supply and its associated load circuits, or a functional circuit that serves as a power source to another circuit.

The electrical power source classification shall be the maximum power measured under each of the following conditions:

- for load circuits: a power source under **normal operating conditions** as specified by the manufacturer into a worst-case load circuit fault (see 6.2.2.2);
- for power source circuits: a worst-case power source fault into the specified normal load circuit (see 6.2.2.3).

The power is measured at points X and Y in Figure 38 and Figure 39.

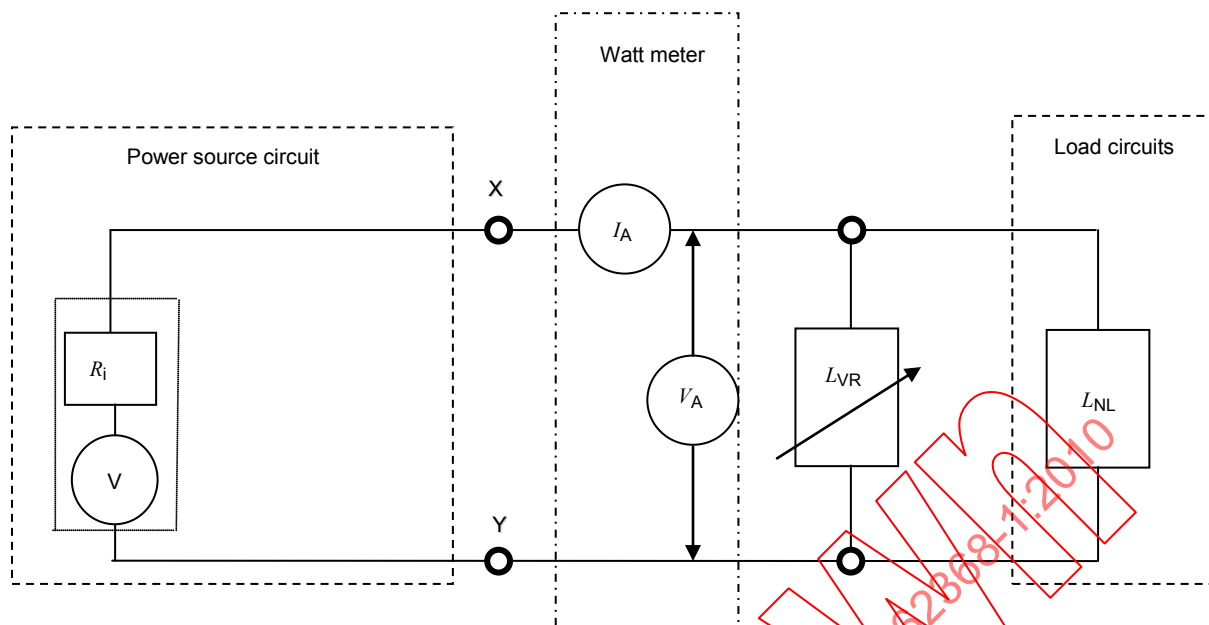
6.2.2.2 Power measurement for worst-case load fault

With reference to Figure 38:

- the measurement may be performed without the load circuit L_{NL} connected, unless the maximum power is dependent on the connection of the load;
- at points X and Y, insert a wattmeter (or a voltmeter, V_A , and a current meter, I_A);
- connect a variable resistor, L_{VR} as shown;
- adjust the variable resistor, L_{VR} , for maximum power. Measure the maximum power and classify the power source according to 6.2.2.4, 6.2.2.5 or 6.2.2.6.

If an overcurrent protective device or circuit operates during the test, the measurement shall be repeated at the point just below the trip current.

NOTE When evaluating accessories connected via cables to the equipment, the impedance of the cable may be taken into account in the determination of PS1 or PS2 on the accessory side.

**Key**

- V voltage source
- R_i internal resistance of the power source
- I_A current from the power source
- V_A voltage at the points where determination of PS power is made.
- L_{VR} variable resistor load
- L_{NL} normal load

Figure 38 – Power measurement for worst-case load fault

6.2.2.3 Power measurement for worst-case power source fault

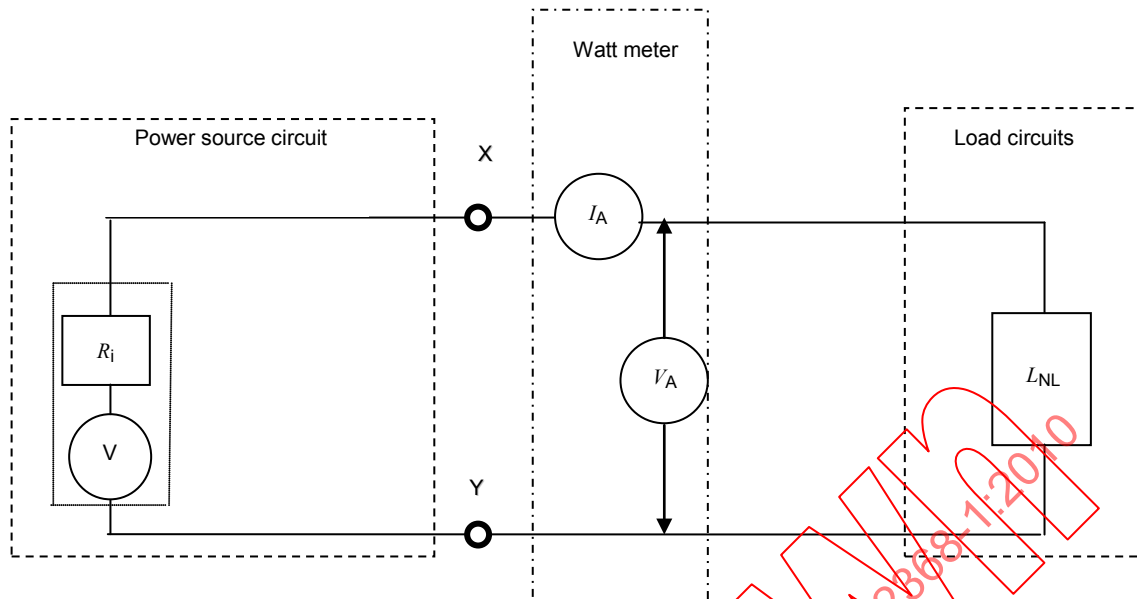
With reference to Figure 39

- At points X and Y, insert a wattmeter (or a voltmeter, V_A , and a current meter, I_A).
- Within the power source circuit, simulate any **single fault condition** that will result in maximum power to the circuit being classified. All relevant components in the power source circuits shall be short-circuited or disconnected one at a time at each measurement.
- Measure the maximum power as specified and classify circuits supplied by the power source according to 6.2.2.4, 6.2.2.5 or 6.2.2.6.

If an overcurrent protective device or circuit operates during the test, the measurement shall be repeated at the point just below the trip current.

NOTE 1 To avoid damage to the components of the normal load, a resistor (equal to the normal load) may be substituted for the normal load.

NOTE 2 Experimentation may be necessary to identify the single component fault that produces maximum power.



Key

- V voltage source
- R_i internal resistance of the power source
- I_A current from the power source
- V_A voltage at the points where determination of PS power is made.
- L_{NL} normal load

Figure 39 – Power measurement for worst-case power source fault

6.2.2.4 PS1

PS1 is a circuit where the power source, (see Figure 40) measured according to 6.2.2, does not exceed:

- 500 W measured during the first 3 s; and
- 15 W measured after 3 s.

For the purpose of this standard, the power available from **external circuits** described in Table 16, ID numbers 11, 12, 13 and 14, are considered to be PS1.

6.2.2.5 PS2

PS2 is a circuit where the power source, (see Figure 40) measured according to 6.2.2:

- exceeds PS1 limits; and
- does not exceed 100 W measured after 5 s.

6.2.2.6 PS3

PS3 is a circuit whose power source exceeds PS2 limits, or any circuit whose power source has not been classified (see Figure 40).

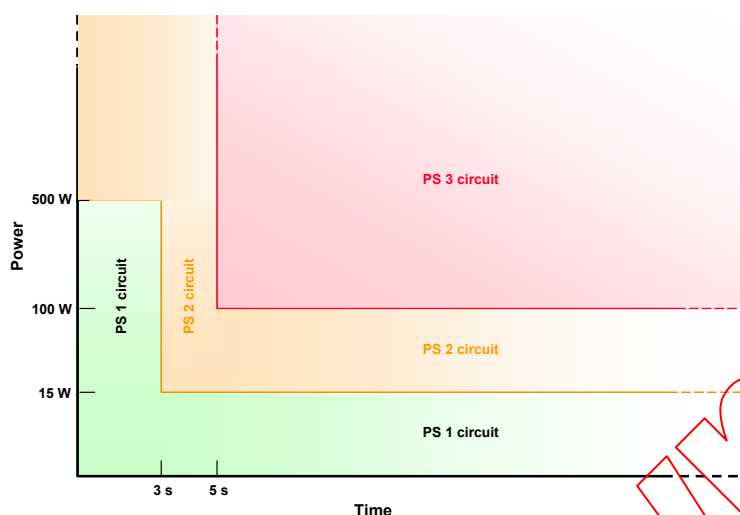


Figure 40 – Illustration of power source classification

6.2.3 Classification of potential ignition sources

6.2.3.1 Arcing PIS

Determination of an **arcing PIS** is performed under **normal operating conditions** unless otherwise specified.

An **arcing PIS** is a location with the following characteristics:

- an open circuit voltage (measured after 3 s) across an open conductor or opening electrical contact exceeding 50 V (peak) a.c. or d.c.; and
- the product of the peak of the open circuit voltage (V_p) and the measured r.m.s. current (I_{rms}) exceeds 15 (that is, $V_p \times I_{rms} > 15$) for any of the following:
 - a contact, such as a switch or connector;
 - a termination, such as one made by a crimp, spring or solder termination;
 - opening of a conductor, such as a printed wiring board trace, as a consequence of a **single fault condition**. This condition does not apply if electronic protection circuits or additional constructional measures are used to reduce the likelihood that such a fault becomes an **arcing PIS**.

An **arcing PIS** is considered not to exist in a PS1 because of the limits of the power source.

NOTE 1 An open conductor in an electric circuit includes those interruptions that may occur in conductive patterns on printed boards.

Reliable or redundant connections are not considered to be an **arcing PIS**.

Redundant connections are any kind of two or more connections in parallel, where in the event of the failure of one connection, the remaining connections are still capable of handling the full power.

Reliable connections are connections that are considered not to open.

NOTE 2 Examples of connections that could be considered reliable are:

- holes of solder pads on a printed board that are through-metallized;
- tubular rivets/eyelets that are additionally soldered;
- machine-made or tool-made crimp or wire-wrap connections.

NOTE 3 If other means are used to avoid the occurrence of an **arcing PIS** and such means have proven to be satisfactory, they could be used as well.

NOTE 4 Connection failure due to thermal fatigue phenomena could be prevented by selection of components with a coefficient of thermal expansion similar to that of the printed board material. Attention should be paid to the location of the component with respect to the fibre direction of the board material.

6.2.3.2 Resistive PIS

Determination of a **resistive PIS** is performed under **normal operating conditions** unless otherwise specified.

A **resistive PIS** is any part in a PS2 or PS3 circuit that:

- has a power capability to dissipate more than 15 W measured after 30 s of normal operation; or

NOTE During the first 30 s there is no limit.

- under **single fault conditions**:
 - has a power exceeding 100 W measured during the 30 s immediately after the introduction of the fault if electronic circuits, regulators or PTC devices are used; or
 - has an available power exceeding 15 W measured 30 s after the introduction of the fault

and in which the part may ignite due to excessive power dissipation or ignite adjacent materials or components.

A **resistive PIS** is considered not to exist in a PS1 because of the limits of the power source.

6.3 Safeguards against fire under normal operating conditions and abnormal operating conditions

6.3.1 Requirements

Under **normal operating conditions** and **abnormal operating conditions**, the following **basic safeguards** are required:

- ignition shall not occur; and
- no part of the equipment shall attain a temperature value greater than 90 % of the spontaneous ignition temperature limit, in Celsius, of the part as defined by ISO 871. When the spontaneous ignition temperature of the material is not known, the temperature shall be limited to 300 °C; and

NOTE 1 This standard currently does not contain requirements for flammable liquids and dust.

- **combustible materials** for components and other parts outside **fire enclosures** (including **electrical enclosures**, **mechanical enclosures** and decorative parts), shall have a **material flammability class** of at least:
 - **HB75** if the thinnest significant thickness of this material is <3 mm, or
 - **HB40** if the thinnest significant thickness of this material is ≥3 mm, or
 - **HBF**.

NOTE 2 Where an **enclosure** also serves as a **fire enclosure**, the requirements for **fire enclosures** apply.

These requirements do not apply to:

- parts with a size of less than 1 750 mm³;
- supplies, **consumable materials**, media and recording materials;
- parts that are required to have particular properties in order to perform intended functions, such as synthetic rubber rollers and ink tubes;

- gears, cams, belts, bearings and other parts that would contribute negligible fuel to a fire, including, labels, mounting feet, key caps, knobs and the like.

6.3.2 Compliance

*Compliance is checked by inspection of the data sheets and by test under **normal operating conditions** according to Clause B.2 and under **abnormal operating conditions** according to Clause B.3. The temperatures of materials are measured continuously until thermal equilibrium has been attained.*

NOTE See B.1.7 for details on thermal equilibrium.

*Temperature limiting **basic safeguards** that comply with the applicable requirements of this standard or the applicable safety device standard shall remain in the circuit being evaluated.*

6.4 Safeguards against fire under single fault conditions

6.4.1 General

This subclause defines the possible **safeguard** methods that can be used to reduce the likelihood of ignition or spread of fire under **single fault conditions**.

There are two methods of providing protection. Either method may be applied to different circuits of the same equipment under the following conditions.

- **Reduce the likelihood of ignition:** Equipment is so designed that under **single fault conditions** no part shall have sustained flaming. This method can be used for any circuit in which the available steady state power to the circuit does not exceed 4 000 W. The appropriate requirements and tests are detailed in 6.4.2 and 6.4.3.
 - **Pluggable equipment type A** is considered not to exceed the steady state value of 4 000 W.
 - **Pluggable equipment type B** and **permanently connected equipment** are considered not to exceed the steady state value of 4 000 W if the product of the nominal **mains** voltage and the **protective current rating** of the installation overcurrent protective device ($V_{\text{mains}} \times I_{\text{max}}$) does not exceed 4 000 W.
- **Control fire spread:** Selection and application of **supplementary safeguards** for components, wiring, materials and constructional measures that reduce the spread of fire and, where necessary, by the use of a second **supplementary safeguard** such as a **fire enclosure**. This method can be used for any type of equipment. The appropriate requirements are detailed in 6.4.4, 6.4.5 and 6.4.6.

6.4.2 Reduction of the likelihood of ignition under single fault conditions in PS1 circuits

No **supplementary safeguards** are needed for protection against PS1. A PS1 is not considered to contain enough energy to result in materials reaching ignition temperatures.

6.4.3 Reduction of the likelihood of ignition under single fault conditions in PS2 circuits and PS3 circuits

6.4.3.1 General

This subclause defines the **supplementary safeguards** needed to reduce the likelihood of ignition under **single fault conditions** in PS2 circuits and PS3 circuits where the available power does not exceed 4 000 W (see 6.4.1).

6.4.3.2 Requirements

The likelihood of ignition can be reduced by employing the following **supplementary safeguards** as applicable:

- flaming shall not occur beyond 5 s;
- providing separation from an **arcing PIS** or a **resistive PIS** as specified in 6.4.7;
- using protective devices that comply with Clause G.2 to Clause G.5 or the relevant IEC component standards for such devices;
- using components that comply with Clauses G.7, G.8 or the relevant IEC component standard;
- for components associated with the **mains**, using components that comply with the relevant IEC component standards and requirements of other parts of this standard.

NOTE Examples of components associated with the **mains** are the supply cord, appliance couplers, EMC filtering components, switches, etc.

The opening of a conductor on a printed board, except as specified in this subclause, shall not be used as a **safeguard**.

Conductors of a printed board of **V-1 class material** may open under **overload condition** provided that the open circuit is not an **arcing PIS**. Conductors on a printed board material that has no **material flammability class** or is classed lower than **V-1 class material** shall not open.

Under a **single fault condition**, the peeling of conductors on a printed board shall not result in the failure of any **supplementary safeguard** or **reinforced safeguard**.

6.4.3.3 Test method

The conditions of Clause B.4, that are possible causes for ignition, are applied in turn. A consequential fault may either interrupt or short circuit a component. In case of doubt, the test shall be repeated two more times with replacement components in order to check that sustained flaming does not occur.

*The equipment is operated under **single fault conditions** and the temperatures of materials are measured continuously until thermal equilibrium has been attained.*

*If a conductor opens during a simulated **single fault condition**, the conductor shall be bridged and the simulated **single fault condition** shall be continued. In all other cases, where an applied **single fault condition** results in interruption of the current before steady state has been reached, the temperatures are measured immediately after the interruption. The circuit shall still comply with this subclause.*

NOTE 1 See B.1.7 for details on thermal equilibrium.

NOTE 2 The **single fault condition** tests may identify a situation applicable to another clause of this standard.

NOTE 3 Consideration of spontaneous ignition temperatures of surrounding materials of the heat source should be taken into account. Temperature rise can be observed after interruption of the current due to thermal inertia.

If the temperature is limited by fuses complying with the IEC 60127 series, the following test is carried out, if necessary, in relation to the characteristic of the fuse.

*The fuse-link is short-circuited and the current that would have passed through the fuse-link under the relevant **single fault condition** is measured.*

- *If the fuse-link current remains less than 2,1 times the current rating of the fuse-link, the temperatures are measured after a steady state has been attained.*
- *If the current either immediately reaches 2,1 times the current rating of the fuse-link or more, or reaches this value after a period of time equal to the maximum pre-arcing time for the relevant current through the fuse-link under consideration, both the fuse-link and the short-circuit link are removed after an additional time corresponding to the maximum*

pre-arcing time of the fuse-link under consideration and the temperatures are measured immediately thereafter.

If the fuse resistance influences the current of the relevant circuit, the maximum resistance value of the fuse-link shall be taken into account when establishing the value of the current.

*Printed board conductors are tested by applying the relevant **single fault conditions** of B.4.4.*

6.4.3.4 Compliance

Compliance is checked by inspection, tests and measurements.

6.4.4 Control of fire spread in PS1 circuits

No **supplementary safeguards** are needed for protection against PS1. A PS1 is not considered to contain enough energy to result in materials reaching ignition temperatures.

6.4.5 Control of fire spread in PS2 circuits

6.4.5.1 General

This subclause describes the **supplementary safeguards** needed to reduce the likelihood of fire spread in PS2 circuits to nearby **combustible materials**.

6.4.5.2 Requirements

A **supplementary safeguard** is required to control the spread of fire from any possible **PIS** to other parts of the equipment as given below.

For conductors and devices that constitute a **PIS** the following apply:

- printed boards shall be made of **V-1 class material**;
- wire insulation and tubing shall comply with IEC 60332-1-2, IEC 60332-2-2 or IEC/TS 60695-11-21;
- devices subject to arcing or changing contact resistance (for example, pluggable connectors) shall comply with one of the following:
 - have materials made of **V-1 class material**; or
 - comply with the flammability requirements of the relevant IEC component standard; or
 - be mounted on material made of **V-1 class material** and be of a volume not exceeding 1 750 mm³.

Battery cells and battery packs shall comply with all of the requirements of Annex M.

All other components in a PS2 circuit shall:

- be mounted on **V-1 class material**; or
- be made of **V-2 class material**, **VTM-2 class material** or **HF-2 class foamed material**; or
- have a mass of **combustible material** of less than 4 g, provided that when the part is ignited, the fire does not spread to another part; or
- be separated from **PIS** by the requirements of 6.4.7; or
- comply with the requirements of the relevant IEC component standard; or
- motors complying with Clause G.8; or
- transformers complying with Clause G.7; or

- be in a sealed **enclosure** of 0,06 m³ or less, consisting totally of non-**combustible material** and having no ventilation openings.

The following materials shall be separated from a **PIS** according to the requirements of 6.4.7, or the materials shall not ignite during **single fault conditions** as specified in 6.4.3.3:

- supplies, **consumable materials**, media and recording materials;
- parts that are required to have particular properties in order to perform intended functions, such as synthetic rubber rollers and ink tubes.

6.4.5.3 Compliance

Compliance is checked by testing or by inspection of the equipment and material data sheets.

6.4.6 Control of fire spread in a PS3 circuit

6.4.6.1 General

This subclause defines the **supplementary safeguards** needed to reduce the likelihood of fire spread in PS3 circuits to nearby **combustible materials**.

6.4.6.2 Requirements

Fire spread in PS3 circuits shall be controlled as specified for PS2 circuits in 6.4.5 and by providing a **fire enclosure** as specified in 6.4.8.

Within the **fire enclosure**, **combustible materials** that are not part of a PS2 or PS3 circuit shall comply with the flammability test of Clause S.1 or be made of **V-2 class material**, **VTM-2 class material** or **HF-2 class foamed material**. These requirements do not apply to:

- parts with a size of less than 1 750 mm²;
- supplies, **consumable materials**, media and recording materials;
- parts that are required to have particular properties in order to perform intended functions, such as synthetic rubber rollers and ink tubes;
- gears, cams, belts, bearings and other parts that would contribute negligible fuel to a fire, including, labels, mounting feet, key caps, knobs and the like;
- tubing for air or 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**.

A **fire enclosure** is not necessary for the following components and materials:

- wire insulation and tubing complying with IEC 60332-1-2, IEC 60332-2-2 or IEC/TS 60695-11-21;
- components, including connectors, complying with the requirements of 6.4.8.1.1, and that fill an opening in a **fire enclosure**;
- plugs and connectors forming part of a power supply cord or interconnecting cable complying with 6.5, Clause G.9 and Clause G.20;
- motors complying with Clause G.8;
- transformers complying with Clause G.7.

6.4.6.3 Compliance

Compliance is checked by inspection of the material data sheets or by test or both.

6.4.7 Separation of combustible materials from a PIS

6.4.7.1 General

This subclause specifies the minimum separation requirements between a **PIS** and **combustible materials** in order to reduce the likelihood of sustained flaming or spread of fire. This can be achieved by either separation by distance (6.4.7.2) or separation by a barrier (6.4.7.3).

Separation requirements from a PIS to a **fire enclosure** are specified in 6.4.8.3.

6.4.7.2 Separation by distance

Combustible material, except the material on which the **PIS** is mounted, shall be separated from an **arcing PIS** or a **resistive PIS** according to Figure 41, Figure 42,

Figure 43 and Figure 44.

Base material of printed boards, on which an **arcing PIS** is located, shall be made of **V-1 class material**, **VTM-1 class material** or **HF-1 class foamed material**.

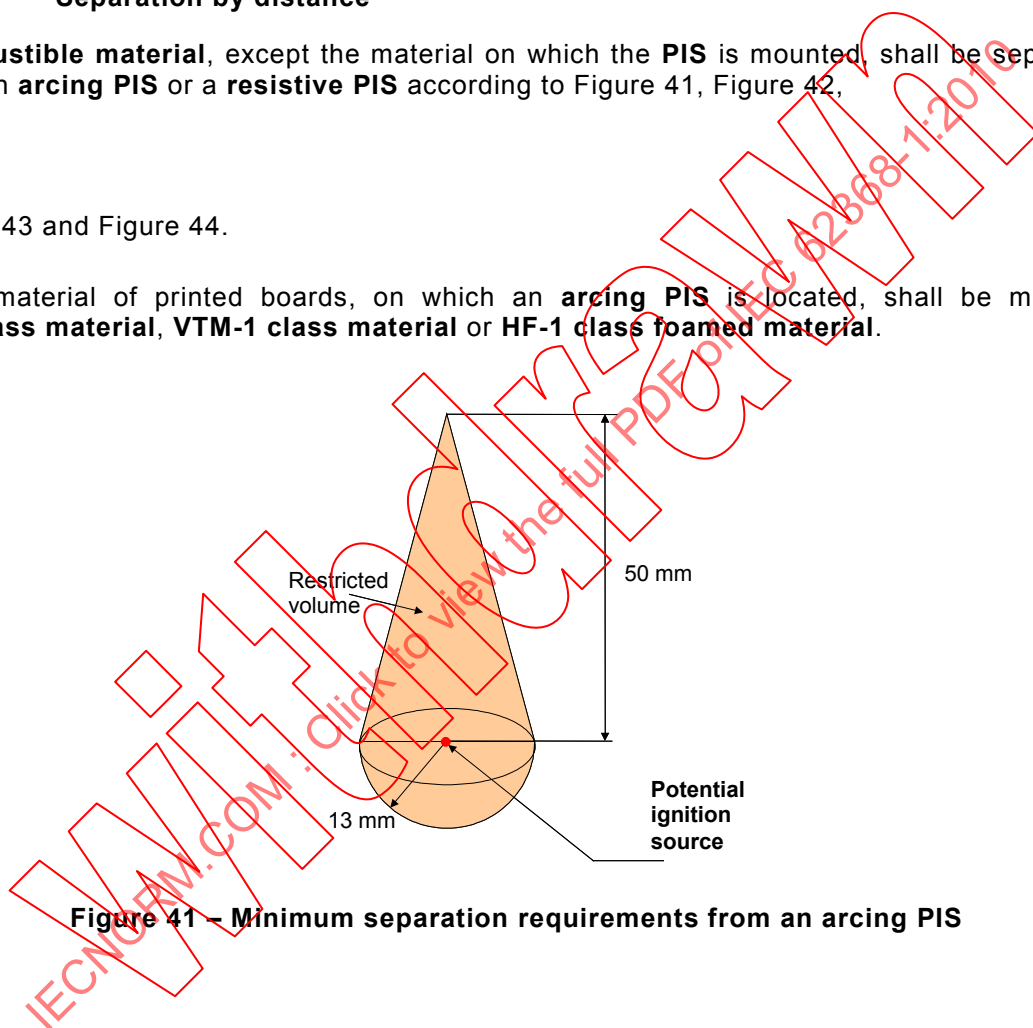
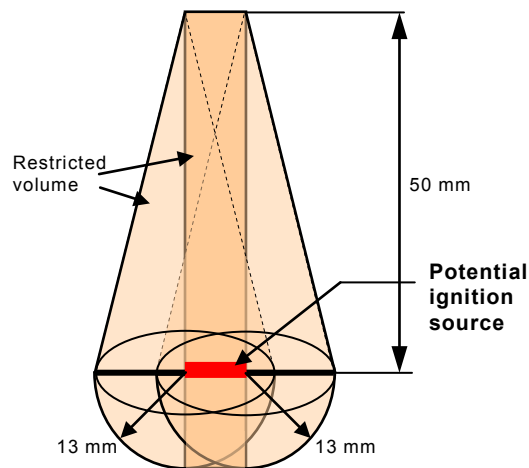


Figure 41 – Minimum separation requirements from an arcing PIS



NOTE This figure can be used for:

- an **arcing PIS** that consists of tracks or areas on printed boards;
- the **resistive PIS** areas of components. Measurements are made from the nearest power dissipating element of the component involved. If in practice it is not readily possible to define the power dissipating part, then the outer **enclosure** of the component is used.

Figure 42 – Extended separation requirements from a PIS

When the airflow across a circuit is moving due to air moving devices, the vertical orientation of the restricted volumes described in Figure 41, Figure 42 and Figure 44 shall be rotated to reflect the effect of the airflow on the flame path. When determining the restricted volumes for each figure, each cone shall be rotated (tilted) around the **PIS** location from 0° (vertical orientation, shown in

Figure 43) to 45° in the direction of the forced airflow.

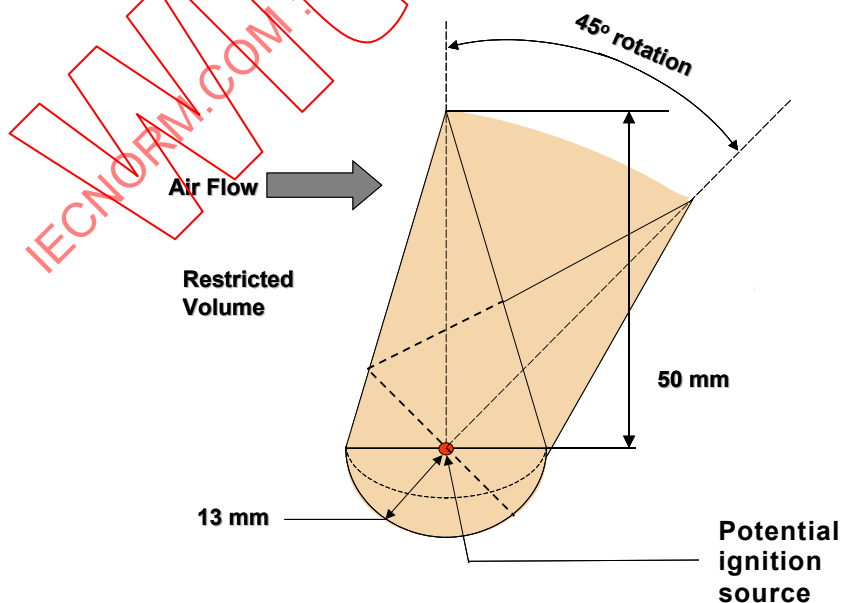


Figure 43 – Rotated separation requirements due to forced air flow

When the distance between a **PIS** and **combustible materials** is less than specified in Figure 41, Figure 42 and

Figure 43 as applicable, the **combustible materials** shall:

- have a mass of less than 4 g provided that when the part is ignited, the fire does not spread to another part; or
- comply with the following flammability requirements:
 - requirements of the relevant IEC component standard; or
 - be made of **V-1 class material**, **VTM-1 class material** or **HF-1 class foamed material**, or comply with IEC 60695-11-5. Severities are identified in Clause S.2.

6.4.7.3 Separation by a fire barrier

Combustible material shall be separated from an **arcing PIS** or a **resistive PIS** by a fire barrier as defined in 6.4.8.1.1 (see Figure 44).

Printed boards are not considered to be a fire barrier against an **arcing PIS** located on the same board. Printed boards complying with 6.4.8 may be considered to be a fire barrier against an **arcing PIS** located on a different board.

Printed boards can be considered to be a fire barrier against a **resistive PIS** provided that the following conditions are met:

- the printed board shall:
 - comply with the flammability test Clause S.1 as used in the application; or
 - be made of **V-1 class material**, **VTM-1 class material** or **HF-1 class foamed material**;
- within the restricted volume, no materials rated less than **V-1 class material** shall be mounted on the same side of a printed board as the **resistive PIS**;
- within the restricted volume, the printed board shall have no PS2 conductors or PS3 conductors (except for the conductors that supply the circuit under consideration). This applies to any side of the printed board as well as the inner layer of the printed board.

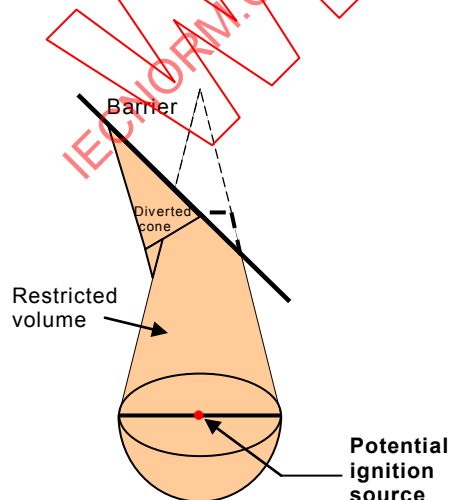


Figure 44a – Illustration showing an angled barrier

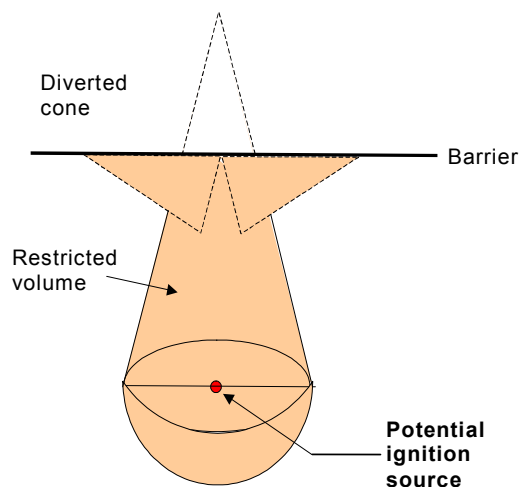


Figure 44b – Illustration showing a horizontal barrier

NOTE 1 The volume of the flame is nearly constant; consequently the shape of the flame is dependent upon the

position and the shape of the barrier. It should be taken into account that different shapes of barriers might give different flame shapes. The restricted area and separation requirements need to be adapted accordingly by the user of the standard.

NOTE 2 Dimensions are identical to Figure 41 and Figure 42 but, except as required in 6.4.8.3, the distance of the barrier from the **PIS** is not significant.

Figure 44 – Deflected separation requirements from a PIS when a fire barrier is used

6.4.7.4 Compliance

Compliance is checked by inspection or measurement or both.

6.4.8 Fire enclosures and fire barriers

The **safeguard** function of the **fire enclosure** and the fire barrier is to impede the spread of fire through the **enclosure** or barrier.

NOTE The **fire enclosure** may be the overall **enclosure**, or it may be within the overall **enclosure**. The **fire enclosure** need not have an exclusive function, but may provide other functions in addition to that of a **fire enclosure**.

6.4.8.1 Fire enclosure and fire barrier material properties

6.4.8.1.1 Requirements for a fire barrier

A fire barrier shall comply with the requirements of Clause S.1.

These requirements do not apply provided that the material is:

- made of non-**combustible material** (for example, metal, glass, ceramic, etc.); or
- made of **V-1 class material** or **VTM-1 class material**.

6.4.8.1.2 Requirements for a fire enclosure

For circuits where the available power does not exceed 4 000 W (see 6.4.1), a **fire enclosure** shall comply with the requirements of Clause S.1.

For circuits where the available power exceeds 4 000 W, a **fire enclosure** shall comply with the requirements of Clause S.5.

These requirements do not apply provided that the material is:

- made of non-**combustible material** (for example, metal, glass, ceramic, etc.); or
- made of
 - **V-1 class material** if the available power does not exceed 4 000 W; or
 - **5VA class material** or **5VB class material** if the available power exceeds 4 000 W.

Material for components that fill an opening in a **fire enclosure** or that is intended to be mounted in such opening shall:

- comply with the flammability requirements of the relevant IEC component standard; or
- be made of **V-1 class material**; or
- comply with Clause S.1.

6.4.8.1.3 Compliance

Compliance is checked by inspection of applicable data sheets or test.

*The **material flammability class** is checked for the thinnest significant thickness used.*

6.4.8.2 Constructional requirements for a fire enclosure and a fire barrier

6.4.8.2.1 Fire enclosure and fire barrier openings

Openings in a **fire enclosure** or in a fire barrier shall be of such dimensions that fire and products of combustion passing through the openings are not likely to ignite material on the outside of the **enclosure** or on the side of a fire barrier opposite to the **PIS**.

The openings to which these properties apply are relative to the site or location of the **PIS** and of **combustible materials**. The locations of openings relative to the flame property are shown in Figure 45 and Figure 46.

Regardless of the equipment orientation, the flame orientation property of the **PIS** is always vertical, unless the equipment contains a forced airflow. Where the equipment has two or more **normal operating condition** orientations, opening properties apply to each possible orientation and airflow direction.

NOTE When the forced airflow across a **PIS** is moving due to air moving devices, the vertical orientation of the volume described in Figure 42 is rotated (tilted) around the **PIS** location from 0° (vertical orientation shown in the figure) to 45° in the direction of the forced airflow (see also

Figure 43).

6.4.8.2.2 Fire barrier dimensions

A fire barrier shall have dimensions sufficient to prevent ignition of the edges of the barrier. The edges of the fire barriers shall extend to beyond the fire cone (see Figure 44).

6.4.8.2.3 Top openings and top opening properties

Top opening properties of a **fire enclosure** and a fire barrier shall apply to openings above a **PIS** as shown in Figure 45.

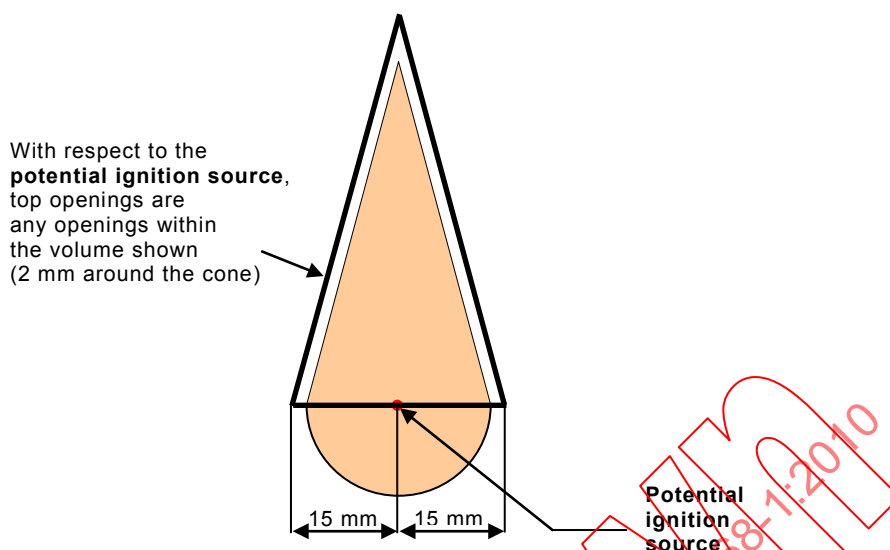
NOTE Any openings within the zone as shown in Figure 45 are regarded to be top openings, including side openings.

Top openings that fall within the volume defined in Figure 45 shall comply with the following test.

*The test is conducted using the needle-flame burner as specified in Clause S.2 placed vertically in a draft-free location. The distance between the inner side of the top openings and the centre of the burner tube is 7 mm ± 1 mm. The sample is placed in its normal operating position. The top openings are covered with a single layer of **cheesecloth**.*

*The flame is applied for a period of 1 min. The **cheesecloth** shall not ignite.*

In case of openings having different dimensions, the test shall be conducted on one opening of each group of the top openings with the same dimensions.



NOTE Dimensions of the cone are identical to Figure 41 and Figure 42.

Figure 45 – Top openings

No test is required provided that the openings do not exceed:

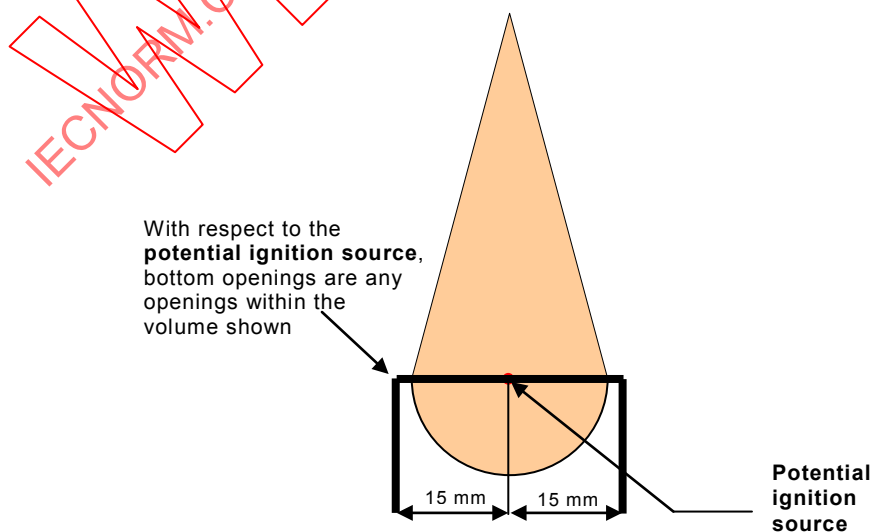
- 5 mm in any dimension, or
- 1 mm in width regardless of length.

6.4.8.2.4 Bottom openings and bottom opening properties

Bottom opening properties of a **fire enclosure** and a fire barrier shall apply to openings that are located in the volume as shown in Figure 46.

NOTE Any openings within the zone as shown in Figure 46 are regarded to be bottom openings, including side openings.

Bottom openings are those openings below a **PIS** and within 30 mm diameter cylinder extending indefinitely below the **PIS**.



NOTE Dimensions of the cone are identical to Figure 41 and Figure 42.

Figure 46 – Bottom openings

Bottom openings shall comply with Clause S.3.

No test is necessary provided that one of the following conditions is met:

- a) the bottom openings do not exceed:
 - 3 mm in any dimension, or
 - 1 mm in width regardless of length;
- b) under components and parts meeting the requirements for **V-1 class material**, or **HF-1 class foamed material** or under components that pass the needle-flame test of IEC 60695-11-5 using a 30 s flame application, bottom openings shall not exceed:
 - 6 mm in any dimension, or
 - 2 mm in width regardless of length;
- c) the bottom openings do not exceed a 2 mm by 2 mm mesh of at least 0,45 mm diameter metal wire.

Where the risk of flaming liquids escaping the equipment exists, the bottom of the **fire enclosure** shall comply with Table 39.

Table 39 – Size and spacing of holes in metal bottoms of fire enclosures

Metal bottom minimum thickness mm	Circular holes		Other shaped openings	
	Maximum diameter of holes mm	Minimum spacing of holes centre to centre mm	Maximum area mm ²	Minimum spacing of openings border to border mm
0,66	1,1	1,7	1,1	0,56
0,66	1,2	2,4	1,2	1,1
0,76	1,1	1,7	1,1	0,55
0,76	1,2	2,4	1,2	1,1
0,81	1,9	3,2	2,9	1,1
0,89	1,9	3,2	2,9	1,2
0,91	1,6	2,8	2,1	1,1
0,91	2,0	3,2	3,1	1,2
1,0	1,6	2,8	2,1	1,1
1,0	2,0	3,0	3,2	1,0

Equipment intended only for use in fixed installations and intended to be floor standing on a non-combustible surface need not be provided with a **fire enclosure** bottom. Such equipment shall be marked in accordance with Clause F.5 in a clearly visible location with the following or equivalent wording:

RISK OF FIRE

Install only on concrete
or other non-combustible floor

6.4.8.2.5 Integrity of the fire enclosure

If part of a **fire enclosure** consists of a door or cover that can be opened by an **ordinary person**, the door or cover shall comply with requirements a), b), or c):

- a) the door or cover shall be interlocked and comply with the **safety interlock** requirements in Annex K;

- b) a door or cover, intended to be routinely opened by the **ordinary person**, shall comply with both of the following conditions:
 - it shall not be removable from other parts of the **fire enclosure** by the **ordinary person**; and
 - it shall be provided with a means to keep it closed during **normal operating conditions**;
- c) a door or cover intended only for occasional use by the **ordinary person**, such as for the installation of accessories, may be removable provided that instructions for correct removal and reinstallation of the door or cover are available.

6.4.8.2.6 Compliance

Compliance is checked by inspection of applicable data sheets and, where necessary, by test.

6.4.8.3 Separation of a PIS from a fire enclosure and a fire barrier

A **fire enclosure** or fire barrier made of **combustible material** shall.

- a) have a minimum distance of 13 mm to an **arcing PIS**; and
- b) have a minimum distance of 5 mm to a **resistive PIS**.

Smaller distances are allowed provided that the part of the **fire enclosure** or fire barrier within the required separation distance complies with one of the following.

- the **fire enclosure** or fire barrier meets the needle-flame test according to IEC 60695-11-5. Severities are identified in Clause S.2. After the test, the **fire enclosure** or fire barrier material shall not have formed any holes that are bigger than allowed in 6.4.8.2.3 or 6.4.8.2.4 as appropriate; or
- the **fire enclosure** or fire barrier is made of **V-0 class material**.

6.5 Internal and external wiring

6.5.1 General

This subclause specifies requirements to reduce the likelihood of fire from internal and external wiring in PS2 circuits and PS3 circuits.

6.5.2 Requirements

In PS2 circuits or PS3 circuits, the insulation on internal or external wiring shall pass the test methods described below.

For conductors with cross-sectional area greater than 0,5 mm², the test methods in IEC 60332-1-2 and IEC 60332-1-3 shall be used.

For conductors of 0,5 mm² or less in area, the test methods in IEC 60332-2-1 and IEC 60332-2-2 shall be used.

NOTE For both internal and external wiring, the test method described in IEC/TS 60695-11-21 may be used instead of the test methods in IEC 60332-1-2, IEC 60332-1-3, IEC 60332-2-1 or IEC 60332-2-2.

6.5.3 Compliance

The insulated conductor or cable shall be acceptable if:

- *the distance between the lower edge of the top support and the onset of charring is greater than 50 mm; and*
- *the filter paper has not ignited during the test duration; and*

- *charring extends downwards to a point less than 540 mm from the lower edge of the top support.*

If the insulated conductor or cable fails the first test, two more tests shall be carried out. If the second and third tests are acceptable, the insulated conductor or cable shall be deemed acceptable.

NOTE These requirements are currently contained within the referenced standards as informative annexes.

6.5.4 Requirements for interconnection to building wiring

Equipment intended to provide power over the wiring system to remote equipment shall limit the output current to a value that does not cause damage to the wiring system, due to overheating, under any external load condition. The maximum continuous current from the equipment shall not exceed a current limit that is suitable for the minimum wire gauge specified in the equipment installation instructions.

NOTE 1 This wiring is not usually controlled by the equipment installation instructions, since the wiring is often installed independent of the equipment installation.

PS2 circuits or PS3 circuits that provide power and that are intended to be compatible with LPS to **external circuits** (see Annex Q) shall have their output power limited to values that reduce the likelihood of ignition within building wiring or external devices located in a different room.

Compliance is checked with Clauses Q.1 and Q.2.

NOTE 2 Circuits to provide power to devices or external components that are intended for use in the same room as the equipment under test are not subject to this requirement. See 6.7 for connection to secondary equipment.

External paired conductor cable circuits, such as those described in Table 16, ID numbers 11, 12, 13 and 14 having a minimum wire diameter of 0,4 mm, shall have the current limited to 1,3 A.

NOTE 3 Time/current characteristics of type gD and type gN fuses specified in IEC 60269-2 comply with the above limit. Type gD or type gN fuses rated 1 A, would meet the 1,3 A current limit.

Compliance is checked with Clause Q.3.

6.5.5 Compliance

Compliance is checked by test, inspection and where necessary by the requirements of Annex Q.

6.6 Likelihood of fire due to entry of foreign objects

This subclause specifies **safeguards** that reduce the likelihood of fire due to the entry of conductive foreign objects into the equipment.

Conductive foreign objects shall not cause bridging of PS2 circuits or PS3 circuits. Top and side openings above those circuits, located at a height of less than 1,8 m above the floor, shall comply with Annex P.

If the entry of a foreign object can result in bridging of PS2 circuits or PS3 circuits, one of the following shall be applied:

- internal barrier(s) shall be provided to deflect the objects away from the relevant circuits; or
- openings in the equipment above the relevant circuits shall be located more than 1,8 m above the floor; or

- the construction above the relevant circuits shall comply with Annex P.

Compliance is checked by inspection or according to Annex P.

6.7 Safeguards against fire due to the connection of secondary equipment

This subclause specifies requirements to reduce the likelihood of fire due to connection of secondary equipment.

Where it is unknown that the connected equipment or accessories (for example, a scanner, mouse, keyboard, DVD drive, CD ROM drive or joystick) are likely to comply with this standard, the delivered power shall be limited to PS2.

Compliance is checked by inspection or measurement.

7 Chemically-caused injury

7.1 General

This clause specifies **safeguards** to reduce the likelihood of injury due to exposure to chemicals. The requirements are not intended to be the only means to reduce the likelihood of chemically-caused injury.

7.2 Reduction of exposure to hazardous chemicals

The exposure to **hazardous chemicals** shall be reduced. Reduction of exposure to **hazardous chemicals** shall be controlled by using containment of the **hazardous chemicals**. Containers shall be sufficiently robust and shall not be damaged or degraded by the contents over the lifetime of the product.

Compliance is checked by

- the examination of the effects the chemical has on the material of the container, and
- any relevant tests of Annex T following which there should be no leakage from the container.

7.3 Ozone exposure

For equipment that produces ozone, the installation and operating instructions shall indicate that precaution must be taken to ensure that the concentration of ozone is limited to a safe value.

NOTE 1 Currently, the recommended long term exposure limit for ozone is $0,1 \times 10^{-6}$ (0,2 mg/m³) calculated as an 8 h time-weighted average concentration. Time-weighted average is the average level of exposure over a given time period.

NOTE 2 Ozone is heavier than air.

Compliance is checked by inspection of instructions or accompanying documents.

7.4 Use of PPE

Where **safeguards**, such as containment of a chemical, are not practical, **PPE** shall be specified in the accompanying documents.

Suitable **PPE** should be chosen taking into account the recommendations given by the manufacturer.

Compliance is checked by inspection of instructions or accompanying documents.

7.5 Use of instructional safeguards and instructions

Where a chemical is capable of causing an injury, **instructional safeguards** as specified in ISO 7010 and instructions shall be applied to the equipment in accordance with Clause F.5.

Compliance is checked by inspection of instructions or accompanying documents.

7.6 Batteries

Batteries shall comply with Annex M.

8 Mechanically-caused injury

8.1 General

This clause specifies **safeguards** to reduce the likelihood of injuries such as cuts, bruises, broken bones, etc., due to transfer of energy from a mechanical energy source to a body part.

Mechanical injury is due to relative motion between the body and **accessible** parts of the equipment, or due to parts ejected from the equipment colliding with a body part.

NOTE 1 In some cases, the person may be the source of the kinetic energy.

NOTE 2 Where not specifically mentioned in this clause, the words “products” and “equipment” also cover carts, stands and carriers used with these products or equipment.

8.2 Mechanical energy source classifications

8.2.1 General classification

Various categories of mechanical energy sources are given in Table 40.

Table 40 – Classification for various categories of mechanical energy sources

Line	Category	MS1	MS2	MS3
1	Sharp edges and corners	Does not cause pain or injury ^b	Does not cause injury ^b but may be painful	May cause injury ^c
2	Moving parts	Does not cause pain or injury ^b	Does not cause injury ^b but may be painful	May cause injury ^c
3	Moving fan blades ^a See Figure 47.	$\frac{RPM}{15\ 000} + \frac{KFactor}{2\ 400} \leq 1$	^{>MS1; and} $\frac{RPM}{22\ 000} + \frac{KFactor}{3\ 600} \leq 1$	^{>MS2}
4	Loosening, exploding or imploding parts.	NA	NA	Examples ^d
5	Equipment mass	≤7 kg	7 kg < mass ≤ 25 kg	>25 kg
6	Wall/ceiling mount	Equipment mass ≤7 kg mounted <2 m ^e	Equipment mass >7 kg mounted <2 m ^e	All equipment mounted ≥2 m

^a The K factor is determined from the formula $K = 6 \times 10^{-7} (m r^2 N^2)$ 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 centre line of the motor (shaft) to the tip of the outer area likely to be contacted, N is the rotational speed (rpm) of the fan blade.

In the end product, the fan maximum operational voltage can be different than the rated voltage of the fan and this difference should be taken into account.

^b The phrase “Does not cause injury” means that a doctor or hospital emergency attention is not needed.

^c The phrase “May cause injury” means that a doctor or hospital emergency attention may be needed.

- ^d The following equipment constructions are examples considered MS3:
- high speed removable plastic solid media such as used in CD drives or DVD drives, capable of rotational speed greater than 8 000 rpm; and
 - CRTs having a maximum face dimension exceeding 160 mm; and
 - lamps in which the pressure exceeds 0,2 MPa when cold or 0,4 MPa when operating are considered high pressure lamps, and shall be classed MS3.
- ^e Manufacturer's installation instructions shall state that the equipment is only suitable for mounting at heights < 2 m.

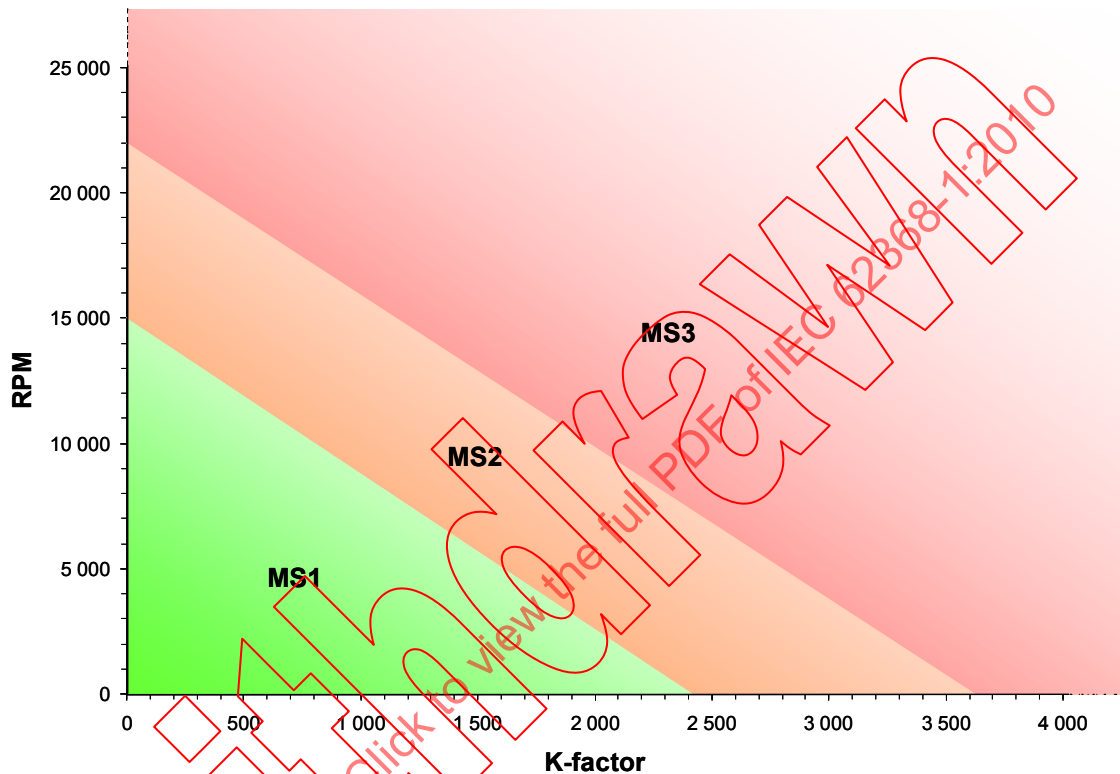


Figure 47 – Illustration showing MS limits for moving fan blades

8.2.2 MS1

MS1 is a mechanical energy source with levels not exceeding MS1 limits under **normal operating conditions** and **abnormal operating conditions** and not exceeding MS2 under **single fault conditions**.

NOTE MS1 may be **accessible** to an **ordinary person**.

8.2.3 MS2

MS2 is a mechanical energy source with levels not exceeding MS2 limits under **normal operating conditions**, **abnormal operating conditions**, and **single fault conditions**, but is not MS1.

NOTE MS2 may be **accessible** to an **instructed person**, and under **single fault conditions**, to an **ordinary person**.

8.2.4 MS3

MS3 is a mechanical energy source with levels exceeding MS2 limits under **normal operating conditions**, **abnormal operating conditions** and **single fault conditions**, or any mechanical energy source declared to be treated as MS3 by the manufacturer.

NOTE Parts classed MS3 may be **accessible** to a **skilled person**.

8.3 Protection against mechanical energy sources

8.3.1 General

This subclause specifies general protection requirements for parts **accessible** to **ordinary persons**, **instructed persons**, and **skilled persons**.

Table 41 gives a summary of the required **safeguards**.

Table 41 – Summary of required safeguards

Person	Number of safeguards required to be interposed between an energy source and a person		
	MS1	MS2	MS3
Ordinary person	0 ^a	1 ^b	2 ^c
Instructed person	0	0	2 ^d
Skilled person	0	0	0 or 1 ^e
^a See 4.3.2.1 and 8.3.2. ^b See 4.3.2.2, 4.3.2.3 and 8.3.2. ^c See 4.3.2.4 and 8.3.2. ^d See 4.3.3.2, 4.3.3.3 and 8.3.3. ^e See 4.3.4.3 and 8.3.4.			

8.3.2 Protection of ordinary persons

No **safeguards** need be interposed between MS1 and an **ordinary person**.

At least one **safeguard** shall be interposed between MS2 and an **ordinary person**.

Except as specified in 8.4.2 and 8.5.2, at least one **equipment basic safeguard** and one **equipment supplementary safeguard** shall be interposed between MS3 and an **ordinary person**.

8.3.3 Protection of instructed person

No **safeguards** need be interposed between MS1 or MS2 and an **instructed person**. However, for MS2 that is not obvious, an **instructional safeguard** shall be provided.

Except as specified in 8.4.2 and 8.5.2, at least one **equipment basic safeguard** and one **equipment supplementary safeguard** shall be interposed between MS3 and an **instructed person**.

8.3.4 Protection of skilled persons

No **safeguards** need to be interposed between MS1, MS2 or MS3 and a **skilled person**. However, for MS3 that is not obvious, an **instructional safeguard** shall be provided.

In addition, other MS3 parts not actively being serviced shall be located or guarded so that unintentional contact with such parts during service operations is an unlikely result in the **skilled person** involuntary recoiling from class 2 or class 3 energy sources being serviced.

NOTE Recoil might occur where the **skilled person** may partially or fully enter inside large equipment for servicing.

8.4 Safeguards against parts with sharp edges and corners

8.4.1 Requirements

This subclause specifies **safeguards** that reduce the likelihood of injury by parts with sharp edges and corners in **accessible** areas of the equipment.

Engineering judgement shall be used to class a mechanical energy source as MS1, MS2 or MS3 according to Table 40, line 1.

Except as provided in 8.4.2, an appropriate **safeguard** shall be provided as given in Table 41.

8.4.2 Instructional safeguard

Where an **accessible** sharp edge or corner is required for the function of the equipment:

- any potential limited exposure shall not be life threatening, and
- the sharp edge or corner shall be obvious to an **ordinary person** or an **instructed person** when exposed, and
- the sharp edge shall be guarded as much as practicable, and
- an **instructional safeguard** shall be used to minimise unintentional contact.

The **instructional safeguard** for the **accessible** sharp edge or corner shall be in accordance with Clause F.5 and shall be fixed to the equipment and located in proximity to the sharp edge or corner and contain a relevant graphical symbol or text with the following or similar appropriate wording:

WARNING Sharp edges present. Do not touch.

8.4.3 Compliance

*Compliance is checked by inspection and, if necessary, by test of Annex V. During and after the application of the force, the sharp edge or corner shall not be **accessible**.*

8.5 Safeguards against moving parts

8.5.1 Requirements

This subclause specifies **safeguards** that reduce the likelihood of injury by moving parts in **accessible** areas of the equipment (for example, pinch points, meshing gears and parts that may start moving due to unexpected resetting of a control device).

Engineering judgement shall be used to class a mechanical energy source as MS1, MS2 or MS3 according to Table 40, line 2.

The phrase “moving parts” in this subclause includes moving fan blades. Moving fan blades are classified according to Table 40, line 3.

NOTE 1 The ability of a part to cause injury is not solely dependent upon the kinetic energy it possesses. Consequently, the classification used in this standard can only be based on typical experience and engineering judgement.

NOTE 2 Examples of factors influencing the energy transfer to a body part include shape of the surface that strikes the body part, elasticity, velocity and the mass of equipment and body part.

A **mechanical enclosure** or barrier used as an **equipment safeguard** shall be so constructed that MS2 or MS3 parts are not **accessible** to an **ordinary person** and that MS3 parts are not **accessible** to an **instructed person**.

Where the likelihood exists that fingers, jewellery, clothing, hair, etc., can be drawn into parts (for example, gears), an **equipment safeguard** shall be provided to prevent injury.

If the **safeguard** is a **safety interlock**, it shall comply with the requirements in Annex K. The movement of the part shall be reduced to MS1 before the part is **accessible**.

An MS3 fan that is arranged, located, enclosed or guarded in such a way that the possibility of contact with the moving parts of the fan is unlikely by an **ordinary person** during **ordinary person** servicing, or by an **instructed person** during **instructed person** servicing, shall be provided with an **instructional safeguard** as specified in 8.5.2.

8.5.2 MS2 or MS3 part required to be accessible for the function of the equipment

If a moving MS2 or MS3 part is required to be **accessible** to an **ordinary person** or an **instructed person** for the function of the equipment:

- any exposure shall not be life threatening; and
- the moving part shall be obvious when exposed; and
- the moving part shall be guarded as much as practicable; and
- an **instructional safeguard** shall be used to minimise unintentional contact; and
- for MS3, a manually activated stopping device shall be clearly visible and placed in a prominent position within 750 mm of the MS3 part.

If the location of a MS3 moving part may not be obvious to a **skilled person**, such as intermittent movement, an **instructional safeguard** shall be provided to minimise unintentional contact. A manually activated stopping device shall be clearly visible and placed in a prominent position within 750 mm of the MS3 part.

Instructional safeguards for a moving part shall be in accordance with Clause F.5 and shall be fixed to the equipment located in proximity to the moving part and contain a relevant

graphical symbol (such as ) for moving fan blades) or text with the following or similar appropriate wording:

WARNING Hazardous moving parts. Keep body parts out of the motion path.

8.5.3 Compliance

The accessibility of moving parts shall be checked by inspection, and if necessary according to Annex V. Selection of the probe will depend on the application.

*Compliance is checked by inspection of the construction and available data, and where necessary, by the relevant tests of Annex T for **enclosures** and barriers.*

Compliance of thermoplastic stability is checked by the test according to Clause T.8, followed by the test of Annex V. Alternatively, compliance can be shown by examination of the construction and available material data.

8.5.4 Special categories of equipment comprising moving parts

8.5.4.1 Large data storage equipment

The requirements of IEC 60950-23 are additional to the relevant requirements in this standard.

Large equipment is typically of such a size that a person may enter completely. Systems may also include similar equipment having areas containing moving parts into which only a complete limb or head may enter. These requirements apply to a three dimensional envelope of 0,75 m³ or more within reach of the moving part.

The following references in IEC 60950-23 shall be treated as follows:

- replace IEC 60950-1:2005, 2.8 by Annex K;
- replace IEC 60950-1:2005, 2.8.6 by Clause K.4;
- replace "SERVICE PERSON" by "**skilled person**";
- replace "OPERATOR ACCESS AREA" by "areas **accessible** by an **ordinary person** as determined by Annex V".

NOTE An example of these systems is a self-contained data storage system.

8.5.4.2 Equipment having an electromechanical device for destruction of media

8.5.4.2.1 General requirements

This subclause specifies **equipment safeguards** to protect persons, including children, for equipment intended to mechanically destroy various media by means of moving parts that draw the media into the equipment. The media destruction device within this equipment is classed as MS3.

NOTE 1 Examples of this type of equipment include household use and home-office use document shredding and similar media destruction devices, as determined by the nature of their power source.

For equipment for use in locations where children are not likely to be present, see Clause F.4.

NOTE 2 This equipment design typically applies to commercial or industrial equipment expected to be installed in locations where only adults are normally present.

Equipment shall be provided with **safeguards** so that MS3 moving parts are not **accessible** to the appropriate jointed test probe of Annex V and the wedge probe of Figure V.4. Requirements for **safety interlocks** are according to Annex K, except that where a moving part cannot be reduced to the appropriate energy class within 2 s, the **safety interlock** shall continue to prevent access.

8.5.4.2.2 Instructional safeguards against moving parts

An **instructional safeguard** shall be provided in accordance with Clause F.5, adjacent to the media feed opening, alerting **ordinary persons** to the following:

- the equipment is not intended for use by children (this product is not a toy);
- avoid touching the media feed opening with the hands, clothing or hair.

For equipment installed where children are likely to be present, the instructions shall contain a statement recommending the equipment be unplugged when not in use for an extended period of time.

8.5.4.2.3 Disconnection from the supply

An isolating switch complying with Annex L shall be provided to disconnect power to MS3 moving parts. A switch with an "OFF" position, that removes all power from the MS3 moving part is acceptable. The switch shall be located where it is easily **accessible** to the user whose body part or clothes may be caught.

The "ON" and "OFF" positions of a two-position switch shall be marked in accordance with F.3.5.2.

For a multi-position switch, the "OFF" position of the switch shall be marked in accordance with F.3.5.2, and the other positions shall be marked with appropriate words or symbols.

8.5.4.2.4 Test method

For strip-cut type media destruction devices and the like, the wedge probe of Figure V.4 is applied with a force up to 45 N.

For cross-cut type media destruction devices and the like, the wedge probe is applied with a force up to 90 N. The force is applied in any direction relative to the opening.

NOTE Media destruction devices are typically identified as either strip-cut type or cross-cut type. A strip-cut media destruction device shreds the media into long strips using a motor-based shredding mechanism. A cross-cut media destruction device shreds the media two or more ways into tiny particles, typically using a more powerful motor and more complex shredding mechanism.

*Any **enclosure** or guard that can be removed or opened by an **ordinary person** or an **instructed person** shall be removed or opened prior to application of the probes.*

8.5.4.2.5 Compliance

Compliance is checked in accordance with V.1.2 and V.1.5. Depending on whether the equipment is a strip-type media destruction device or cross-cut media destruction device, the wedge probe of Figure V.4 is applied with the forces specified in this subclause. The wedge probe shall not contact any moving part.

*Where the equipment is provided with a **safety interlock**, compliance is checked according to Annex K, except where a moving part cannot be reduced to the appropriate energy class within 2 s, the **safety interlock** shall continue to prevent access.*

8.5.5 Protection of persons against loosening, exploding or imploding parts

8.5.5.1 Protection against MS3 parts

Where the equipment contains high speed parts, pressurized surfaces or the like, **safeguards** shall be provided to prevent the parts or fragments such as broken media and glass from injuring persons.

The following equipment constructions are examples considered MS3:

- high speed removable plastic solid media such as used in CD drives or DVD drives, capable of rotational speed greater than 8 000 rpm; and
- CRTs having a maximum face dimension exceeding 160 mm; and
- lamps, in which the pressure exceeds 0,2 MPa when cold or 0,4 MPa when operating, are considered high pressure lamps and shall be classed MS3.

Compliance is checked in accordance with 8.5.5.2.1, 8.5.5.2.2 and Annex U, as applicable.

To contain any other loose or broken parts, a **double safeguard** or **reinforced safeguard** shall be sufficiently robust to

- contain the parts; or
- attenuate the energy of the parts to MS1 level.

Compliance is checked by inspection, or, if necessary, by test. The test force to the inside of the enclosure, if necessary, shall be 1,25 times that of the calculated force from a broken or loose part.

8.5.5.2 Requirements and test methods

8.5.5.2.1 Mechanical enclosure requirements for rotating solid media

8.5.5.2.1.1 General

This subclause assesses containment of damaged solid media classified as MS3 in accordance with 8.5.5.1 that may shatter during **normal operating conditions**. The movable media door and tray assembly are tested in accordance with 8.5.5.2.1.2 to assess the size of the potential gap during the static force test where media fragments may be expelled.

8.5.5.2.1.2 Test methods

The size of the gap 'X' between the media door or tray assembly and the enclosure is measured while the following force is applied.

A force of $F \pm 10\%$ is applied to the inside of the cover at the most unfavourable location. The formula for calculating the static force to be applied is:

$$F = S \times mv^2 / R_o$$

where

- F* is the force in Newtons to be applied;
- S* = 0,250 when no deflector is used (considered worst case fractional size of fragment mass);
- S* = 0,125 when a deflector is used (considered worst case fractional size of fragment mass);
- m* is the mass in kilograms of the media;
- v* is the velocity in metres per second of the outside diameter of the media;
- R_o* is the outer radius in metres of the media.

NOTE 1 The entire mass of the media is as specified by the manufacturer.

NOTE 2 Typical CD and DVD media will be within this range.

- For a CD (in accordance with IEC 60908)
 - thickness: 1,20 mm $\begin{smallmatrix} +0,3 \\ -0,1 \end{smallmatrix}$ mm,
 - mass: 14 g to 33 g.
- For a DVD (in accordance with ECMA-267)
 - thickness: 1,20 mm $\begin{smallmatrix} +0,3 \\ -0,06 \end{smallmatrix}$ mm,
 - mass: 13 g to 20 g.

8.5.5.2.1.3 Compliance

Compliance is checked by inspection and, if necessary, by the following tests in accordance with Figure 48 or Figure 49, as appropriate.

Where a media deflector is not used, the cover on the door shall not break, separate from the drive or flex such as to create an opening greater than 'X' mm measured between any part of the media door and the nearest outer enclosure surface through which media fragments could be expelled. A cylindrical probe or feeler gauge shall be used to measure the opening (see Figure 48). 'X' is the smallest thickness in millimetres of the media specified by the manufacturer.

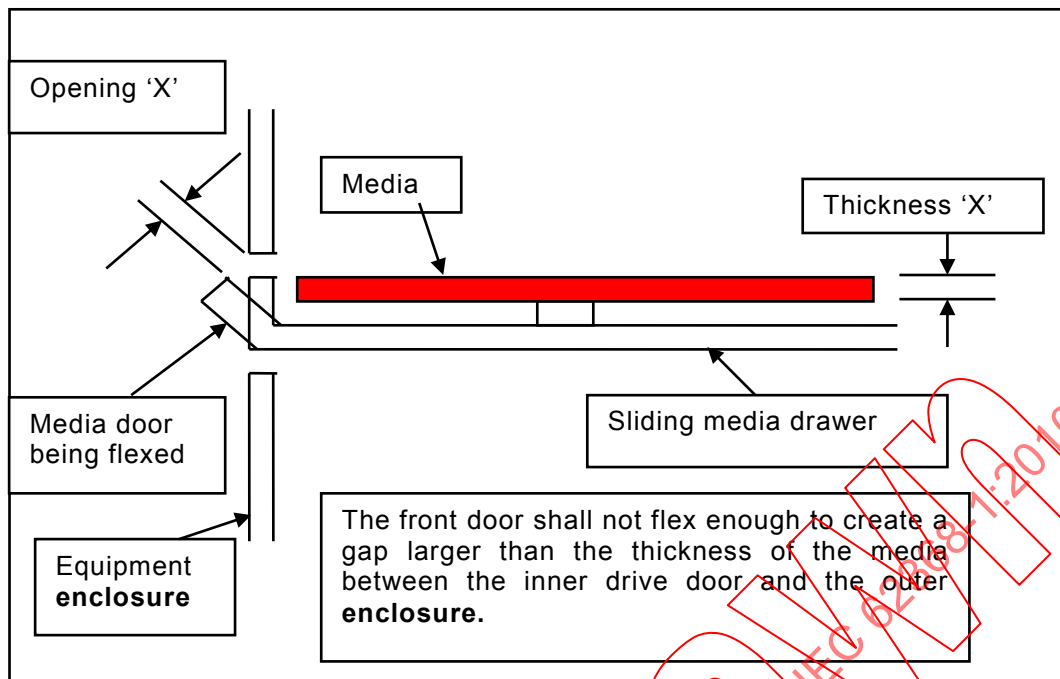


Figure 48 – Example for determining opening 'X' without a deflector

Where a media deflector is used, the cover on the door/deflector combination shall not break, separate from the drive or flex such as to create an opening through which media fragments could be expelled (see Figure 49).

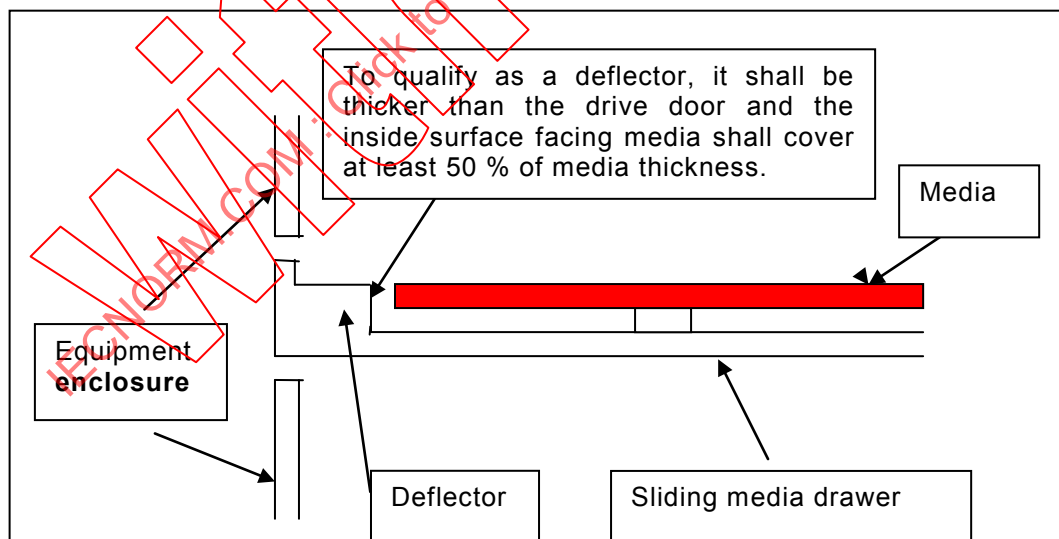


Figure 49 – Example for determining opening 'X' with a deflector

8.5.5.2.2 High pressure lamps

8.5.5.2.2.1 General

The containment mechanism for high pressure lamps that are considered MS3 shall have adequate strength to contain an **explosion** of the lamp so as to reduce the likelihood of injury

to an **ordinary person** or **instructed person** during normal use, or lamp assembly replacement, as appropriate.

Particles are considered MS1 parts if they are contained within the lamp assembly or equipment **enclosure** as tested in accordance with 8.5.5.2.2.2.

Particles are considered MS2 parts if they are less than 0,8 mm in the longest axis.

Particles are considered MS3 parts if they are equal to or greater than 0,8 mm in the longest axis.

8.5.5.2.2.2 Test methods

For the protection against the effects of a high pressure lamp failure, the following test is performed as follows:

- *lamp assemblies considered MS3 parts during field replacement are tested separate from the equipment;*
- *lamp assemblies only considered MS3 parts during operation, may be tested separately, or as normally installed in the equipment, or both.*

*An **explosion** of the lamp is stimulated by mechanical impact, electronic pulse generator or similar method. The lamp shall operate for at least 5 min to obtain operational temperature and pressure. To evaluate the rupture results for potential debris area and particle size, a dark sticky mat (or another adequate method) of adequate size is placed near the exhaust vent of the equipment. The equipment opening shall be oriented to maximize potential for particles to be expelled from the product horizontally across the dark sticky mat. After the rupture, the glass particles generated are measured using a magnified glass piece with a 0,1 mm resolution. The test shall be conducted to simulate the worst case operating position specified in the instructions.*

NOTE It is recommended to have the sticky mat a dark blue colour for easier inspection of potential glass debris.

An example of an electronic pulse generator method is given in Figure D.3.

The charge is increased in steps of 5 J until the lamp ruptures are repeatable.

8.5.5.2.2.3 Compliance

Compliance is checked by physical inspection or, if necessary, by the tests of 8.5.5.2.2.2.

*When tested, inspect the dark sticky mat for glass particles. No MS3 particle shall be found and no MS2 particles shall be found beyond 1 m of the **enclosure** opening.*

8.6 Stability of equipment

8.6.1 Requirements

This subclause specifies performance requirements that reduce the likelihood of MS2 or MS3 equipment becoming physically unstable to the point of tip over.

Classification of products for the purposes of assessing equipment stability is to be done according to Table 40, line 5.

Free standing MS2 or MS3 equipment shall be subjected to the stability test of 8.6.2.2 at an angle of 10°.

NOTE Examples of this type of equipment include some loudspeaker systems and some audio systems.

Free standing MS2 or MS3 equipment, having controls that are accessed during normal use or having a display with moving images, shall be tested according to the floor standing tests of 8.6.2 and the non-floor standing tests of 8.6.3 as appropriate.

Floor standing MS2 or MS3 equipment that is fixed to the building structure shall be subjected to the horizontal force test of 8.7.2 only.

Individual units that are designed to be mechanically fixed together on site and are not used individually, or **stationary equipment**, shall be assessed by inspection after installation according to the manufacturer's instructions and, if necessary, tested according to 8.6.2.2.

Where thermoplastic materials are involved in the construction, the relevant mechanical tests shall be conducted after the stress relief test in Clause T.8 when the equipment has cooled to room temperature.

Non-floor standing MS3 equipment, tested according to 8.6.3.1 and 8.6.3.2, shall have an **instructional safeguard** in accordance with Clause F.5, elements 3 and 4, located in the instructions for installation or use, containing the following information or equivalent:

WARNING

Never place the equipment in an unstable location. The equipment may fall, causing serious personal injury or death. Many injuries, particularly to children, can be avoided by taking simple precautions such as:

- Using cabinets or stands recommended by the manufacturer of the equipment.
- Only using furniture that can safely support the equipment.
- Ensuring the equipment is not overhanging the edge of the supporting furniture.
- Not placing the equipment on tall furniture (for example, cupboards or bookcases) without anchoring both the furniture and the equipment to a suitable support.
- Not standing the equipment on cloth or other materials placed between the equipment and supporting furniture.
- Educating children about the dangers of climbing on furniture to reach the equipment or its controls.

8.6.2 Static stability for floor standing equipment

8.6.2.1 Requirements

This subclause addresses the stability of equipment that can be handled, moved or relocated during intended use or installation.

The MS2 or MS3 equipment shall not tip over when installed according to the installation instructions, or during relocation.

The equipment shall be blocked, if necessary, by means of a stop of the smallest dimensions possible to keep it from sliding or rolling during the test. During the tests, containers, if any, are to contain the amount of substance within their rated capacity that will result in the most disadvantageous condition.

Compliance is checked by inspection or, if necessary, by test. The equipment shall not tip over.

8.6.2.2 Static stability test

All doors, drawers, casters, adjustable feet and other appurtenances, if used by an **ordinary person**, are arranged in any combination that results in the least stability. Equipment provided with multi-positional features shall be tested in the least favourable position based on the equipment construction. However, if the casters are intended only to transport the unit, and if the installation instructions require adjustable feet to be lowered after installation, then the adjustable feet (and not the casters) are used in this test.

- a) MS3 equipment shall not tip over when a force equal to 20 % of the weight of the unit, but not more than 250 N, is applied in any direction, except upwards, to any point on the equipment in such a way as to produce the maximum overturning moment, at a height not exceeding 1,5 m from the floor. The test force shall be discontinued if the equipment remains stable after being tilted 15° from vertical. Alternatively, the equipment shall be tipped at any angle up to and including 15° from the vertical.
- b) MS3 equipment shall not tip over when a constant downward force of 800 N is applied at the point of leverage for a maximum moment to any point of any horizontal surface of at least 125 mm by at least 200 mm, at any height up to 1 m from the floor. The 800 N force is applied by means of a suitable test apparatus 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 equipment; the test apparatus need not be in full contact with uneven surfaces (for example, corrugated or curved surfaces). Equipment having a shape or a flexibility of the surface that is not likely to be used as a step or a ladder are exempt from the test.

NOTE Examples are products in combination with a cart or stand or products with protrusion or recess where the construction is obviously not to be used as a step or ladder.

Where MS3 equipment is subject to periodic maintenance or routinely serviced or repaired at its intended use location, the doors, drawers, etc. or any other adjustment means **accessible** to an **instructed person** or **skilled person** shall be arranged in any combination specified by the servicing instructions that results in the least stability. The test of a) above is repeated if necessary.

8.6.2.3 Relocation stability test

Floor standing equipment expected to be moved or relocated by **ordinary persons** and having wheels with a minimum diameter of less than 100 mm shall have all doors, drawers, casters, adjustable feet and other appurtenances arranged in any combination that results in the least stability. A unit provided with multi-positional features shall be tested in the least favourable position based on the equipment construction.

Floor standing equipment expected to be moved or relocated by an **instructed person** or a **skilled person** and having wheels with a minimum diameter of less than 100 mm shall have all doors, drawers, etc., positioned in accordance with the manufacturer's instructions. A unit provided with multi-positional features shall be tested in the least favourable position based on the equipment construction.

Floor standing MS2 or MS3 equipment shall not tip over when tilted to an angle of 10° from its normal upright position in any direction. If the equipment is such that when it is tilted through an angle of 10° when standing on a horizontal plane, a part of it not normally in contact with the supporting surface would touch the horizontal plane, the equipment is placed on a horizontal support so that contact does not occur with the horizontal surface and the combination is tilted in the most unfavourable direction through an angle of 10°. Alternatively, the equipment may be placed on a plane and is rotated through an angle of 360° about its normal vertical axis while tilted at 10°.

NOTE The test on the horizontal support may be necessary (for example, for equipment provided with small feet, casters or the like).

8.6.3 Non-floor standing equipment having controls that are accessed during normal use or having displays with moving images

8.6.3.1 Glass slide test

*MS2 or MS3 equipment (except for floor standing equipment) likely to be used in the home or similar installation environments where they may be **accessible** to children, is placed on a clean, dry, glass covered horizontal surface so that only the supporting feet are in contact with the glass. The glass-covered surface is then tilted in the most unfavourable direction through an angle of 10°.*

During the tests, the equipment shall not slide or tip over.

8.6.3.2 Horizontal force test

8.6.3.2.1 General

This subclause addresses the risk of children being attracted to MS2 or MS3 equipment likely to be elevated above the floor with normally **accessible** controls or displays with moving images resulting in their attempt to climb onto devices that may tip over easily. This requirement does not apply to other equipment.

NOTE Equipment with front mounted user controls and moving images are considered to increase the frequency of children being attracted to displays and thereby increasing the likelihood of the child attempting to climb or move the equipment.

8.6.3.2.2 Test method

MS2 or MS3 equipment is to be placed on a horizontal non-skid surface with all doors, drawers, casters, adjustable feet and other movable parts arranged in any combination that results in the least stable condition. The equipment shall be blocked, if necessary, by means of a stop of the smallest dimensions possible, to keep it from sliding or rolling when subjected to one of the following tests:

- a) an externally applied horizontal force of 13 % of the weight of the equipment or 100 N, whichever is less, is applied in a horizontal direction to that point on the equipment that will result in the least stability. The force shall not be applied more than 1,5 m above supporting surface; or*
- b) the equipment shall be moved through any angle of tilt up to and including 15° from the vertical.*

During the test, the equipment shall not tip over.

8.7 Equipment mounted to a wall or ceiling

8.7.1 General

This subclause specifies how to minimise the likelihood of injury caused by equipment falling due to failure of the mounting means.

The mounting means of MS2 or MS3 equipment intended for wall or ceiling mounting shall be capable of vertically supporting four times the weight of the equipment, and also lateral stress. The mounting hardware shall either be provided with the equipment, or described in detail in the user instructions (for example, length of screws and type of mounting surface suitable for the installation, etc.). Classification of equipment for the purposes of assessing wall mounting means is to be done according to Table 40, line 6.

8.7.2 Test method

The equipment is mounted in accordance with the manufacturer's instructions and mounting means positioned, when possible, to represent the most severe stress on the supports.

A downward force, in addition to the weight of the equipment, is applied downwards through the centre of gravity for 60 s. The additional force shall be equal to three times the weight of the equipment, but not less than 50 N in total. The equipment and its associated mounting means shall remain secure during the test.

In addition, for wall mounted equipment, a horizontal force of 50 N is applied laterally for 60 s.

8.7.3 Compliance

Compliance is checked by inspection of the construction and of available data or, where necessary, by the test of 8.7.2.

8.8 Handle strength test method

8.8.1 General

This subclause specifies how to reduce the likelihood of injury from a handle failure causing the equipment to fall for other than MS1 equipment having only one handle.

This subclause applies to a handle that is declared by the manufacturer for the purpose of lifting or carrying the equipment.

For the purposes of this subclause, the equipment is classified according to Table 40, line 5.

8.8.2 Compliance and test method

The equipment shall pass the following test:

A weight shall be uniformly applied over a 75 mm width at the centre of the handle, without clamping.

The weight shall be the equipment weight plus an additional weight as specified below:

- *for MS1 equipment, with two or more handles, a weight that exerts a force of three times the weight of the equipment;*
- *for MS2 equipment, a weight that exerts a force of three times the weight of the equipment;*
- *for MS3 equipment with a mass 50 kg or less, a weight that exerts a force of two times the weight of the equipment or 75 kg, whichever is greater;*
- *for MS3 equipment with a mass greater than 50 kg, a weight that exerts a force of one times the weight of the equipment or 100 kg, whichever is greater.*

The additional weight shall be started at zero and gradually increased so that the test value is attained in 5 s to 10 s and maintained for 60 s. When more than one handle is provided, the force shall be distributed between the handles. The distribution of the forces shall be determined by measuring the percentage of the equipment's weight sustained by each handle with the equipment in the intended carrying position. When MS2 equipment is furnished with more than one handle, and it can be considered capable of being carried by only one handle, each handle shall be capable of sustaining the total force.

*As a result of the test, the handle, its securing means, or that portion of the **enclosure** to which it is secured, shall not break, crack, or detach from the equipment.*

8.9 Wheels or casters attachment requirements

8.9.1 General

This subclause specifies how to reduce the likelihood of MS3 and some MS2 equipment, including carts, stands and similar carriers that support the equipment, from tipping over during movement. For the purposes of this subclause, the equipment is classified according to Table 40, line 5.

8.9.2 Test method

*Wheels or casters on MS3 equipment, or their supporting cart, stand or similar carrier, intended to be moved as part of its **normal operating conditions**, shall be capable of withstanding a pull of 20 N without being damaged or pulled free from its securing means. The pull force is to be applied by a weight, or a steady pull, to the wheel or caster for a period of 1 min in any direction made possible by the construction.*

8.10 Carts, stands, and similar carriers

8.10.1 General

This subclause specifies how to minimise the risk of tipping, material breakdown, or mismatching of cart, stand or similar carrier relevant to the mounted equipment.

The equipment shall be stable with the cart, stand or similar carrier. For the purposes of this subclause, the MS classifications of Table 40, line 5 are applied using the combined mass of both the equipment and the carts or stands specified with the equipment.

All carts and stands specified for use with the equipment shall be subjected to the applicable tests described in the following subclauses. A cart, stand or carrier shall be subjected to the applicable tests alone and again with the equipment specified by the manufacturer placed on the cart or stand.

MS3 equipment, including their supporting carts, stands and similar carriers that support the equipment, that are not moved as part of its **normal operating conditions**, shall comply with the horizontal force test of 8.6.3.2.

MS2 or MS3 equipment more than 1 m in height, including equipment mounted on their specified cart, stand or carrier, shall comply with the relocation stability test in 8.6.2.3 except that the tip angle becomes 15°. If equipment is provided with wheels or casters that allow the equipment to only move in limited directions, the test is only applied in those directions (for example, an electronic white board).

8.10.2 Marking and instructions

A cart, stand or similar carrier that is specified by the manufacturer for use with specific equipment, but is packaged and marketed separately from the equipment, shall be provided with an **instructional safeguard** in accordance with Clause F.5.

Elements 2, 3 and 4 as appropriate shall include the manufacturer's name, distinctive catalogue designation of equipment to be supported, model or series, and equipment name; and the following statement or equivalent text:

CAUTION
This (cart, stand or carrier) is intended for use only with (manufacturer's name),
(model number or series), (equipment name).
Use with other equipment may result in instability causing injury.

When it is not feasible to include a specific equipment model number or series designation on the cart, stand or similar carrier, this information shall be provided in the instructions.

Equipment only intended and shipped for use with a specific cart, stand or similar carrier, shall be provided with an **instructional safeguard** in accordance with Clause F.5.

Elements 2, 3 and 4 as appropriate shall include:

CAUTION
This (equipment name) is for use only with (manufacturer's name), (model number or series),
(cart, stand or carrier). Use with other (carts, stands, or carriers) may result in instability
causing injury.

8.10.3 Cart, stand or carrier loading test and compliance

A cart, stand or carrier shall be constructed so that permanent deformation or damage that is capable of resulting in injury to a person, does not occur when it is subjected to a force of 220 N applied for 1 min to any grippable or leverage point accessible to a child.

To determine compliance, the force is applied through the end of a 30 mm diameter circular cylinder. The force is to be applied to a shelf drawer, dowel rung support, or equivalent part that is within 750 mm from the floor and will support some or all of a child's weight. The force is to be applied for 1 min with the cart or stand at room temperature. The part shall not collapse or break so as to expose sharp edges or produce pinch points that are capable of resulting in injury.

In addition, a cart, stand or other carrier shall be constructed so that permanent deformation or damage that is capable of resulting in injury to persons does not occur when each supporting surface is individually loaded with:

- *the manufacturer's intended load plus 440 N for the surface intended to support a display with moving images; or*
- *four times the manufacturer's intended load or 100 N, whichever is greater but not to exceed 440 N, is applied to all applicable surfaces.*

A dedicated storage area intended to accommodate specific accessories such as media tapes, discs, etc. shall be fully loaded to the rated load.

The weight is to be applied for 1 min on each supporting surface, with the other supporting surfaces unloaded.

8.10.4 Cart, stand or carrier impact test

When tested as described below, a cart, stand or carrier shall not produce a risk of injury to persons.

A single 7 J impact is to be applied to any part of the cart or stand and the test method is to be as described in Clause T.6. However, a cart, stand or carrier made of glass shall be tested instead according to T.9.1.

8.10.5 Mechanical stability

A cart, stand or carrier, including floor standing, by itself, and where applicable in combination with its intended MS2 or MS3 equipment, shall be subjected to the applicable tests described in 8.6.2.3 and 8.6.3.2.

For the purposes of these tests, the weight shall be considered as the total weight of the equipment plus the weight of the cart, stand or carrier. The equipment shall be installed according to the manufacturer's instructions and the horizontal force shall be applied to either the cart, stand or carrier or intended equipment to produce a maximum overturning moment on the equipment at a point up to a maximum height of 1,5 m above the floor level.

If during the tests of 8.6.2.3 and 8.6.3.2 the equipment starts to slide or tip relative to the cart, stand or carrier, only the horizontal force test shall be repeated by reducing the force to 13 % of the weight of the equipment alone, or 100 N, whichever is less.

The equipment and cart or stand shall not tip over.

8.10.6 Thermoplastic temperature stability

An equipment, cart, stand or carrier using thermoplastic materials in its construction shall withstand the test of Clause T.8, without any shrinkage, warpage, or other distortion of the thermoplastic materials that results in the equipment failing to comply with 8.10.3, 8.10.4 and 8.10.5.

8.11 Mounting means for rack mounted equipment

8.11.1 Requirements

This subclause applies to the mounting means of MS2 and MS3 equipment 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, equipment subassemblies or racks having a top installation position less than 1 m in height from the supporting surface.

For the purpose of this subclause, the mechanical mounting means will be referred to as slide-rail. This subclause specifies requirements for the slide-rail to reduce the likelihood of injury by retaining the equipment in a safe position and not allowing the slide-rails to buckle, 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.

Classification of products for the purposes of assessing equipment stability is to be done according to Table 40, line 5.

Such slide-rails shall have end stops that prevent the equipment from unintentionally sliding off the mounting means.

8.11.2 Mechanical strength test, variable *N*

The slide-rail 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 30 mm in diameter. If applying this force could damage the equipment, a metal plate or other means of distributing 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 intended 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 state the maximum load that is intended to be placed on the shelf in order to determine the force that needs to be applied to the shelf. An **instructional safeguard** 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 30 mm in diameter.*

8.11.3 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 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 end stops are being considered at this time.

8.11.4 Compliance

Compliance is checked by inspection and available manufacturer's data. If data is not available, then the tests according to 8.11.2 and 8.11.3 are conducted.

The equipment and its associated slide-rails shall remain secure during the tests. One complete cycle of travel on its slide-rails after completion of each test shall be performed. 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 of the equipment at its centre point 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.

8.12 Telescoping or rod antennas

A telescoping or rod antenna shall be provided with a minimum 6,0 mm diameter button or ball on the end. An antenna end piece and the sections of a telescoping antenna shall be secured in such a manner as to prevent removal.

Compliance is checked by inspection and the test of Clause T.10.

9 Thermal burn injury

9.1 General

This clause specifies safeguards to reduce the likelihood of skin burn injury as the result of conduction of thermal energy from parts of equipment.

9.2 Thermal energy source classifications

9.2.1 General

This subclause describes the different energy sources and defines their limits under **normal operating conditions** and **abnormal operating conditions** at normal room ambient of 25 °C. **Single fault conditions** are not considered.

9.2.2 TS1

TS1 is a thermal energy source with levels not exceeding TS1 limits in Table 42 under **normal operating conditions**, and not exceeding TS2 limits in Table 42 under **abnormal operating conditions**. If, under **abnormal operating conditions**, the equipment continues to function, TS1 does not exceed the TS2 limits specified for contact durations less than 1 s. Where the malfunction of the equipment is evident, no limits apply.

NOTE TS1 may be **accessible** to an **ordinary person**.

9.2.3 TS2

TS2 is a thermal energy source with levels exceeding TS1 limits under **normal operating conditions** but not exceeding TS2 limits in Table 42 under **normal operating conditions** and **abnormal operating conditions**. If, under **abnormal operating conditions**, the equipment continues to function, the TS2 limits specified for contact durations less than 1 s apply. Where the malfunction of the equipment is evident, no limits apply.

NOTE TS2 may be **accessible** to an **instructed person**, and under **single fault conditions**, to an **ordinary person**.

TS2 may be **accessible** to **ordinary persons** if an **instructional safeguard** is in place.

9.2.4 TS3

TS3 is a thermal energy source with levels exceeding the appropriate TS2 limits in Table 42 under **normal operating conditions** and **abnormal operating conditions**, or any thermal energy source declared to be TS3.

NOTE Parts and surfaces classed TS3 may be **accessible** to a **skilled person**.

9.2.5 Touch temperature levels

Table 42 – Touch temperature limits

	Accessible parts ^a	Maximum temperature (T_{max}) °C			
		Metal	Glass, porcelain and vitreous material	Plastic and rubber ^b	Wood
TS1	Handles, knobs, grips, etc., and external surfaces held in normal use (>1 min) ^c	48	48	48	48
TS1	Handles, knobs, grips, etc., and external surfaces held for short periods of time or touched occasionally (>10 s and <1 min) ^c	51	56	60	60
TS1	Handle, knobs, grips etc., and external surfaces touched occasionally for very short periods (>1 s and <10 s) ^c	60	71	77	107
TS1	External surfaces that need not be touched to operate the equipment (<1 s) ^c	70 ^d	80 ^d	94 ^d	140
The limits for TS2 are 10 K higher than the TS1 limits.					
^a Except for handles, knobs, grips etc., the following parts inside the equipment need not comply with this table provided an instructional safeguard in accordance with Clause F.5 is provided on or near the hot part (see 9.4.2): – a part that does not need to be touched to operate the equipment and if unintentional contact with the part is unlikely; – internal parts of the equipment requiring heat for the intended function (for example, a document laminator, thermal print head, fuser heater, etc.) provided the parts are unlikely to be touched by an ordinary person under normal operating conditions. ^b For each material, account shall be taken of the data for that material to determine the appropriate maximum temperature. ^c Time of contact shall be determined by the manufacturer. For outside parts of metal that are covered with plastic material of at least 0,3 mm thick, a temperature rise which corresponds to the permissible temperature limit of the plastic and rubber is allowed. ^d For the following areas and external surfaces, the temperature limit is 100 °C unless a higher limit is specified above: – an area on the external surface of the equipment that has no dimension exceeding 50 mm, and that is not likely to be touched in normal use; or – accessible surfaces of the equipment requiring heat for the intended function (for example, equipment that contains a document laminator, thermal print head, fuser heater, etc.), and that are not likely to be touched in normal use; or – heatsinks and metallic parts directly covering heatsinks, except those on surfaces incorporating switches or controls handled during normal use. For these areas and parts, an instructional safeguard in accordance with Clause F.5 shall be provided on or near the hot part.					

9.3 Protection against thermal energy sources

9.3.1 General

This subclause specifies protection requirements for parts **accessible** to **ordinary persons**, **instructed persons**, and **skilled persons**.

9.3.2 Protection of an ordinary person

9.3.2.1 Protection of an ordinary person against TS1

No **safeguard** need be interposed between TS1 and an **ordinary person**.

9.3.2.2 Protection of an ordinary person against TS2

At least one **safeguard** shall be interposed between TS2 and an **ordinary person**. This **safeguard** may be:

- an **equipment safeguard** such as thermal insulation; or
- an **instructional safeguard** in accordance with Clause F.5.

For use of **instructional safeguards**, see 9.4.2.

9.3.2.3 Protection of an ordinary person against TS3

At least one equipment **basic safeguard** and one **supplementary safeguard** shall be interposed between TS3 and an **ordinary person**.

NOTE The **supplementary safeguard** may be an **instructional safeguard**.

9.3.2.4 Compliance

Compliance is checked by inspection.

9.3.3 Protection of an instructed person

9.3.3.1 Protection of an instructed person against TS2

No **equipment safeguard** need be interposed between TS2 and an **instructed person**.

9.3.3.2 Protection of an instructed person against TS3

At least one equipment **basic safeguard** and one **supplementary safeguard** shall be interposed between TS3 and an **instructed person**.

NOTE The **supplementary safeguard** may be an **instructional safeguard**.

Compliance is checked by inspection.

9.3.4 Protection of a skilled person

Parts and surfaces classed TS3 shall be provided with an **equipment safeguard** or provided with an **instructional safeguard** so that unintentional contact with such parts and surfaces during service operations is unlikely to cause the **skilled person** to recoil into other class 3 energy sources (see Figure 19).

Compliance is checked by inspection.

9.4 Requirements for safeguards

9.4.1 Equipment safeguard

9.4.1.1 Requirements

An **equipment safeguard** shall limit the transfer of thermal energy (source temperature) under **normal operating conditions** and **abnormal operating conditions** or limit accessibility to a thermal energy source to a touch temperature as specified by the TS classification according to Table 42.

Temperature limits are applied only for those **abnormal operating conditions** where the equipment continues to function and the **abnormal operating condition** is not obvious. If the equipment stops functioning, then the limits are not applicable.

9.4.1.2 Test method and compliance

This test is run with the room ambient conditions as defined in B.1.7, except that the room ambient temperature shall be 25 °C.

*The equipment shall be operated in a manner the manufacturer determines likely to result in elevated thermal conditions of **accessible** surfaces and parts.*

NOTE This may not be the condition of maximum input current or wattage but the condition that delivers the highest thermal level to the part in question.

*Compliance is checked by measuring the steady state temperature of **accessible** surfaces.*

9.4.2 Instructional safeguard

An **instructional safeguard** shall be provided in accordance with Clause F.5 and be comprised of

- the symbol , IEC 60417-5041 (2002); or
- the following statement or equivalent text:

CAUTION
Hot surface. Do not touch.

Compliance is checked by inspection.

10 Radiation

10.1 General

This clause specifies how to reduce the likelihood of exposure of persons to injurious levels of both ionising and non-ionising electromagnetic radiation. This clause also provides protection against hearing impairment from excessive sound levels that may be produced by electronic equipment.

10.2 Radiation energy source classifications

10.2.1 RS1

RS1 has levels not exceeding RS1 limits under **normal operating conditions** and **abnormal operating conditions** and not exceeding RS2 limits under **single fault conditions**. When a person is exposed to RS1, the energy is undetectable to detectable but not painful.

NOTE An **ordinary person** may be exposed to RS1.

10.2.2 RS2

RS2 has levels not exceeding RS2 limits under **normal operating conditions**, **abnormal operating conditions** and under **single fault conditions**, but is not RS1. When a person is exposed to RS2, the energy may be detectable to painful. Exposure to RS2 is acceptable within given exposure limits and related short time periods (dose rates).

NOTE An **instructed person** may be exposed to RS2. Under **single fault conditions**, an **ordinary person** may also be exposed to RS2.

10.2.3 RS3

RS3 has levels exceeding RS2 limits, or any energy source declared to be RS3. When a person is exposed to RS3, the energy, even at short exposure (instantaneous power or power density), is considered injurious.

NOTE A **skilled person** may have access to RS3 with appropriate **instructional safeguards** and **skill safeguards** in place. National regulations limit the radiation level and exposure time where a **skilled person** is working live where RS3 may be present.

10.3 Requirements for electromagnetic radiation

10.3.1 Protection of persons from non-ionising radiation

10.3.1.1 General

This subclause specifies safeguards to reduce the risk of harmful effects of non-ionising radiation to all persons.

NOTE Diodes emitting coherent light (such as super luminescent diodes) should be treated as a laser.

10.3.1.2 Non-ionising radiation from lasers

10.3.1.2.1 Requirements

Equipment containing one or more lasers (including laser diodes) shall comply with IEC 60825-1, IEC 60825-2 or IEC 60825-12 as applicable.

Where a laser of class 3R, 3B or 4 is present, a **tool** shall be required to gain access.

10.3.1.2.2 Compliance

Radiation energy classification is determined by

- *measuring according to the IEC 60825 series, or*
- *checking the available manufacturer's data sheet.*

Compliance is checked to the applicable standard(s) within the IEC 60825 series.

NOTE 1 As of the date of this standard, the applicable standards are IEC 60825-1, IEC 60825-2 and IEC 60825-12.

*Equipment that does not exceed the accessible emission limit for Class 1 under all conditions of operation, maintenance and failure is not required to have a laser warning **instructional safeguard** or laser explanatory label. Such equipment is exempt (see Clause 1 of IEC 60825-1:2007).*

NOTE 2 Accessible emission limit is defined in IEC 60825-1:2007, 3.3.

10.3.1.3 Non-ionising optical radiation from lamps and lamp systems (including LEDs)

10.3.1.3.1 General

Equipment containing lamps or lamp systems 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 **safeguards** to eliminate unnecessary optical radiation exceeding the limits specified in IEC 62471. Low power applications of LEDs need not comply with IEC 62471.

NOTE 1 General purpose incandescent and fluorescent lamps, with ordinary glass envelopes, are not considered to emit significant UV radiation.

NOTE 2 Some examples of low power applications of LEDs that are exempt from the above requirements are those used as:

- indicating lights;
- infra-red devices such as used in home entertainment devices;
- infra-red devices for data transmission such as used between computers and computer peripherals;
- optocouplers; and
- other similar low power devices.

NOTE 3 If optical radiation is broadband visible and IR-A radiation and the luminance of the source does not exceed 10^4 cd/m², 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).

NOTE 4 For UV-C limits (wavelengths between 180 nm and 200 nm), the value of IEC 62471 for 200 nm is used.

The marking requirements in Clause F.5 are not required for a door or cover that is provided with a **safety interlock** switch that disconnects power to the UV lamp when the door or cover is opened, or any other mechanism that prevents UV radiation from being **accessible**.

In IEC 62471,

- the exempt group is RS1,
- risk group 1 and risk group 2 are RS2,
- risk group 3 is RS3.

10.3.1.3.2 Requirements

Except for the following condition of a) or b), optical radiation shall either

- be contained by the **enclosure** of the lamps and lamp system or the **enclosure** of the equipment; or
- not exceed the relevant limits for the exempt group given in IEC 62471 for **normal operating conditions** (for example, 8 h exposure for UV radiation).

NOTE 1 Lamp systems containing lamps covered by 6.1.1 of IEC 62471:2006 are exempt from the above requirements.

NOTE 2 The exempt group is described in 6.1.1 of IEC 62471:2006.

a) For UV radiation:

Equipment that produces visible 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 3 Glass with a thickness of 2 mm usually complies with this requirement.

Higher UV exposure levels are acceptable for shorter periods (up to 100 s for RS2) for maintenance and cleaning operations, if it is necessary for the UV lamp to be on during these operations. However, optical radiation shall not exceed the limits for risk group 2 (moderate risk) given in IEC 62471. The relevant exposure limits for the reduced time intervals for these operations shall be stated in the instructions.

Doors and covers that, when open, would allow access to RS2 shall have an **instructional safeguard** provided in accordance with Clause F.5 and be comprised of:

- the symbol , consisting of IEC 60417-5751 (2002) combined with the triangle shaped warning sign from ISO 3864-2, or

- the following statement or equivalent text:

WARNING Turn off the UV lamp before opening.

If the UV radiation symbol is used on the equipment, both the symbol and an **instructional safeguard** similar to the above marking shall appear together in the instructions. Where a symbol is used, its meaning shall be explained in the instructions.

If **skilled persons** are likely to be exposed to higher emissions than those specified above, in an area only **accessible** to **skilled persons**, and it is necessary for the equipment to remain energized while being serviced, an **instructional safeguard** shall be provided in accordance with Clause F.5 and be comprised of:

- the symbol , consisting of IEC 60417-5751 (2002) combined with the triangle shaped warning sign from ISO 3864-2, or
- the following statement or equivalent text:

WARNING Use UV radiation eye and skin protection during servicing.

The marking shall be located where readily visible during the servicing operation. The **instructional safeguard** shall be visible prior to opening the means of access to the RS3.

If the UV radiation symbol is used on the equipment, both the symbol and an **instructional safeguard** similar to the above marking shall appear together in the servicing instructions.

- b) For visible radiation:

If the emission of high levels of visible radiation is required for the equipment's intended function, an **instructional safeguard** shall be provided in accordance with Clause F.5 and be comprised of:

- the symbol , consisting of IEC 60417-5012 (2002) combined with the triangle shaped warning sign from ISO 3864-2, or
- the following statement or equivalent text:

WARNING Do not stare into beam.

Higher exposure levels are acceptable for shorter periods of time for maintenance and cleaning operations, if it is necessary for the lamp to be on during these operations, however optical radiation shall not exceed the limits for risk group 2 (moderate risk) given in IEC 62471. The relevant limits are those for the expected time intervals for these operations, which shall be stated in the instructions.

For doors and covers that when open would allow higher emissions than those specified above to be **accessible**, an **instructional safeguard** shall be provided in accordance with Clause F.5 and be comprised of:

- the symbol , consisting of IEC 60417-5012 (2002) combined with the triangle shaped warning sign from ISO 3864-2, or

- the following statement or equivalent text:

WARNING
Turn off the lamp before opening.

The **instructional safeguard** shall be in accordance with Clause F.5. The above marking is not required for a door or cover that is provided with a **safety interlock** switch that disconnects power to the lamp when the door or cover is opened, or any other mechanism that prevents visible radiation from being **accessible**.

If the visible radiation symbol is used on the equipment, both the symbol and an **instructional safeguard** similar to the above marking shall appear together in the instructions. Where a symbol is used, its meaning shall be explained in the instructions.

If **skilled persons** are likely to be exposed to higher emissions than those specified above, and it is necessary for the equipment to remain energized while being serviced, an **instructional safeguard** shall be provided in accordance with Clause F.5 and be comprised of:

- the symbol , consisting of IEC 60417-5012 (2002) combined with the triangle shaped warning sign from ISO 3864-2, or
- the following statement or equivalent text:

WARNING
Use eye protection during servicing.

The marking shall be located where readily visible during the servicing operation.

If the visible radiation symbol is used on the equipment, both the symbol and an **instructional safeguard** similar to the above marking shall appear together in the service instructions.

10.3.1.3.3 Compliance

Compliance is checked by evaluation of available data sheets, by inspection and, if necessary, by measurement.

NOTE For guidance on measuring techniques, see IEC 62471.

10.3.2 Non-ionizing radiation from radio frequencies in the range 0 Hz to 300 GHz

These types of radiation are not covered by this standard.

NOTE 1 National regulations apply.

NOTE 2 In the member countries of CENELEC, the amount of non-ionizing radiation is regulated by European Council Recommendation 1999/519/EC of 12 July 1999 on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz).

NOTE 3 For intentional radiators, ICNIRP guidelines should be taken into account for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields (up to 300 GHz). For hand-held and body-mounted devices, attention is drawn to IEC 62209-1 and IEC 62209-2.

10.3.3 Protection of persons from ionizing radiation (X-radiation)

10.3.3.1 General

This subclause defines the level of ionising radiation to reduce the risk of injury to persons, and describes the method of measurement for ionising radiation.

10.3.3.2 Requirements

Equipment shall not generate ionising radiation at levels that are injurious to persons. For an **ordinary person** and an **instructed person**, the limits of RS1 shall not be exceeded. For **skilled persons**, the limits of RS2 shall not be exceeded.

An **equipment safeguard** shall be interposed between all persons and a RS2 or RS3. In addition, if a **skilled person** may be exposed to RS2, then an **instructional safeguard** is required.

10.3.3.3 Compliance

*For RS1, at any point 50 mm from the surface of the area **accessible to ordinary persons and instructed persons**, the dose-rate shall not exceed 36 pA/kg (5 μ Sv/h, or 0,5 mR/h).*

NOTE 1 This value is consistent with International Commission on Radiation Protection (ICRP) Publication 60.

*For RS2, for protection of a **skilled person**, an additional measurement is made with any part of the cabinet, case, and chassis removed per maintenance instructions (CRT exposed) at the maximum test voltage applicable and under the conditions in accordance with 10.3.3.4. At any point 100 mm from the outer surface of any component of the equipment, the dose-rate shall not exceed 185 pA/kg (25 μ Sv/h, or 2,5 mR/h).*

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 100 mm from the surface of the equipment, the dose-rate shall not exceed 1 μ Sv/h (0,1 mR/h) taking account of the background level. For complete requirements refer to the above Directive.

NOTE 3 In the USA, the measuring conditions in the U.S. Code of Federal Regulations Title 21 Part 1020 are as given below (for complete requirements, refer to the above regulations).

Measurements are made with the equipment under test connected to the following source of supply:

- 130 V if the **rated voltage** is between 110 V and 120 V;
- 110 % of the **rated voltage**, if the **rated voltage** is not between 110 V and 120 V.

During the measurements:

- all user and service **accessible** controls are adjusted to combinations that produce maximum x-radiation emissions; and
- **abnormal operating conditions** of any component or circuit malfunction causing an increase of x-radiation emissions are to be simulated.

NOTE 4 In Canada, the measuring conditions in the Consolidated Regulations of Canada, c.1370 are as given below (for complete requirements refer to the above regulations).

Measurements are made with the equipment under test connected to the following source of supply:

- 127 V if the **rated voltage** is between 110 V and 120 V;
- 110 % of the **rated voltage**, if the **rated voltage** is not between 110 V and 120 V.

During the measurements all user and service **accessible** controls are adjusted to combinations that produce maximum x-radiation emissions.

10.3.3.4 Test method

Equipment that is likely to produce ionizing radiation is checked by measuring the amount of radiation. Account is taken of the background level.

The amount of radiation is determined by means of a radiation monitor of the ionizing chamber type with an effective area of 1 000 mm² or by measuring equipment of other types giving equivalent results.

*Measurements are made with the equipment under test operating at the most unfavourable supply voltage (see B.2.3) and with controls for an **ordinary person** and an **instructed person**, and controls for a **skilled person** that are not locked in a reliable manner, adjusted so as to give maximum radiation whilst maintaining the equipment operative for normal use.*

NOTE 1 Soldered joints and fixing by application of paint, epoxy, or similar materials are considered reliable locking means.

*Moreover, the measurement shall be made under any **abnormal operating condition** and **single fault conditions** that can cause an increase of the high-voltage, provided an intelligible picture is maintained for 5 min, at the end of which the measurement is made and averaged over 5 min.*

During the measurements, an intelligible picture is to be maintained.

A picture is considered to be intelligible if the following conditions are met:

- *a scanning amplitude of at least 70 % of the usable screen for both width and height;*
- *a minimum luminance of 50 cd/m² with locked blank raster provided by a test generator;*
- *not more than 12 flashovers in a 1 h period;*
- *a horizontal resolution corresponding to at least 1,5 MHz in the centre with a similar vertical degradation.*

NOTE 2 In the USA and Canada, an intelligible picture is in synchronization while covering 60 % of the viewable screen area.

10.3.4 Protection of materials from lamps that produce UV radiation

Materials 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.

NOTE Metals, glass and ceramic materials do not need to be assessed.

Compliance is checked by the tests in Annex C.

10.4 Protection against acoustic energy sources

10.4.1 General

This subclause specifies **safeguard** requirements for protection from acoustic energy sources that are closely coupled to the ear, for all persons.

NOTE In Australia the limits in AS/ACIF S004 apply for telecommunications-network-connected equipment.

10.4.2 Requirements

The following shall comply with the requirements of 10.4.3:

small battery powered equipment whose purpose is to listen to recorded or broadcasted sound, that uses wired headphones or earphones that can be worn in or on or around the ears, and that allows the user to walk around.

NOTE 1 Examples are portable mini-disk or CD players, MP3 audio players or similar equipment.

NOTE 2 Other equipment is under consideration.

10.4.3 Protection of ordinary persons

An **instructional safeguard** shall be provided in accordance with Clause F.5, using the following wording or similar:

To prevent possible hearing damage, do not listen at high volume levels for long periods. As a guide to setting the volume level, check that you can still hear your own voice, when speaking normally while listening with the headphones.

NOTE The **instructional safeguard** indicates that exposure to an acoustic energy source over extended periods may cause injury. The **instructional safeguard** provides sufficient information to enable the consumer to understand the effect of listening to loud sound levels.

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Withdrawn

Annex A (informative)

Examples of equipment within the scope of this standard

Some examples of equipment within 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)
Consumer electronic equipment (including professional audio, video and musical instrument equipment)	Receiving equipment and amplifiers for sound and/or vision, supply equipment intended to supply other equipment covered by the scope of this standard, electronic musical instruments, and electronic accessories such as rhythm generators, tone generators, music tuners and the like for use with electronic or non-electronic musical instruments, audio and/or video educational equipment, video projectors, video cameras and video monitors, video games, juke boxes, record and optical disc players, tape and optical disc recorders, antenna signal converters and amplifiers, antenna positioners, Citizen's Band equipment, equipment for imagery, electronic light effect equipment, intercommunication equipment using low voltage mains as the transmission medium, cable head-end receivers, multimedia equipment, electronic flash equipment
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 base stations, 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)

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

Annex B

(normative)

Normal operating condition tests, abnormal operating condition tests and single fault condition tests

B.1 General

B.1.1 Introduction

This annex specifies various tests and test conditions applicable to the equipment.

B.1.2 Test applicability

If it is evident that a particular test is not applicable, or not necessary after inspection of available data, the test shall not be made. Tests in this standard shall be conducted only if safety is involved.

In order to establish whether or not a test is applicable, the circuits and construction shall be carefully investigated to take into account the consequences of possible faults. The consequence of a fault may or may not require the use of a **safeguard** to reduce the likelihood of injury or fire.

B.1.3 Type of test

Except where otherwise stated, tests specified are **type tests**.

B.1.4 Test samples

Unless otherwise specified, the sample under test shall be representative of the actual equipment or shall be the actual equipment.

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

If a test could be destructive, a model may be used to represent the condition to be evaluated.

NOTE In view of the amount of resource involved in testing and in order to minimize waste, it is recommended that all parties concerned jointly consider the test program, the test samples and the test sequence. Tests that may result in the destruction of the test sample are recommended to be carried out last.

B.1.5 Measurement of voltages to earth

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

- the protective earthing terminal (if any); and
- any other conductive part required to be connected to protective earth (for example, see 5.6); 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 $5\,000\ \Omega \pm 10\%$ shall be connected across the voltage measuring instrument.

The 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.

B.1.6 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, compliance may be confirmed by reviewing any relevant data or previous test results that are available instead of carrying out the specified **type tests**.

B.1.7 Temperature measurement conditions

The test measurement set-up shall reproduce the most severe equipment installation conditions. Where a maximum temperature ($T_{\max}$) is specified for compliance with tests, it is based on the assumption that the room ambient air temperature will be $25\ ^\circ\text{C}$ when the equipment is operating. However, the manufacturer may specify a different maximum ambient air temperature.

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

With reference to those tests that are to be continued until steady state temperatures are attained, thermal equilibrium is considered to exist if the temperature rise does not exceed $3\ \text{K}$ in $30\ \text{min}$. If the measured temperature is at least 10% less than the specified temperature limit, thermal equilibrium is considered to exist if the temperature rise does not exceed $1\ \text{K}$ in $5\ \text{min}$.

Unless a particular method is specified, temperatures of windings shall be determined either by the thermocouple method or by any other method giving the average temperature of the winding wires such as the resistance method.

B.2 Normal operating conditions

B.2.1 General

Except where specific test conditions are stated elsewhere 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 **normal operating conditions** taking into account the following parameters:

- supply voltage;
- supply frequency;
- environmental conditions (for example, the manufacturer's rated maximum ambient temperature);
- physical location of equipment and position of movable parts, as specified by the manufacturer;
- operating mode, including external loading due to interconnected equipment;
- adjustment of a control.

For audio amplifiers and equipment containing an audio amplifier, additional test conditions apply, see Annex E.

B.2.2 Supply frequency

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

B.2.3 Supply voltage

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

- multiple **rated voltages**,
- extremes of **rated voltage ranges**,
- tolerance on **rated voltage** as declared by the manufacturer.

If the manufacturer has not declared a tolerance, it shall be taken as +10 % and –10 % for a.c. **mains** and +20 % and –15 % for d.c. **mains** only.

Where a test subclause does not require the most unfavourable supply voltage (by not making a specific reference to B.2.3), the supply voltage is the value of the **rated voltage** or any value in the **rated voltage range**.

B.2.4 Normal operating voltages

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 external to the equipment, including ringing signals received from **external circuits** as indicated in Table 16, ID numbers 11, 12, 13 and 14.

Externally generated **mains transient voltages** and **external circuit** transient voltages shall not be considered:

- when determining **working voltages**, because such transients have been taken into account in the procedures for determining minimum **clearances** (see 5.4.2);
- when classifying circuits in the equipment as ES1, ES2 and ES3 (see 5.2).

B.2.5 Input test

In determination of the input current or input power, the following variables shall be considered:

- loads due to optional features, offered or provided for by the manufacturer for inclusion in or with the equipment under test;
- loads due to other units of equipment intended by the manufacturer to draw power from the equipment under test;
- loads that could be connected to any standard supply outlet on the equipment that is **accessible** to an **ordinary person**, up to the value specified by the manufacturer;
- for equipment containing an audio amplifier, see Annex E;
- for displays with moving images, the following settings shall apply:
 - the 'Three vertical bar signal' shall be used as defined in 3.2.1.3 of IEC 60107-1:1997; and

- user **accessible** picture controls shall be adjusted so as to obtain the maximum power consumption; and
- sound settings shall be as defined in Clause E.1 of this standard.

Artificial loads may be used to simulate such loads during testing.

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

Compliance is checked by measuring the input current or input power of the equipment under the following conditions:

- where equipment has more than one **rated voltage**, the input current or input power is measured at each **rated voltage** and at each tolerance of the **rated voltage**;
- where equipment has one or more **rated voltage ranges**, the input current or input power is measured at each end of each **rated voltage range** and at the tolerance of each end of each **rated voltage range**
 - where a single value of **rated current** or **rated power** is marked, it is compared with the higher value of input current or input power measured in the associated **rated voltage range**, but excluding the tolerances on the voltages,
 - where two values of **rated current** or **rated power** are marked, separated by a hyphen, they are compared with the two values measured in the associated **rated voltage range** but excluding the tolerances on the voltages.

The measured input current or input power under **normal operating conditions**, but at the **rated voltage** or at any voltage within the **rated voltage range**, shall not exceed the **rated current** or **rated power** by more than 10 %.

B.2.6 Operating temperature measurement conditions

B.2.6.1 General

Temperatures measured on the equipment shall conform to B.2.6.2 or B.2.6.3, 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 specified by the manufacturer, or 25 °C, whichever is greater.

B.2.6.2 Operating temperature dependent heating/cooling

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.

Alternatively, the temperature measurement may be made under ambient conditions with the heating/cooling device at its least effective setting or with the device defeated.

B.2.6.3 Operating temperature independent heating/cooling

For equipment where the amount of heating or cooling is not designed to be dependent on ambient temperature, the method in B.2.6.2 may be used. 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 $(T_{\text{max}} + T_{\text{amb}} - T_{\text{ma}})$.

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

B.2.7 Battery charging under normal operating conditions

Under **normal operating conditions**, the **maximum charging current**, **upper limit charging voltage**, **lowest charging temperature** and the **highest charging temperature** shall comply with the requirements of Annex M as applicable.

B.3 Simulated abnormal operating conditions

B.3.1 General

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

Each **abnormal operating condition** shall be applied in turn, one at a time.

Faults that are the direct consequence of the **abnormal operating condition** are deemed to be a **single fault condition**.

The equipment, installation, instructions, and specifications shall be examined to determine those **abnormal operating conditions** that might reasonably be expected to occur.

As a minimum, the following examples of **abnormal operating conditions** shall be considered, as applicable, in addition to those mentioned in B.3.2 to B.3.7:

- for paper handling equipment, a paper jam;
- for equipment with controls **accessible** to an **ordinary person**, adjustment of the controls, both individually and collectively, for worst-case operating conditions;
- for audio amplifiers with controls **accessible** to an **ordinary person**, adjustment of the controls, both individually and collectively, for worst-case operating conditions, without applying the conditions specified in Annex E;
- for equipment with moving parts **accessible** to an **ordinary person**, a moving parts jam;
- for equipment with media, incorrect media, incorrect size media, and incorrect media quantity;
- for equipment with replenishable liquids or liquid cartridges, or replenishable materials, liquids or materials spilled into the equipment.

Before introducing any of the above **abnormal operating conditions**, the equipment shall be operating under **normal operating conditions**.

B.3.2 Covering of ventilation openings

The top, sides and the back of equipment, if such surfaces have ventilation openings, shall be covered one at a time with a piece of card (thick, stiff paper or thin cardboard) of 200 g/m² density, with dimensions not less than each tested surface, covering all openings.

Openings on different surfaces on top of the equipment (if any) are covered simultaneously by separate pieces of card.

Openings on top of the equipment, on a surface inclined at an angle greater than 30° and smaller than 60° to the horizontal, from which an obstruction is free to slide, are excluded.

On the back and the sides of the equipment, the card is attached to the upper edge and allowed to hang freely.

NOTE There are no requirements for blocking openings in the bottom of the equipment.

B.3.3 DC mains polarity test

If the connection to the d.c. **mains** is not polarized and the connection is **accessible** to an **ordinary person**, then the possible influence of polarity shall be taken into account when testing equipment designed for d.c.

B.3.4 Setting of voltage selector

Equipment to be supplied from the **mains** and provided with a voltage setting device to be set by the **ordinary person** or an **instructed person**, is tested with the **mains** voltage setting device at the most unfavourable position.

B.3.5 Maximum load at output terminals

Output terminals of equipment supplying power to other equipment, except socket-outlets directly connected to the **mains**, are connected to the most unfavourable load impedance, including short circuit.

B.3.6 Reverse battery polarity

If it is possible for an **ordinary person** to insert replaceable batteries with reversed polarity, the equipment is tested in all possible configurations with one or more batteries reversed (see also Annex M).

B.3.7 Audio amplifier abnormal operating conditions

Abnormal operating conditions for audio amplifiers are specified in Clause E.2.

B.3.8 Compliance during and after abnormal operating conditions

*During an **abnormal operating condition** that does not lead to a **single fault condition**, all **safeguards** shall remain effective. After restoration of **normal operating conditions**, all **safeguards** shall comply with applicable requirements.*

*If an **abnormal operating condition** leads to a **single fault condition**, Clause B.4 applies.*

B.4 Simulated single fault conditions

B.4.1 General

When applying simulated **single fault conditions**, parts, supplies, and media shall be in place if they are likely to have an effect on the outcome of the test.

The introduction of any **single fault condition** shall be applied in turn one at a time. Faults, that are the direct consequence of the **single fault condition**, are deemed to be part of that **single fault condition**.

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

The following **single fault conditions** shall be considered:

- an **abnormal operating condition** that results in a **single fault condition**. For example, an **ordinary person** overloading external output terminals, or an **ordinary person** incorrectly setting a selector switch;
- a **basic safeguard** failure or a **supplementary safeguard** failure;
- except for **safeguard** components (that is, components complying with Clause G.13), a component failure simulated by short-circuiting any two leads and open-circuiting any one lead of the component;
- when required by B.4.4, a failure of **functional insulation**.

B.4.2 Temperature controlling device

Except for temperature controlling **safeguards**, according to Clauses G.2 to G.5, any single device or component of a circuit controlling the temperature during temperature measurement shall be open-circuited or short-circuited, whichever is more unfavourable.

Temperatures shall be measured according to B.1.7.

B.4.3 Motor tests

B.4.3.1 Blocked motor test

Motors are blocked or the rotor is locked in the end product if it is obvious that such an action will result in an increase in internal ambient temperature of the equipment (for example, locking the rotor of the fan motor to stop air flow).

B.4.3.2 Compliance

Compliance is checked by inspection and examination of the available data or by testing according to Clause G.8.

B.4.4 Short circuit of functional insulation

B.4.4.1 Short circuit of clearances for functional insulation

Unless the **clearance** for **functional insulation** complies with the **clearance** for **basic insulation** or with the electric strength test of Table 31 for **basic insulation**, **clearances** for **functional insulation** shall be short-circuited.

B.4.4.2 Short circuit of creepage distances for functional insulation

Unless the **creepage distance** for **functional insulation** complies with the **creepage distance** for **basic insulation** or with the electric strength test of 5.4.11.1 for **basic insulation**, **creepage distances** for **functional insulation** shall be short-circuited.

B.4.4.3 Short circuit of functional insulation on coated printed boards

Unless the **functional insulation** complies with the separation distance of Table G.12 or with the electric strength test of 5.4.11.1 for **basic insulation**, **functional insulation** on a coated printed board shall be short-circuited.

B.4.5 Short circuit and interruption of electrodes in tubes and semiconductors

Electrodes in electronic tubes and leads of semiconductor devices shall be short-circuited, or if applicable, interrupted. One lead at a time is interrupted or any two leads connected together in turn. See B.4.1 for exceptions to this test.

B.4.6 Short circuit or disconnection of passive components

Resistors, capacitors, windings, loudspeakers, VDRs and other passive components shall be short-circuited or disconnected, whichever is more unfavourable.

These **single fault conditions** do not apply to:

- PTC thermistors complying with IEC 60730-1:1999, Clauses 15, 17, J.15 and J.17;
- a PTC providing IEC 60730-1 Type 2.A.L. action;
- short circuit between the input and output terminations of optocouplers that comply with the relevant **clearances**, **creepage distances** and distance through insulation requirements of this standard;
- short circuit between the input and output of transformers that comply with the relevant **clearances** and **creepage distances** requirements of this standard;
- resistors complying with the tests of 5.5.3.6 and 5.5.4;
- capacitors complying with IEC 60384-14 and assessed according to 5.5.3.2 of this standard;
- components complying with the safety requirements of relevant IEC component standards or complying with Annex G.

B.4.7 Continuous operation of components

*Motors, relay coils or the like, intended for **short-time operation** or **intermittent operation**, are operated continuously if this can occur during operation of the equipment.*

*For equipment rated for **short-time operation** or **intermittent operation**, the test is repeated until steady-state conditions are reached, irrespective of the operating time. For this test, the **thermostats**, **temperature limiters** and **thermal cut-offs** are not short-circuited.*

*In circuits not directly connected to the **mains** and in circuits supplied by a d.c. power distribution system, electromechanical components normally energized intermittently, except for motors, a fault shall be simulated in the drive circuit to cause continuous energizing of the component.*

The duration of the test shall be as follows:

- for equipment or components whose failure to operate is not evident to an **ordinary person**, 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 shorter.

B.4.8 Compliance during and after single fault conditions

During and after a **single fault condition**, a class 1 energy source or class 2 energy source shall not become a class 3 energy source.

For a class 3 energy source, during and after a **single fault condition**, at least one **safeguard** shall continue to comply with the requirements for that **safeguard**.

B.4.9 Battery charging under single fault conditions

Under **single fault conditions**, the **maximum charging current**, **upper limit charging voltage**, **lowest charging temperature** and the **highest charging temperature** shall comply with the requirements of Annex M as applicable.

Annex C (normative)

UV radiation

C.1 Protection of materials in equipment from UV radiation

C.1.1 General

This annex defines the test requirements and test procedures for materials that have safety properties and that are subject to UV radiation exposure.

C.1.2 Requirements

The following requirements apply only to equipment containing lamps that produce significant UV radiation 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.

NOTE 2 Filters and/or lenses may provide a **safeguard** and may serve as part of the **enclosure**.

Table C.1 – 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	ISO 527 series	70 %
	or flexural strength ^{a,b}	ISO 178	70 %
Parts providing impact resistance	Charpy impact ^c or Izod impact ^a or	ISO 179-1	70 %
		ISO 180	70 %
	Tensile impact ^c	ISO 8256	70 %
All parts	Material flammability class	See Clause S.4 of this standard	^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 0,75 mm.

^d The **material flammability class** may change as long as it does not fall below that specified in Clause 6 of this standard.

C.1.3 Test method

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 C.1 are carried out on the parts.

Samples taken from the parts, or consisting of identical material, are prepared according to the standard for the test to be carried out. They are then exposed to UV radiation (conditioned) according to Clause C.2. 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 percentage retention of properties after test, samples that have not been conditioned according to Clause C.2 are tested at the same time as the conditioned samples.

The retention shall be as specified in Table C.1.

C.2 UV light conditioning test

C.2.1 Test apparatus

Samples are exposed to UV light by using one of the following apparatus:

- *a twin enclosed carbon-arc (see C.2.3) with continuous exposure. The test apparatus shall operate with a black-panel temperature of $63\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$; or*
- *a xenon-arc (see C.2.4) with continuous exposure. The test apparatus shall operate with a 6 500 W, water-cooled xenon-arc lamp, a spectral irradiance of $0,35\text{ W/m}^2$ at 340 nm, a black-panel temperature of $63\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$.*

C.2.2 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.

C.2.3 Carbon-arc light-exposure test

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.

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 that is necessary for operation of the apparatus.

Materials are exposed to the light continuously for a minimum of 720 h.

Materials tested with water spray are also considered acceptable.

C.2.4 Xenon-arc light-exposure test

The apparatus described in ISO 4892-2, or equivalent, is used in accordance with the procedures given in ISO 4892-1 and ISO 4892-2:2006 using cycle 2 of method A of Table 3, without water spray.

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 that is necessary for operation of the apparatus.

Materials are exposed to the light continuously for a minimum of 1 000 h.

Materials tested with water spray are also considered acceptable.

Annex D (normative)

Test generators

D.1 Impulse test generators

These circuits produce test pulses as referenced in Table D.1. In this table:

- the circuit 1 surge is typical of voltages induced into telephone wires and coaxial cables in long outdoor cable runs due to lightning strikes to their earthing shield;
- the circuit 2 surge is typical of earth potential rises due to either lightning strikes to power lines or power line faults;
- the circuit 3 surge is typical of voltages induced into antenna system wiring due to nearby lightning strikes to earth.

NOTE Extreme care is necessary when using these test generators due to the high electric charge stored in the capacitor C_1 .

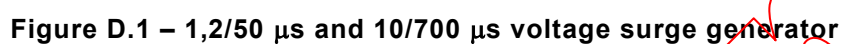
The circuit in Figure D.1, using the component values in circuits 1 and 2 of Table D.1, is used to generate impulses, the C_1 capacitor being charged initially to a voltage U_C .

Circuit 1 of Table D.1 generates 10/700 μs impulses (10 μs virtual front time, 700 μs virtual time to half value) to simulate transients in **external circuits** as indicated in Table 16, ID numbers 11, 12, 13, 14, 15, 16 and 17.

Circuit 2 of Table D.1 generates 1,2/50 μs impulses (1,2 μs virtual front time, 50 μs virtual time to half value) to simulate transients in power distribution systems.

The impulse wave shapes are under open-circuit conditions and can be different under load conditions.

*During the test, the peak voltage of the applied impulse shall not be less than the peak impulse test voltage (for example, see Table 21) and the pulse shape (for example, 1,2 μs virtual front time, 50 μs virtual time to half value for the 1,2/50 μs impulse) shall remain substantially the same as under open-circuit conditions. Components in parallel with the **clearance** may be disconnected during this test.*



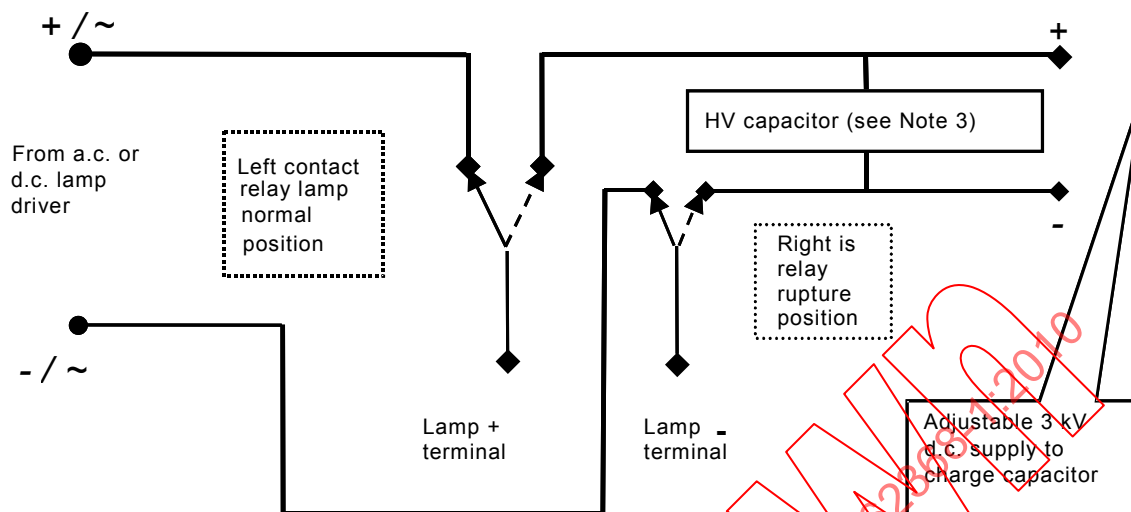
The circuit in Figure D.1 using the component values of circuit 3 in Table D.1, is used to generate impulses, the C_1 capacitor being charged initially to a voltage U_c . The switch used in Table D.1 is a critical part of the circuit.



	Test impulse	Figure	R_s	C_1	C_2	R_1	R_2	R_3
Circuit 1	10/700 μs	D.1	-	20 μF	0,2 μF	50 Ω	15 Ω	25 Ω
Circuit 2	1,2/50 μs	D.1	-	1 μF	30 nF	76 Ω	13 Ω	25 Ω
Circuit 3	-	D.2	15 M Ω	1 nF	-	1 k Ω	-	-

NOTE Circuits 1 and 2 are based on ITU-T Recommendation K.44.

D.3 Electronic pulse generator



NOTE 1 The operating pressure of the lamp can be converted to energy (Joules). The operating energy level is the recommended starting point for the test charge.

NOTE 2 The relay is a 5 kV double pole defibrillator type, nitrogen filled. A defibrillator qualified relay is sufficient. See IEC 60601-2-4.

NOTE 3 The HV capacitor is rated 0,42 μ F 5 kV.

Figure D.3 – Example of an electronic pulse generator

Annex E (normative)

Test conditions for equipment containing audio amplifiers

E.1 Audio amplifier normal operating conditions

Audio amplifiers shall operate at a frequency of 1 000 Hz. In cases where an amplifier is not intended for operation at 1 000 Hz, the **peak response frequency** shall be used.

All of the following shall be considered under **normal operating conditions**:

- a) The equipment shall be operated in such a way as to deliver 1/8 **non-clipped output power** to the **rated load impedance**. Alternatively, a band-limited pink noise signal may be used for operation after **non-clipped output power** is established using a sine wave. The noise bandwidth of the test signal shall be limited by a filter of a characteristic as shown in Figure E.1.

If clipping cannot be attained, the maximum attainable power shall be considered as the **non-clipped output power**.

Tone controls are to be set at mid-range.

- b) The most unfavourable **rated load impedance** or open circuit of any output whichever is most onerous.
- c) Organs or similar instruments that have a tone-generator unit shall be operated with any combination of two bass pedal keys, if present, and ten manual keys depressed. All stops and tabs that can increase the output power shall be activated and the equipment shall be adjusted to deliver 1/8 of the maximum attainable output power.
- d) For audio amplifiers used in an electronic musical instrument that cannot generate a continuous tone, the signal described in a) shall be applied to the signal input terminals or to the appropriate input stage of the audio amplifier.
- e) Where the intended amplifier function depends on phase difference between two channels, there shall be a phase difference of 90° between signals applied to the two channels. For multi-channel amplifiers, where some channels cannot be operated independently, those channels shall be loaded to 1/16 of the **non-clipped output power**.
- f) When determining whether a part or terminal contact is above ES1 or ES2 (see Table E.1), the equipment shall be operated to deliver maximum **non-clipped output power** into its **rated load impedance**. The load is removed and the electrical energy source class is determined from the resulting open-circuit output voltage.
- g) The temperature measurements shall be carried out with the equipment positioned in accordance with the instruction manual provided by the manufacturer, or, in the absence of instructions, the equipment shall be positioned 5 cm behind the front edge of an open-fronted wooden test box with 1 cm free space along the sides and top and 5 cm depth behind the equipment.

Table E.1 – Audio signal electrical energy source classes and safeguards

Audio signal voltage V r.m.s.	Class	Examples of safeguards between energy source and ordinary person	Example of safeguards between energy source and instructed person
0 up to 71	ES1	No safeguard necessary	No safeguard necessary
Above 71 and up to 120	ES2	Insulated terminals ^a marked with ISO 7000:2004, symbol  0434a or symbol  0434b	No safeguard necessary
		Instructional safeguard for uninsulated parts of terminals and bare wiring ^b	
Above 120	ES3	Connectors conforming to the requirements of IEC 61984 and marked with  , IEC 60417-5036 (2002)	

NOTE When using a single-pole plug or a bare wire to make connection with a contact of a terminal for earth or antenna or for audio, video or associated signals, accessibility is determined by the use of test probe in Figure V.5. The test is not applied to terminals marked with the symbol IEC 60417-5036 (2002).

^a Terminals that have no conductive parts **accessible** after wiring are installed according to instructions.

^b An **instructional safeguard** indicating that touching uninsulated terminals or wiring may result in an unpleasant sensation.

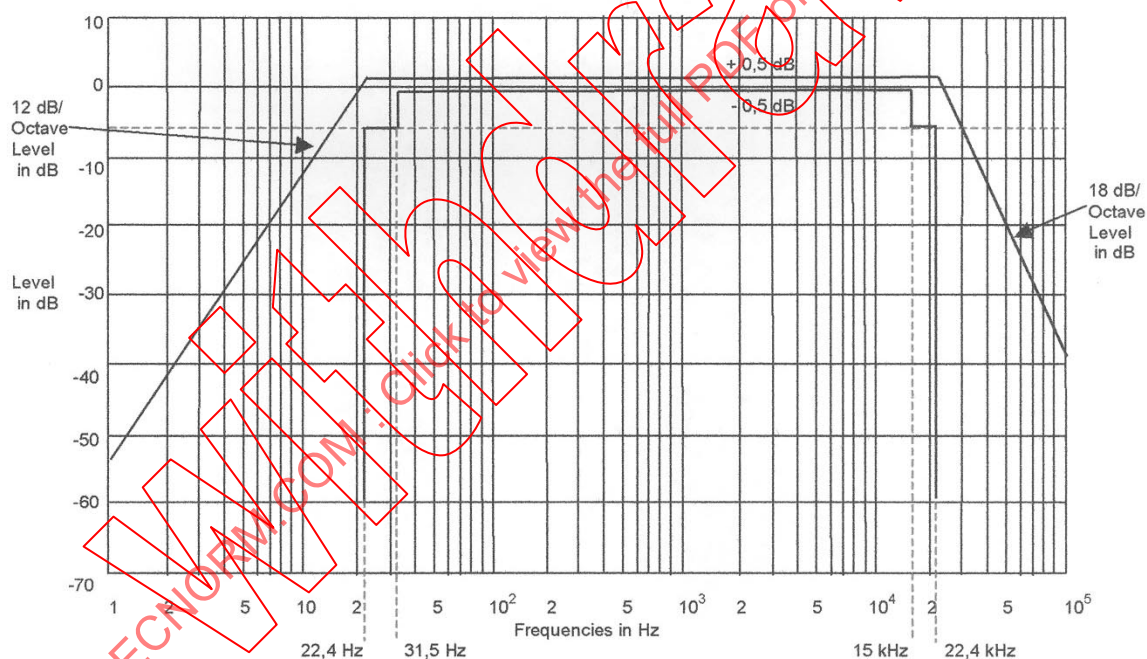


Figure E.1 – Band-pass filter for wide-band noise measurement

For equipment containing an audio amplifier, if continuous operation is not possible, the amplifier shall be operated at the maximum signal level that allows continuous operation.

E.2 Audio amplifier abnormal operating conditions

Abnormal operating conditions shall be simulated by adjusting the controls to the most unfavourable output power from zero up to the maximum attainable output power into the most unfavourable **rated load impedance** connected to the output terminals. Short circuit of the output terminals is also considered to be an **abnormal operating condition**.

Annex F (normative)

Equipment markings, instructions, and instructional safeguards

F.1 General

This annex specifies equipment markings, equipment instructions, and **instructional safeguards** necessary for equipment installation, operation, maintenance, and servicing in accordance with the requirements of this standard.

Unless symbols are used, safety related equipment marking, instructions and **instructional safeguards** must be in a language accepted in the respective countries.

This annex does not apply to markings on components. Markings on components are specified in the relevant component standard.

This annex may apply to sub-assemblies such as power supplies.

NOTE 1 Where the term marking is used in the standard, it also applies to instructions and required elements of an **instructional safeguard**.

NOTE 2 See Table F.1 for examples of markings. Equipment markings and instructions are not limited to those specified in this annex. Equipment may bear additional markings and may be provided with additional instructions not required by this annex. Other applicable standards and regulations may require additional markings or instructions. However, care shall be taken so that additional markings and instructions do not contradict the markings and instructions required by this annex.

F.2 Letter symbols and graphical symbols

F.2.1 Letter symbols

Letter symbols for quantities and units shall be in accordance with IEC 60027-1.

F.2.2 Graphical symbols

Graphical symbols shall be in accordance with IEC 60417 or ISO 3864-2 or ISO 7000. In the absence of suitable symbols in IEC 60417 or ISO 3864-2 or ISO 7000, the manufacturer may design specific graphical symbols.

NOTE A new symbol should be developed according to human factor principles and according to ISO 3864-2.

F.2.3 Compliance

Compliance is checked by inspection.

F.3 Equipment markings

F.3.1 Equipment marking locations

In general, equipment markings shall be located near or adjacent to the part or region that is the subject of the marking.

Equipment markings specified in F.3.2, F.3.3, F.3.6.2 and F.3.7 shall be on the exterior of the equipment, excluding the bottom. However, these markings may be in an area that is easily **accessible** by hand, for instance

- under a lid, or
- on the exterior of the bottom of
 - **direct plug-in equipment, hand-held equipment, transportable equipment, or**
 - **movable equipment** with a mass not exceeding 18 kg, provided that the location of the marking is given in the instructions.

Markings shall not be put on parts that can be removed without the use of a **tool**, unless they apply to this part

For **permanently connected equipment**, installation instructions shall be provided either as markings on the equipment, or in the instructions, or in a separate installation instruction document.

For rack or panel mounted equipment exceeding 18 kg, markings may be on any surface that becomes visible after removal of the equipment from the rack or panel.

Unless the meaning of the marking is obvious, the marking shall be explained in the instructions.

Compliance is checked by inspection.

F.3.2 Equipment identification markings

F.3.2.1 Manufacturer identification

The manufacturer or responsible vendor shall be identified by means of a marking on the equipment. Identification may be the manufacturer's name, the responsible vendor's name, trademark, or other equivalent identification.

F.3.2.2 Model identification

The model number, model name, or equivalent shall be identified by means of a marking on the equipment.

F.3.2.3 Compliance

Compliance is checked by inspection.

F.3.3 Equipment rating markings

F.3.3.1 Equipment without direct connection to mains

If a unit is not provided with a means for direct connection to the **mains**, it need not be marked with any electrical rating, such as its **rated voltage, rated current, rated power** or **rated frequency**.

F.3.3.2 Nature of the supply voltage

The nature of the supply voltage, d.c., a.c., or three-phase a.c., shall be marked on the equipment and shall immediately follow the equipment voltage rating. If a symbol is used to identify a.c. or d.c., the symbol $\sim$ IEC 60417-5032 (2002), shall be used for a.c. and the symbol $\equiv$ IEC 60417-5031 (2002), shall be used for d.c.

Three-phase equipment may be identified with “3-phase” or “3Ø” or any other arrangement that clearly indicates the phase of the supply voltage of the equipment.

F.3.3.3 Rated voltage

The **rated voltage** of the equipment shall be marked on the equipment. The voltage rating marking shall be immediately followed by the nature of the supply marking.

The **rated voltage** may be:

- a single, nominal value, or
- a single nominal value and a tolerance percentage of the nominal value, or
- two or more nominal values separated by a solidus (/), or
- a range indicated by minimum and maximum values separated by a hyphen, or

any other arrangement that clearly indicates the voltage of the equipment.

If the equipment has more than one nominal voltage, all such voltages may be marked on the equipment. However, the voltage for which the equipment is set shall be clearly indicated (see F.3.4).

Three-phase equipment shall be marked with the phase-to-phase voltage, a symbol indicating power supply system in accordance with IEC 61293, a solidus (/), the phase-to-neutral voltage, the symbol for voltage (V) and the number of phases, in that order. Any other arrangement that clearly indicates the three-phase **rated voltage** of the equipment is also acceptable.

NOTE The solidus (/) represents the word “or” and the hyphen (-) represents the word “to”.

F.3.3.4 Rated frequency

The **rated frequency** of the equipment shall be marked on the equipment.

The **rated frequency** may be:

- a single, nominal value, or
- a single nominal value and a tolerance percentage of the nominal value, or
- two or more nominal values separated by a solidus (/), or
- a range indicated by minimum and maximum values separated by a hyphen, or
- any other arrangement that clearly indicates the **rated frequency** of the equipment.

F.3.3.5 Rated current or rated power

The **rated current** or **rated power** of the equipment, as determined according to B.2.5, shall be marked on the equipment.

For three-phase equipment, the **rated current** or **rated power** is the current or power of one phase.

NOTE 1 The **rated current** or **rated power** need not be stated to more than one significant digit.

NOTE 2 In some countries, for markings on equipment, a comma is required as the decimal designator.

If the equipment has a socket-outlet for providing **mains** power to other equipment, the **rated current** or **rated power** of the equipment shall include the assigned current or power of the socket-outlet.

See F.3.5.1 for marking requirements for a **mains** socket-outlet.

If the equipment has more than one **rated voltage**, the **rated current** or **rated power** for each **rated voltage** shall be marked on the equipment. The arrangement of the markings shall clearly indicate the **rated current** or **rated power** associated with each **rated voltage** of the equipment.

F.3.3.6 Equipment with multiple supply connections

If the equipment has multiple supply connections, each connection shall be marked with its **rated current** or **rated power**.

If the equipment has multiple supply connections, and if each connection has a different **rated voltage** than the other supply connections, each connection shall be marked with its **rated voltage**.

The overall system electrical rating need not be marked.

F.3.3.7 Compliance

Compliance is checked by inspection.

F.3.4 Voltage setting device

If the equipment employs a voltage setting device that is operable by an **ordinary person** or an **instructed person**, the act of changing the voltage setting shall also change the indication of the voltage for which the equipment is set. The setting shall be readily discernable when the equipment is ready for use.

If the equipment employs a voltage-setting device that is operable only by a **skilled person**, and if the act of changing the voltage setting does not also change the indication of the voltage rating, an **instructional safeguard** shall state that, when changing the voltage setting, the indication of the voltage setting must also be changed.

Compliance is checked by inspection.

F.3.5 Terminals and operating devices

F.3.5.1 Mains appliance outlet and socket-outlet markings

If a **mains** appliance outlet in accordance with IEC 60320-2-2 is provided on the equipment, the **rated voltage** and assigned current or power shall be marked adjacent to the appliance outlet.

If the **mains** socket-outlet is configured in accordance with IEC/TR 60083 or a relevant national standard, the assigned current or power shall be marked. If the voltage of the socket-outlet is the same as the **mains** voltage, the voltage need not be marked.

F.3.5.2 Switch position identification marking

The position of a disconnect switch or circuit-breaker shall be identified. Such identification may be comprised of words, symbols, or an illuminated indicator.

If a symbol is used, the symbol shall be in accordance with IEC 60417.

F.3.5.3 Replacement fuse identification and rating markings

If a fuse is replaceable by an **ordinary person** or an **instructed person**, identification of a suitable replacement fuse shall be marked adjacent to the fuseholder. Identification shall include:

- fuse current rating;
- if the fuse needs a special breaking capacity which is necessary for the **safeguard** function, the appropriate symbol that indicates the breaking capacity;
- if the fuse can be replaced with a fuse of a different voltage rating, the fuse voltage rating;
- if the fuse is a time-delay fuse, and the time-delay is necessary for the **safeguard** function, the appropriate symbol that indicates the time-delay.

If a fuse is replaceable by an **ordinary person**, the codings of the relevant fuses shall be explained in the user instructions.

If a fuse is not replaceable by an **ordinary person** or an **instructed person**:

- identification of a suitable replacement fuse shall be marked adjacent to the fuse or shall be provided in the service instructions;
- if the fuse is or could be in the neutral of the **mains** supply, an **instructional safeguard** shall state that the fuse is in the neutral, and that the **mains** must be disconnected to de-energize the phase conductors.

If a fuse is not intended to be replaceable, fuse ratings need not be marked.

F.3.5.4 Replacement battery identification marking

If a battery can be replaced by an incorrect type of replaceable battery, an **instructional safeguard** shall be provided in accordance with Clause F.5

F.3.5.5 Compliance

Compliance is checked by inspection.

F.3.6 Equipment markings related to equipment classification

F.3.6.1 Class I equipment

F.3.6.1.1 Protective earthing conductor terminal

The terminal intended for connection of **class I equipment** to the installation **protective earthing conductor** shall be identified with the symbol , IEC 60417-5019 (2006).

A terminal intended for connection of a class I sub-assembly (for example, a power supply), or a component (for example, a terminal block) to the equipment **protective earthing conductor** may be identified with either symbol , IEC 60417-5019 (2006), or with symbol , IEC 60417-5017 (2006).

F.3.6.1.2 Neutral conductor terminal

For **permanently connected equipment**, the terminal, if any, intended exclusively for connection of the **mains** neutral conductor shall be identified by the capital letter “N”.

F.3.6.1.3 Protective bonding conductor terminals

Terminals for **protective bonding conductors** need not be identified. However, if such terminals are identified, they shall be marked with the earth symbol $\perp$, IEC 60417-5017 (2006). A component terminal marked with the symbol $\oplus$, IEC 60417-5019 (2006), is acceptable as identification of a **protective bonding conductor** terminal.

F.3.6.1.4 Terminal marking location

The terminal markings specified in F.3.6.1 shall not be placed on screws, removable washers, or other parts that can be removed when conductors are being connected.

F.3.6.2 Class II equipment

Class II equipment shall bear the symbol $\square$, IEC 60417-5172 (2003).

The symbol shall not be used on:

- equipment that is provided with a **protective earthing conductor** or terminal, including equipment having (a) conductor(s) connected to such a terminal but the conductor(s) is not earthed for safety purposes (for example, a conductor used for functional purposes only); or
- equipment containing a **protective bonding conductor** used only to maintain continuity of protective earthing circuits to other equipment in a system of interconnected equipment.

F.3.6.3 Compliance

Compliance is checked by inspection.

F.3.7 Equipment IP rating marking

If the equipment is intended for other than IPX0, the equipment shall bear the IP number according to the degree of protection against ingress of water in accordance with IEC 60529.

If the equipment is intended for IP3X or better, the equipment shall bear the IP number according to the degree of protection against ingress of foreign objects.

Compliance is checked by inspection.

F.3.8 Durability, legibility and permanence of markings

In general, all markings required to be on the equipment shall be durable and legible, and shall be easily discernable under normal lighting conditions.

Unless otherwise specified, **instructional safeguards** do not have to be in colour. If an **instructional safeguard** is in colour, the colour should be in accordance with the ISO 3864 series. Markings that are engraved or moulded need not be in contrasting colours provided that they are legible and readily discernable under normal lighting conditions.

Compliance is checked by inspection.

Printed or screened markings shall also be permanent. Permanency is determined by the tests of F.3.9.

F.3.9 Test for the permanence of markings

F.3.9.1 General

Each printed or screened marking shall be tested according to this subclause.

If the data sheet for a label confirms compliance with the test requirements, the test need not be performed.

F.3.9.2 Testing procedure

The test is conducted by rubbing the marking by hand without appreciable force for 15 s with a piece of cloth soaked with water and at a different place or on a different sample for 15 s with a piece of cloth soaked with the petroleum spirit specified in F.3.9.3.

F.3.9.3 Petroleum spirit

Petroleum spirit is a reagent grade hexane with a minimum of 85 % 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).

F.3.9.4 Compliance

After each test, the marking shall remain legible. If the marking is on a separable label, the label shall show no curling and shall not be removable by hand.

F.4 Instructions

When information with regard to safety is required according to this standard, this information shall be given in an instruction for installation or instruction for initial use. This information shall be available prior to installation and initial use of the equipment.

Equipment for use in locations where children are not likely to be present and that is evaluated using the jointed test probe of Figure V.2 shall have the following or equivalent statement in the user instructions.

NOTE 1 This equipment design typically applies to commercial or industrial equipment expected to be installed in locations where only adults are normally present.

This equipment is not suitable for use in locations where children are likely to be present.

NOTE 2 See also ISO/IEC Guide 37, instructions for use of products of consumer interest.

The instructions shall include the following as far as applicable.

- For equipment intended only for use in a **restricted access area**, the instructions shall state so.
- For audio equipment with terminals classified as ES3 in accordance with Table E.1, and for other equipment with terminals marked in accordance with F.3.6.1, the instructions shall require that the external wiring connected to these terminals shall be installed by a **skilled person**, or shall be connected by means of ready-made leads or cords that are constructed in a way that would prevent contact with any ES3 circuit.
- If protective earthing is employed as a **safeguard**, the instructions shall require connection of the equipment **protective earthing conductor** to the installation **protective**

earthing conductor (for example, by means of a power cord connected to a socket-outlet with earthing connection).

- d) For equipment with **protective earthing conductor** current exceeding the ES2 limits of 5.2.2.2, the equipment shall bear an **instructional safeguard** in accordance with 5.7.6.
- e) If a symbol is marked on the equipment, the instructions shall explain the meaning of the symbol.
- f) If a **permanently connected equipment** is not provided with an all-pole **mains** switch, the instructions for installation shall state that an all-pole **mains** switch in accordance with Annex L shall be incorporated in the electrical installation of the building.
- g) If a replaceable component or module provides a **safeguard** function, identification of a suitable replacement component or module shall be provided in the **ordinary person** instructions or **instructed person** instructions, or **skilled person** instructions, as applicable.

Compliance is checked by inspection.

F.5 Instructional safeguards

Unless otherwise specified in this standard:

- an **instructional safeguard** is comprised of element 1a or 2 or both, together with elements 3 and 4. Elements 1a, 1b, 2, 3, and 4 are specified in Table F.1. Any **instructional safeguard** element placed on the equipment must be visible to the person prior to potential exposure to the class 2 energy source or class 3 energy source parts.

Unless otherwise specified in this standard:

- the complete **instructional safeguard** shall be marked on the equipment, or
- element 1a or element 2 or both shall be marked on the equipment and the complete **instructional safeguard** shall be in the text of an accompanying document. If a suitable symbol for element 1a is not available, then element 1b may be marked on the equipment and the complete **instructional safeguard** shall be in the text of an accompanying document.

Table F.1 – Instructional safeguard element description and examples

Element	Description	Example
1a	A symbol that identifies the nature of the class 2 or class 3 energy source or the consequences that can be caused by the class 2 or class 3 energy source.	
1b	A symbol or set of symbols such as ISO 7000-0434 and ISO 7000-1641 to refer to text in an accompanying document. These symbols may be combined.	
2	Text that identifies the nature of the class 2 or class 3 energy source or the consequences that can be caused by the energy source, and the location of the energy source.	Hot parts!
3	Text that describes the possible consequences of energy transfer from the energy source to a body part.	Burned fingers when handling the parts
4	Text that describes the safeguard action necessary to avoid energy transfer to a body part.	Wait one-half hour after switching off before handling parts

The symbol for elements 1a and 1b shall be from IEC 60417, or ISO 3864-2, or ISO 7000, or equivalent.

Figure F.1 illustrates one example of the arrangement of the four elements that comprise a complete **instructional safeguard**. Other arrangements in the positioning of the elements are also acceptable.

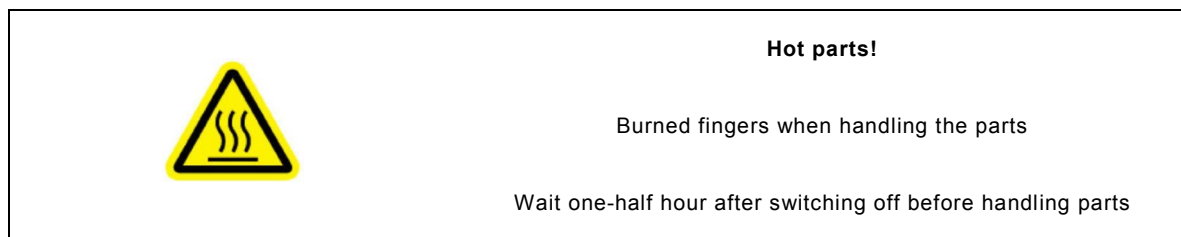


Figure F.1 – Example of an instructional safeguard

See Table F.2 for examples of markings, instructions, and **instructional safeguards**.

Table F.2 – Examples of markings, instructions, and instructional safeguards

Rating	Example
Rated d.c. voltage	48 V d.c. 48 V — — —
Rated a.c. voltage	230 V ~ 230 V ~ ±10 % 100/120/220/240 V a.c. 100–250 V a.c.
Rated 3-phase voltage	400 Y/230 V 3Ø 208 Y/120 V 3-phase 208 Y/120 V 3 ~
Rated frequency	50-60 Hz 50/60 Hz
Rated current	1 A
Instruction	Example
Positioning of cell, IEC 60417-5002 (2002)	
AC, IEC 60417-5032 (2002)	~
DC, IEC 60417-5031 (2002)	— — —
Class II equipment, IEC 60417-5172 (2003)	
Caution, ISO 7000, 0434a or 0434b (2004)	
Dangerous voltage, IEC 60417-5036 (2002)	
Earth; ground, IEC 60417-5017 (2006)	
Protective earth; protective ground, IEC 60417-5019 (2006)	

Annex G (normative)

Components

G.1 Switches

G.1.1 General

This subclause specifies requirements for switches that are located in PS2 or PS3 or in an **arcing PIS** or a **resistive PIS**.

G.1.2 Requirements for switches

A switch shall not be fitted in a **mains** supply cord.

A switch may be tested separately or in the equipment.

A switch shall comply with all of the following:

- comply with the requirements of IEC 61058-1, whereby the following applies:
 - 10 000 operating cycles (see 7.1.4.4 of IEC 61058-1:2000);
 - the switch shall be suitable for use in a normal pollution situation (see 7.1.6.2 of IEC 61058-1:2000);
 - the switch shall be of level 3 regarding the resistance to heat and fire (see 7.1.9.3 of IEC 61058-1:2000);
 - for **mains** switches the speed of contact making and breaking shall be independent of the speed of actuation;
 - the characteristics of the switch with regard to the ratings and classification (see IEC 61058-1) shall be appropriate for the function of the switch under **normal operating conditions** as given below:
 - the ratings of the switch (see Clause 6 of IEC 61058-1:2000);
 - the classification of the switch according to:
 - nature of supply (see 7.1.1 of IEC 61058-1:2000);
 - type of load to be controlled by the switch (see 7.1.2 of IEC 61058-1:2000);
 - ambient air temperature (see 7.1.3 of IEC 61058-1:2000);
- the switch shall be so constructed that it does not attain excessive temperatures during intended use;

Compliance is checked according to IEC 61058-1.

*Compliance is checked in the on-position according to 16.2.2 d), l) and m) of IEC 61058-1:2000, taking into account the total current rating of **mains** socket-outlets, if any, including peak surge current according to Table G.1.*

- a **mains** switch controlling **mains** socket-outlets shall withstand the endurance test with an additional load according to Figure 9 and Figure 10 of IEC 61058-1:2000. The total current rating of the additional load shall correspond to the marking of the socket-outlets. The peak surge current of the additional load shall have a value as shown in Table G.1.

Switches used as **disconnect devices** shall comply with the requirements in Annex L.

Table G.1 – Peak surge current

Total current rating of the switch controlled socket-outlets A up to and including	Peak surge current A
0,5	20
1,0	50
2,5	100
over 2,5	150

G.1.3 Test method

For **mains** switches the tests of IEC 61058-1 shall be applied with the modifications shown in G.1.2.

G.1.4 Compliance

After the tests, the switch shall show no damage in the sense of this standard. In particular, it shall show no deterioration of its **enclosure**, no reduction of **clearances** and **creepage distances** and no loosening of electrical connections or mechanical fixings.

G.2 Thermal cut-offs**G.2.1 Requirements for thermal cut-offs**

A **thermal cut-off safeguard** shall comply with requirements a) and b), or c).

a) The **thermal cut-off**, when tested as a separate component, shall comply with the requirements and tests of the IEC 60730 series as far as applicable:

- the **thermal cut-off** shall be of type 2 action (see 6.4.2 of IEC 60730-1:1999);
- the **thermal cut-off** shall have at least micro-disconnection, type 2B (see 6.4.3.2 and 6.9.2 of IEC 60730-1:1999);
- the **thermal cut-off** shall have a trip-free mechanism in which contacts cannot be prevented from opening against a continuation of a fault, type 2E (see 6.4.3.5 of IEC 60730-1:1999);
- the number of cycles of automatic action shall be at least:
 - 3 000 cycles for a **thermal cut-off** with automatic reset used in circuits that are not switched off when the equipment is switched off (see 6.11.8 of IEC 60730-1:1999),
 - 300 cycles for a **thermal cut-off** with automatic reset used in circuits that are switched off together with apparatus and for **thermal cut-off** with no automatic reset that can be reset by hand from the outside of the equipment (see 6.11.10 of IEC 60730-1:1999),
 - 30 cycles for a **thermal cut-off** with no automatic reset and that cannot be reset by hand from the outside of the equipment (see 6.11.11 of IEC 60730-1:1999);
- the **thermal cut-off** shall be tested as designed for a long period of electrical stress across insulating parts (see 6.14.2 of IEC 60730-1:1999);
- the **thermal cut-off** shall meet the conditioning requirements for an intended use of at least 10 000 h (see 6.16.3 of IEC 60730-1:1999);
- the contact gap, and the distance between the terminations and connecting leads of the contacts, shall comply with 13.1.4 and 13.2 of IEC 60730-1:1999.

b) The characteristics of the **thermal cut-off** with regard to

- the ratings of the **thermal cut-off** (see Clause 5 of IEC 60730-1:1999);

- the classification of the **thermal cut-off** according to the:
 - nature of supply (see 6.1 of IEC 60730-1:1999);
 - type of load to be controlled (see 6.2 of IEC 60730-1:1999);
 - degree of protection provided by **enclosures** against ingress of solid objects and dust (see 6.5.1 of IEC 60730-1:1999);
 - degree of protection provided by **enclosures** against harmful ingress of water (see 6.5.2 of IEC 60730-1:1999);
 - pollution situation for which the **thermal cut-off** is suitable (see 6.5.3 of IEC 60730-1:1999);
 - maximum ambient temperature limit (see 6.7 of IEC 60730-1:1999);

shall be appropriate for the application in the equipment.

c) The **thermal cut-off** when tested as a part of the equipment shall:

- have at least micro-disconnection according to IEC 60730-1 withstanding a test voltage according to 13.2 of IEC 60730-1:1999, and
- have a trip-free mechanism in which contacts cannot be prevented from opening against a continuation of a fault, and
- be conditioned for 300 h when the equipment is operated under **normal operating conditions** at an ambient temperature of 30 °C or higher if specified by the manufacturer, and
- be subjected to a number of cycles of automatic action as specified under a) for a **thermal cut-off** tested as a separate component, by estimating the relevant fault conditions.

G.2.2 Test method

The **thermal cut-off** is checked according to the test specifications of IEC 60730 series by inspection and by measurement. The test is made on three specimens.

G.2.3 Compliance

The requirements of G.2.1 shall be fulfilled.

No sustained arcing shall occur during the test. After the test, the **thermal cut-off** shall show no damage in the sense of this standard. In particular, it shall show no loosening of electrical connections or mechanical fixings.

G.3 Thermal links

G.3.1 Requirements for thermal links

A thermal link shall meet either requirement a) or b) below.

a) The thermal link when tested as a separate component, shall comply with the requirements of IEC 60691.

The characteristics of the thermal link with regard to

- the ambient conditions (see Clause 5 of IEC 60691:2002);
- the electrical conditions (see 6.1 of IEC 60691:2002);
- the thermal conditions (see 6.2 of IEC 60691:2002);
- the rating of the thermal link (see Clause 8 b) of IEC 60691:2002);
- the suitability for sealing in, or use with impregnating fluids or cleaning solvents (see Clause 8 c) of IEC 60691:2002),

shall be appropriate for the application in the equipment under **normal operating conditions** and under **single fault conditions**.

The electric strength of the thermal link shall meet the requirements of 5.4.11.1 of this standard except across the disconnection (contact parts) and except between terminations and connecting leads of the contacts, for which 10.3 of IEC 60691:2002 applies.

b) The thermal link when tested as a part of the equipment shall be:

- aged for 300 h at a temperature corresponding to the ambient temperature of the thermal link when the equipment is operated under **normal operating conditions** at an ambient temperature of 30 °C or higher if specified by the manufacturer, and
- subjected to such **single fault conditions** of the equipment that cause the thermal link to operate. During the test, no sustained arcing and no damage in the sense of this standard shall occur, and
- capable of withstanding two times the voltage across the disconnection and have an insulation resistance of at least 0,2 MΩ, when measured with a voltage equal to two times the voltage across the disconnection.

G.3.2 Compliance and test method

If a thermal link is tested as a separate component according to G.3.1 a) above, compliance is checked according to the test specifications of IEC 60691, by inspection and measurement.

If a thermal link is tested as a part of the equipment according to G.3.1 b) above, compliance is checked by inspection and by the specified tests in the given order. The test is carried out three times. The thermal link is replaced partially or completely after each test.

NOTE When the thermal link cannot be replaced partially or completely, the complete component part including the thermal link (for example, a transformer) should be replaced.

No failure is allowed.

G.4 PTC thermistors

PTC thermistors used as **safeguards** shall comply with Clauses 15, 17, J.15 and J.17 of IEC 60730-1:1999 or shall provide IEC 60730-1 Type 2.A.L. action.

For PTC thermistors whose power dissipation exceeds 15 W for the rated zero-power resistance at an ambient temperature of 25 °C determined as given in IEC 60738-1, the encapsulation or tubing shall be made of **V-1 class material**.

Compliance is checked by inspection and where applicable by the tests of IEC 60730-1.

G.5 Overcurrent protective devices

Overcurrent protective devices shall comply with their applicable IEC standards.

Compliance is checked by inspection.

G.6 Protective devices not mentioned in Clauses G.2 to G.5

G.6.1 Other protective devices requirements

Such protective devices (for example, fusing resistors, fuse-links not standardized in IEC 60127 series or miniature circuit breakers) shall have adequate rating including breaking capacity.

For non-resettable protective devices, such as fuse-links, a marking shall be located close to the protective device, so that correct replacement is possible.

G.6.2 Compliance and test method

*Compliance is checked by inspection and by performing **single fault condition testing** as specified in Clause B.4.*

The test is carried out three times.

No failure is allowed.

G.7 Transformers

G.7.1 General

Transformers shall comply with one of the following:

- meet the requirements given in G.7.2 to G.7.3;
- in case of switch mode devices, meet the requirements of IEC 61204-7;
- meet the requirements of IEC 61558-1 and the relevant parts of IEC 61558-2 with the following additions and limitations:
 - the limit values for ES1 of this standard apply (see 5.2.2.2),
 - for **working voltages** above 1 000 V r.m.s., see 18.3 of IEC 61558-1:2005, the highest of the test voltages according to Table 31, Table 32 and Table 33 have to be applied,
 - the overload test according to G.7.3.

NOTE 1 Examples of relevant parts of IEC 61558-2 are:

- IEC 61558-2-1: Separating transformers;
- IEC 61558-2-4: Isolating transformers;
- IEC 61558-2-6: Safety isolating transformers.

NOTE 2 Switch mode power supplies are addressed in IEC 61204-7.

G.7.2 Insulation

G.7.2.1 Requirements

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 Clause 5 and pass the relevant electric strength tests, according to the application of the insulation in the equipment.

Precautions shall be taken to prevent the reduction below the required 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.

Examples of acceptable forms of construction are the following (there are other acceptable forms of construction):

- 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.

If a transformer is fitted with an earthed screen for protective purposes, the transformer shall pass the test of 5.6.6.4 between the earthed screen and the earthing terminal of the transformer.

No electric strength test applies to insulation 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 windings that have terminations continue to apply.

G.7.2.2 Compliance criteria

Compliance is checked by inspection, measurement and where applicable by test.

G.7.3 Transformer overload tests

G.7.3.1 Test conditions

If the tests are carried out 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 winding isolated from the **mains** loaded in turn, with any other winding isolated from the **mains** loaded between zero and its specified maximum load to result in the maximum heating effect.*

The output of a switch mode power supply is loaded to result in the maximum heating effect in the transformer.

*Where an **overload condition** cannot occur or is unlikely to cause a **safeguard** to fail, the tests are not made.*

G.7.3.2 Compliance

Maximum temperatures of windings shall not exceed the values in Table G.2 when measured as specified in B.1.7, and determined as specified below:

- with external overcurrent protection: at the moment of operation, for determination of the time until the overcurrent protection operates, reference may be made to a data sheet of the overcurrent protection device showing the trip time versus the current characteristics;
- with an automatic reset **thermal cut-off**: as shown in Table G.2 and after 400 h;
- with a manual reset **thermal cut-off**: at the moment of operation;
- for current limiting transformers: after the temperature has stabilized.

If the temperature of the windings of a transformer with a ferrite core, measured as specified in B.1.7, exceeds 180 °C, it shall be retested at maximum rated ambient temperature ($T_{amb} = T_{ma}$), and not as calculated according to B.2.6.3.

Windings isolated from the **main**s, 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 the transformer continues to comply with B.4.8.

During the test the transformer shall not emit flames or molten metal.

Table G.2 – Temperature limits for transformer windings and for motor windings (except for the motor running overload test)

Method of protection	Maximum temperature °C							
	Class 105 (A)	Class 120 (E)	Class 130 (B)	Class 155 (F)	Class 180 (H)	Class 200 (N)	Class 220 (R)	Class 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 ^a	150	165	175	200	225	245	265	295

The classes are related to the classification of electrical insulating materials and electrical insulating systems in accordance with IEC 60085. The assigned letter designations are given in parentheses.

^a The arithmetic average temperature is determined as follows:

The graph of temperature against time (see

Figure G.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:

$$t_A = \frac{t_{\max} + t_{\min}}{2}$$

where

$t_{\max}$ is the average of the maxima,

$t_{\min}$ is the average of the minima.

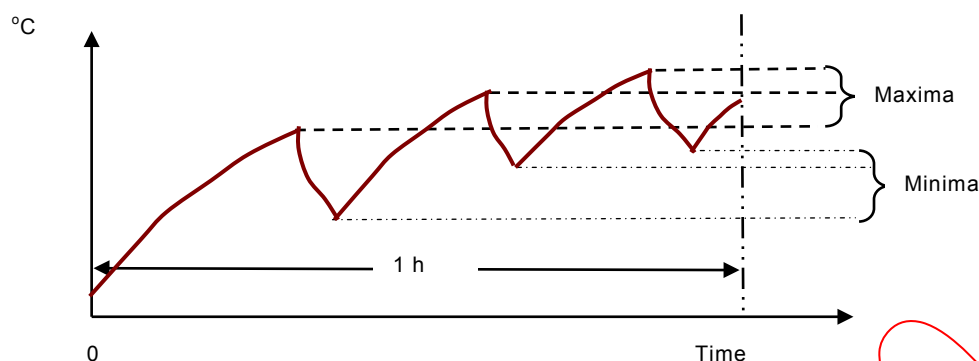


Figure G.1 – Determination of arithmetic average temperature

G.7.3.3 Alternative test method

The transformer is placed on a wooden board that is covered with a single layer of **wrapping tissue** and the transformer in turn is covered with a single layer of **cheesecloth** until either:

- the overload protection device operates,
- the winding becomes an open circuit,
- the load cannot be increased any further without reaching a short circuit or foldback condition,
- 7 h is reached.

During the test the transformer shall not emit flames or molten metal.

If the transformer voltage exceeds ES1, the **basic safeguard** or **reinforced safeguard** provided in the transformer shall withstand the electric strength test in 5.4.11.1 as applicable after it has cooled to room temperature.

G.8 Motors

G.8.1 General requirements

Motors other than d.c. motors, supplied from circuits isolated from the a.c. **mains** shall comply with the overload tests of G.8.3 and G.8.4 and, where applicable, G.8.8, G.8.9 and G.8.10.

However, the following motors are exempt from the test of G.8.3:

- 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 supplied from circuits isolated from the a.c. **mains** shall comply with the tests of G.8.5, G.8.6 and G.8.10. DC motors that by their intrinsic operation normally operate under locked-rotor conditions, such as stepper motors, are not tested and d.c. motors 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 G.8.5.

G.8.2 Motor overload test conditions

Unless otherwise specified, during the test, the equipment is operated at **rated voltage** or at the highest voltage of the **rated voltage range**.

The tests are carried out either in the equipment or under simulated conditions on the bench. Separate samples may be used for bench tests. Simulated conditions include:

- any protection device 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 B.1.7. Where thermocouples are used they are applied to the surface of the motor windings. Temperatures are measured 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-offs**, 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.

G.8.3 Running overload test

A running overload test is carried out by operating the motor under **normal operating conditions**. 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 G.8.4), until the overload protection device operates.

The motor winding temperatures are measured during each steady period.

G.8.4 Locked-rotor overload test

A locked-rotor test is carried out starting at room temperature.

The duration of the test is as follows:

- a motor protected by inherent or external impedance is operated on locked-rotor for 15 days except that testing is discontinued when the windings of the motor reach a constant temperature;
- a motor with an automatic reset protection device is cycled on locked-rotor for 18 days;
- a motor with a manual reset protection device is cycled on locked-rotor 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 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 10 cycles for a motor with a manual reset protection device, or at the time of operation of a non-resettable protection device.

During the test, protection devices shall operate reliably without permanent damage to the motor including:

- 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;*
- *deterioration of the insulation.*

Discoloration of the insulation may occur, 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 acceptable.

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 only for the purpose of demonstrating the capability of the device to make and break locked-rotor current for an extended period of time.

G.8.5 Running overload test for d.c. motors

G.8.5.1 Requirement

The test of G.8.5.2 is carried out only if a possibility of an overload occurring is determined by inspection or by review of the design. For example, the test need not be carried out where electronic drive circuits maintain a substantially constant drive current.

Motors shall be tested in accordance with G.8.5.2.

If difficulty is experienced in obtaining accurate temperature measurements, due to the small size or unconventional design of the motor, the method of G.8.5.3 can be used instead.

G.8.5.2 Test method

*The motor is operated under **normal operating conditions**. 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, the winding becomes an open circuit or the load cannot be increased any further without reaching a locked rotor condition.*

The motor winding temperatures are measured during each steady period.

G.8.5.3 Alternative test method

*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** until either:*

- *the overload protection device operates,*
- *the winding becomes an open circuit,*
- *the load cannot be increased any further without reaching a locked rotor condition,*
- *7 h is reached.*

*During or at the conclusion of the test, there shall be no ignition of the **wrapping tissue** or **cheesecloth**.*

G.8.5.4 Electric strength test

*Following the test of G.8.5.2 or G.8.5.3, as applicable, if the motor voltage exceeds ES1, the **basic safeguard** or **reinforced safeguard** provided in the motor shall withstand the electric strength test in 5.4.11.1 after it has cooled to room temperature, but with test voltages reduced to 0,6 times the specified values.*

G.8.6 Locked-rotor overload test for d.c. motors

G.8.6.1 Requirement

Motors shall pass the test in G.8.6.2.

Where difficulty is experienced in obtaining accurate temperature measurements because of the small size or unconventional design of the motor, the method G.8.6.3 can be used instead followed by the electric strength test of G.8.7.1.

G.8.6.2 Test method

The motor is operated at the voltage used in its application and with its rotor locked for 7 h or until steady conditions are established, whichever is longer.

G.8.6.3 Alternative test method

*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 **cheesecloth**.*

The motor is then operated at the voltage used in its application and with its rotor locked for 7 h or until steady conditions are established, whichever is the longer.

*There shall be no ignition of the **wrapping tissue** or **cheesecloth**.*

G.8.7 Compliance

G.8.7.1 Electric strength test

Following the test of G.8.6.2 or G.8.6.3, as applicable, if the motor voltage exceeds ES1, and after it has cooled to room temperature, the motor shall withstand the electric strength test in 5.4.11.1 but with test voltages reduced to 0,6 times the specified values.

G.8.7.2 Maximum temperatures

For the tests according to G.8.4 and G.8.6.2, the temperature limits as specified in Table G.2 shall not be exceeded.

For the tests according to G.8.3 and G.8.5.2, the temperature limits as specified in Table G.3 shall not be exceeded for each class of insulating material.

Table G.3 – Temperature limits for running overload tests

Maximum temperature							
°C							
Class 105 (A)	Class 120 (E)	Class 130 (B)	Class 155 (F)	Class 180 (H)	Class 200 (N)	Class 220 (R)	Class 250 -
140	155	165	190	215	235	255	275
The classes are related to the classification of electrical insulating materials and electrical insulating systems in accordance with IEC 60085. The assigned letter designations are given in parentheses.							

G.8.8 Compliance and test method 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 during and after the test shall not exceed the values specified in Table G.2.

NOTE Locked-rotor is specified because some motors may not start and variable results could be obtained.

G.8.9 Compliance and test method for three-phase motors

*Three-phase motors are tested under **normal operating conditions**, with one phase disconnected, unless circuit controls prevent the application of voltage to the motor when one or more supply phases are missing.*

The effect of other loads and circuits within the equipment may necessitate that the motor be tested within the equipment and with the three supply phases disconnected one at a time.

Temperatures during and after the test shall not exceed the values specified in Table G.2.

G.8.10 Compliance and test method for series motors

Series motors are operated at a voltage equal to 1,3 times the voltage rating of the motor for 1 min with the lowest possible load.

*After the test, windings and connections shall not have worked loose and all applicable **safeguards** shall remain effective.*

G.9 Mains supply cords

G.9.1 General

Except as specified in 5.6.7.2, a **mains** supply cord shall be of the sheathed type and comply with the following as appropriate:

- if rubber 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 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 (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 (designation 60227 IEC 53);
 - for equipment provided with a detachable power supply cord, be not lighter than light PVC sheathed flexible cord according to IEC 60227-1 (designation 60227 IEC 52);

NOTE 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;
- other types of cords can be used if they have similar electro-mechanical properties as above.

Mains supply cords shall have conductors with cross-sectional areas not less than those specified in Table G.4 (see also 5.6.7).

Table G.4 – Sizes of conductors in mains supply cords

Rated current of the equipment ^a A up to and including	Nominal cross-sectional area mm ²	AWG [cross-sectional area in mm ²] see NOTE 2
3	0,50 ^b	20 [0,5]
6	0,75	18 [0,8]
10	1,00 (0,75) ^c	16 [1,3]
16	1,5 (1,0) ^d	14 [2]
25	2,50	12 [3]
32	4,00	10 [5]
40	6,00	8 [8]
63	10,00	6 [13]
80	16,00	4 [21]
100	25,00	2 [33]
125	35,00	1 [42]
160	50,00	0 [53]

NOTE 1 IEC 60320-1 specifies acceptable combinations of appliance couplers and flexible cords, including those covered by conditions ^b, ^c and ^d. However, a number of countries have indicated that they do not accept all of the values listed in this table, particularly those covered by conditions ^b, ^c and ^d.

NOTE 2 AWG 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 Gauge. This term is commonly used to designate wire sizes in North America.

^a The **rated current** includes currents that can be drawn from a socket-outlet providing **mains** power for other equipment.

^b This nominal cross-sectional area is allowed only for **class II equipment** and provided that the length of the supply cord, measured between the point where the cord, or the cord guard, enters the equipment, and the entry to the plug, does not exceed 2 m.

^c The value in parentheses applies to detachable power supply cords fitted with the connectors rated 10 A in accordance with IEC 60320-1 (types C13, C15, C15A and C17), provided that the length of the cord does not exceed 2 m.

^d The value in parentheses applies to detachable power supply cords fitted with the connectors rated 16 A in accordance with IEC 60320-1 (types C19, C21 and C23), provided that the length of the cord does not exceed 2 m.

Equipment intended to be used by musicians on the stage (for example, musical instruments and amplifiers) shall have:

- an appliance inlet according to IEC 60320-1 for connection to the **mains** by detachable cord sets; or
- a means of stowage to protect the **mains** cord when not in use (for example, a compartment, hooks or pegs).

G.9.2 Compliance and test method

Compliance is checked by inspection.

In addition, screened cords shall comply with IEC 60227-7.

The appropriate cord shall be used. 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 electric strength test between the screen and all other conductors.*

G.9.3 Cord anchorages and strain relief for non-detachable power supply cords

G.9.3.1 General

This subclause specifies **safeguards** against strain being transmitted to the equipment terminations of the conductors of cords or interconnecting cables connected to ES2, ES3, PS3, or **mains** circuits.

G.9.3.2 Cord strain relief

G.9.3.2.1 Requirements

A knot shall not be used as a strain relief mechanism.

A screw that bears directly on the cord or cable shall not be used as a strain relief mechanism.

When a linear force and a torque is applied to a **non-detachable power supply cord** or cable, a **basic safeguard** shall prevent strain from being transmitted to the cord or cable terminations. Furthermore, the strain relief shall prevent the cord or cable from being longitudinally displaced by more than 2 mm. **Clearances** and **creepage distances** shall not be reduced below the values specified in 5.4.2 (**clearances**), and 5.4.3 (**creepage distances**).

The linear force applied to the cord or cable is specified in Table G.5. The force is applied in the most unfavourable direction for 1 s and repeated 25 times.

Table G.5 – Strain relief test force

Mass of the equipment kg	Force N
Up to and including 1	30
Over 1 up to and including 4	60
Over 4	100

A torque of 0,25 Nm is applied for 1 min to the cord or cable immediately after the linear force application. The torque is applied as close as practicable to the strain relief mechanism and is repeated in the opposite direction.

Compliance is determined by applying the linear force and torque and inspecting the conductor slack during the test.

G.9.3.2.2 Strain relief mechanism failure

If the **basic safeguard** (strain relief mechanism) should fail and strain is transmitted to the **non-detachable power supply cord** or cable terminations, a **supplementary safeguard** shall ensure that the earth termination is the last to take the strain.

*Compliance is determined by inspection and, if necessary, by defeating the **basic safeguard** and inspecting the conductor slack while applying the force in Table G.5.*

G.9.3.2.3 Cord sheath or jacket position

The cord or cable sheath or jacket shall extend from the **basic safeguard** (strain relief mechanism) into the equipment at least one-half the diameter of the cord or cable.

Compliance is checked by inspection.

G.9.3.2.4 Strain relief comprised of polymeric material

If the **basic safeguard** (strain relief mechanism) is comprised of polymeric material, the **basic safeguard** shall retain its structural properties following the mould stress relief according to Clause T.8.

*Compliance is determined according to the force and torque tests of G.9.3.2 after the **basic safeguard** has come to room temperature.*

G.9.4 Cord entry

This subclause specifies **safeguards** against electric shock and electrically-caused fire from cords or cables connected to ES3, PS3, or **mains** circuits.

The entry of a cord or cable into the equipment shall be provided with the **safeguards** against electric shock as specified in Clause 5. If the cord jacket passes the electric strength test of 5.4.11.1 for **supplementary insulation**, the cord jacket may be considered a **supplementary safeguard**.

The cord or cable entry shall be provided with a **supplementary safeguard** so as:

- to prevent abrasion of the cord or cable surface which might lead to electrically-caused fire; and
- to prevent the cord or cable from being pushed into the equipment and touching parts or surfaces which might electrically or physically damage the cord or cable jacket or insulation that, in turn, might lead to electric shock or electrically-caused fire.

*Compliance is determined following the tests of G.9.3 by an electric strength test between the cord or cable conductors and **accessible** conductive parts. The test voltage shall be as required for the applied **safeguards** in accordance with 5.4.11.1.*

G.9.5 Non-detachable cord bend protection

G.9.5.1 Requirements

The **non-detachable power supply cord** of **hand-held equipment** or equipment intended to be moved while in operation shall be provided with a **safeguard** against jacket, insulation, or conductor damage due to bending at the equipment entrance.

Alternatively, the inlet or bushing shall be provided with a smoothly rounded bell-mouthed opening having a radius of curvature equal to at least 1,5 times the overall diameter of the cord with the largest cross-sectional area to be connected.

The cord bending **safeguard** 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.

G.9.5.2 Compliance and test method

*The equipment is so placed that the axis of the cord bending **safeguard**, where the cord emerges, 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 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 $23\text{ °C} \pm 2\text{ °C}$.

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 $1,5 D$.

Compliance is checked by inspection, by measurement and, where necessary, by the test of G.9.5.2 with the cord as delivered with the equipment.

G.9.6 Cord replacement

If the equipment **enclosure** is not sealed, **non-detachable power supply cords** are considered replaceable by an **instructed person** or by a **skilled person**.

To facilitate replacement, the design of cord terminations shall permit easy disconnection and reconnection without damaging the replacement cord or the equipment terminals. Specifically, cord terminations shall not be soldered to a printed wiring board.

Furthermore, for ordinary replacement cords, the strain relief mechanism shall be readily removable and re-installable.

Compliance is checked by inspection.

G.9.7 Supply wiring space

G.9.7.1 General requirements

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 Table G.4.

G.9.7.2 Stranded wire

G.9.7.2.1 Requirements

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 considered 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.

G.9.7.2.2 Compliance and test method

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 an ES3 source, the free wire shall not touch any conductive part which is **accessible** or is connected to an **accessible** conductive part or, in the case of double insulated equipment, any conductive part which 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 ES3 source.

G.10 Metal Oxide Varistors

G.10.1 General

This subclause specifies how to provide **safeguards** against electric shock and against fire, caused by failure of the MOV.

An MOV connected between **mains** and earth shall comply with the **basic safeguard** of G.10.2. In addition, for fire and shock hazard, the MOV shall comply with the **supplementary safeguards** of G.10.3 and with the reliable earthing requirements of 5.6.8.2.

An MOV connected across the **mains** shall comply with the **basic safeguard** of G.10.2 and **supplementary safeguards** of G.10.3.

NOTE 1 An MOV is sometimes referred to as a VDR.

NOTE 2 Such connections described above make the MOV a **PIS**.

G.10.2 Basic safeguard

This subclause specifies requirements for a MOV that serves as a **basic safeguard** against fire or electric shock.

Component properties:

An MOV shall comply with IEC 61051-2, taking into account all of the following:

a) 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.

b) Maximum continuous voltage (2.1.2 of IEC 61051-2:1991):

- 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**.

c) Pulse current (Table I group 1 of IEC 61051-2:1991).

For the test, a combination pulse 6 kV/3 kA is used, having a 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 of IEC 61051-2:1991, the MOV voltage after the test shall not have changed by more than 10 % when measured with the manufacturer's specified current.

The body of surge suppression MOVs shall be made of **V-0 class material**.

G.10.3 Supplementary safeguards

G.10.3.1 General

This subclause specifies **supplementary safeguards** to be provided against fire resulting from both sudden and gradual failure of an MOV connected directly across the **mains** or between **mains** and protective earth (see 5.6.8.2).

G.10.3.2 Sudden failure

One of the following **safeguards** shall be provided:

a) The use of a restricted area for an **arcing PIS** circuit as specified in 6.4.7.

b) The use of a protective device:

- 10 A maximum rated fuse of adequate breaking capacity, or equivalent, is connected in series with the MOV; or
- another protective device may be used, provided that the combination complies with a limited short-circuit test, with the MOV shorted out. The product shall be tested in accordance with 9.3.1 of IEC 60127-1:2006, Method A, for breaking capacity of 1 500 A. The test shall not result in the failure of **safeguards** against fire or shock.

c) The use of a **fire enclosure** meeting the requirements of 6.4.8. If the MOV is separated from the **fire enclosure** by a distance of less than 13 mm, the requirements for smaller separation distances in 6.4.8.3 shall apply.

G.10.3.3 Gradual failure

*The **safeguard** is that requirements for a PS3 circuit shall be complied with, including one of the following:*

a) 6.4.3, prevent ignition, or

b) 6.4.6, control of fire spread.

For fault tests as required in a) above, failure is simulated by the following test method.

If the voltage rating of the MOV is such that it will conduct at twice the maximum **rated voltage** of the equipment, ($2 \times V_r$) or lower, the equipment and a test resistor R_x connected in series with the **mains** supply to the equipment is energized from an a.c. source of $2 \times V_r$. Components in parallel with the MOV that may be affected by this test shall be disconnected.

The test shall be performed with $R1 = 2 \times V_r / 0,125$.

If the circuit does not open, the test shall be continued for 4 h, then repeated with lower values of R_x in turn, until the circuit opens:

$$R2 = 2 \times V_r / 0,5,$$

$$R3 = 2 \times V_r / 2,5,$$

$$R4 = 2 \times V_r / 5,$$

$$R5 = 2 \times V_r / 10,$$

$R6 = \text{half the previous value, etc.}$

The test shall not result in fire or shock within the sense of this standard.

NOTE 1 For temporary overvoltages from the **mains**, see IEC 60664-1.

NOTE 2 A gas discharge tube may be used in series with the MOV.

G.11 Wound components

G.11.1 Wire insulation in wound components

G.11.1.1 General

The following requirements apply to winding wire including lead-out wires whose insulation provides **basic insulation**, **supplementary insulation** or **reinforced insulation**.

NOTE 1 For insulation provided in addition to insulation on winding wire, see G.11.2.

Solvent-based enamel is not considered to provide **supplementary insulation** or **reinforced insulation**, under any circumstances.

Solvent-based enamel is only accepted as **basic insulation** if used for winding insulation as described in G.11.1.2.

If the **peak working voltage** does not exceed ES2, there is no dimensional or constructional requirement.

If the **peak working voltage** exceeds ES2, one of the following, a), b), or c) applies:

- a) There is no dimensional or constructional requirement for **basic insulation** that is not under mechanical stress (for example, from winding tension). For **basic insulation** that is under such mechanical 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 0,4 mm provided by a single layer; or

- comply with 5.4.4.6 and with Annex J.
- c) The winding wire shall comply with Annex J. 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 not more 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 5.4.4.5 a), b) or c).

NOTE 3 For wires insulated by an extrusion process, sealing is inherent to the process.

The winding wire shall pass a **routine test** for electric strength test, using the test as specified in Clause J.3.

G.11.1.2 Solvent-based enamel winding insulation

Solvent-based enamel is considered **basic insulation** where all the following conditions are met:

- the **basic insulation** provided in a wound component between an **external circuit** or internal circuit operating at ES2 and ES1;
- the insulation over all conductors comprises enamel complying with the requirements of a grade 2 winding wire of IEC 60317 series of standards with the **routine test** conducted at the highest voltage of Table 31 and Table 32;
- the finished component is subjected to a **type test** for electric strength (between windings and between windings and the core, see G.7.2.1), in accordance with 5.4.11.1;
- the finished component is subjected to **routine tests** for electric strength (between windings and between windings and the core, see G.7.2.1), in accordance with 5.4.11.1.

Except as given in 4.3.2.3, the core of the above wound component shall not be **accessible** to an **ordinary person**.

G.11.1.3 Protection against mechanical stress in wound components

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, one of the following applies:

- protection against mechanical stress shall be provided. For example, this protection can be achieved by providing physical separation in the form of insulating sleeving or sheet material, or by using double the required number of insulation layers on the winding wire; or
- the wound component passes the endurance tests of G.11.3.

Additionally, **basic insulation**, **supplementary insulation** or **reinforced insulation** in finished wound components shall pass **routine test** for electric strength in accordance with 5.4.11.1.

G.11.1.4 Compliance and test method

Compliance is checked by 5.4.4.1 and, where required, by G.11.3. If the tests of Annex J are required, they are not repeated if the material data sheets confirm compliance.

G.11.2 Additional insulation in wound components

G.11.2.1 General requirements

The following requirements apply to insulation in a wound component, provided in addition to the insulation on winding wire or other wire. For example, this includes:

- insulation between windings; and
- insulation between a winding wire or other wire and any other conductive part in the wound component.

If the **peak working voltage** does not exceed ES2, there is no dimensional or constructional requirement.

If the **peak working voltage** exceeds ES2,

- for **basic insulation** 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 a single layer; or
 - comply with 5.4.4.6.

G.11.2.2 Compliance and test method

Compliance is checked by inspection and measurement.

G.11.3 Endurance test on wound components

G.11.3.1 General test requirements

Where required by G.11.1.3, three samples of the wound component are subjected to 10 test cycles with each test cycle consisting of a heat run (see G.11.3.3), a vibration test (see G.11.3.4) and a humidity conditioning (see 5.4.10).

After the heat run (see G.11.3.3), the samples are allowed to cool down to ambient temperature.

The samples are then subjected to a vibration test of G.11.3.4.

The samples are then subjected for two days to the humidity conditioning of 5.4.10.

The tests described below are made before the start of the 10 cycles and after each cycle.

The electric strength test of 5.4.11.1 is carried out.

*After the electric strength test, the test of G.11.3.5 is made on wound components that are supplied from the **mains**, except for switching mode power supply.*

G.11.3.2 Compliance

If, after the completion of all 10 cycles, one or more samples have failed, the wound component is considered not to comply with the endurance test.

For wound components supplied from the **mains**, there shall be no breakdown of the insulation between the turns of a winding, between input and output windings, between adjacent input windings and between adjacent output windings, or between the windings and any conductive core.

G.11.3.3 Heat run test

Depending on the type thermal classification of the insulation, the specimens are kept in a heating cabinet for a combination of time and temperature as specified in Table G.6. The 10 cycles are carried out with the same combination.

The temperature in the heating cabinet shall be maintained within a tolerance of $\pm 5^\circ\text{C}$.

Table G.6 – Test temperature and testing time (days) per cycle

Thermal classification	Class 105 (A)	Class 120 (E)	Class 130 (B)	Class 155 (F)	Class 180 (H)	Class 200 (N)	Class 220 (R)	Class 250 -
Test temperature °C	Testing time duration for the test of G.11.3.2							
290								4 days
280								7 days
270								14 days
260							4 days	
250							7 days	
240						4 days	14 days	
230						7 days		
220					4 days	14 days		
210					7 days			
200					14 days			
190				4 days				
180				7 days				
170				14 days				
160			4 days					
150		4 days	7 days					
140		7 days						
130	4 days							
120	7 days							
The classes are related to the classification of electrical insulating materials and electrical insulating systems in accordance with IEC 60085. The assigned letter designations are given in parentheses. The manufacturer shall specify the test duration or the test temperature.								

G.11.3.4 Vibration test

Specimens are tested according to G.21.3.4.

G.11.3.5 Wound components supplied from the mains

One input circuit is connected to a voltage equal to a test voltage of at least 1,2 times the **rated voltage**, at double the **rated frequency** for 5 min. No load is connected to the transformer. During the test, multiple wire windings, if any, are connected in series.

*A higher test frequency may be used; the duration of the period of connection, in minutes, then being equal to 10 times the **rated frequency** divided by the test frequency, but not less than 2 min.*

*The test voltage is initially set at **rated voltage** and gradually increased up to 1,2 times the initial value, and then maintained for the time specified. If during the test there is a non-linear change of current in an uncontrollable manner, it is regarded as breakdown between winding turns.*

G.12 Circuits generating starting pulses

G.12.1 Insulation in circuits generating starting pulses

For a circuit generating starting pulses to ignite a discharge lamp, and if the circuit is an ES1, the requirements for **functional insulation** apply between the circuit and other conductive parts.

If the circuit is not ES1, the requirements for **basic insulation**, **supplementary insulation** and **reinforced insulation** apply to **creepage distances** and distances through insulation. For **clearances**, see G.12.2.

NOTE For **working voltages** in the above cases, see 5.4.1.9.1, i).

G.12.2 Clearances in circuits generating starting pulses

For a circuit generating starting pulses to ignite a discharge lamp, and if the circuit is not ES1, the **clearances** are determined by one of the following methods:

- a) Determine the minimum **clearance** in accordance with 5.4.2.7; 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 5.4.11.1, or
 - apply 30 pulses having amplitude equal to the highest of the required test voltages in Table 31, Table 32 and Table 33 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 5.4.1.9.1, i).

G.13 IC current limiters

IC current limiters used for current limiting in power sources to become PS1 or PS2 are not shorted from input to output if all of the following conditions are met:

- **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 ES1 circuits;
- the IC current limiters limit the current to manufacturer's defined 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 of manual operation or reset; are supplied by a source whose output does not exceed 250 VA and the output current is limited to 5 A or less;
- the IC current limiters limit the current or voltage to manufacturer's defined drift after each of the following conditioning tests:

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.

- Clause 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 μ F capacitor in parallel with the output;
- 10 000 cycles of turning enable on and off with an iron-core inductor having 352 mH inductance at 1 kHz and 11 Ω d.c. resistance connected in the output circuit;
- 10 000 cycles of turning enable on and off while input connected to a capacitor rated 425 μ F and shorting the output;
- 10 000 cycles of turning input pin on and off while a capacitor rated 425 μ F to the input supply keeping enable active and shorting the output;
- 10 000 cycles of turning input pin on and off with an iron-core inductor having 352 mH inductance at 1 kHz and 11 Ω d.c. resistance 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.

After each of the tests above, the device shall limit the current in accordance with its specification as applicable (an open circuit is considered an acceptable result).

G.14 Test for resistors serving as safeguard

G.14.1 General

This subclause specifies test requirements for resistors bridging insulation to ensure that they do not significantly change in value over a long period of time.

When required by 5.5.2.7 or 5.5.3.6, ten samples are tested for the resistor test of G.14.2. A sample is a single resistor if used alone, or a group of resistors in series.

G.14.2 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 $\pm$ 2 °C;*
- humidity: 93 % $\pm$ 3 % relative humidity;*
- test duration: 21 days;*
- each sample is then subjected to 10 impulses of alternating polarity, using the impulse test generator circuit 2 of Table D.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 allowed.

The lowest resistance value of the ten samples tested is used to measure the current when determining compliance with Table 4.

NOTE If a resistor or a group of resistors is connected between a circuit supplied by the **mains** and coaxial cable, G.14.3 applies.

G.14.3 Test for resistors serving as safeguards between the mains and an external circuit consisting of a coaxial cable

G.14.3.1 General

This subclause specifies test requirements for resistors bridging insulation between the **mains** and an **external circuit** consisting of a coaxial cable and ensures that they do not significantly change in value over a long period of time.

When required by 5.5.4, ten samples of resistors (a sample is a single resistor if used alone or a group of resistors in series) are subjected to the conditioning of G.14.2 and the test in detail d) of G.14.2 is replaced by the following test of G.14.3.2 or G.14.3.3 as applicable.

G.14.3.2 Voltage surge test

Each sample is then subjected to 50 discharges from the impulse test generator circuit 3 of Table D.1, at not more than 12 discharges per minute, with U_c equal to 10 kV if the sample resistor is connected to coaxial cable connected to antenna (see Table 16).

G.14.3.3 Impulse test

Each sample is subjected to 10 pulses from the impulse test generator circuit 1 of Table D.1, with U_c equal to 4 kV or 5 kV of alternating polarity with a minimum of 60 s interval between pulses as applicable (see Table 16).

G.14.3.4 Compliance

After the tests of G.14.3.2 or G.14.3.3, the resistance of each sample shall not have changed by more than 20 %. No failure is allowed.

G.15 Capacitors and RC units serving as safeguards bridging insulation

G.15.1 General

This subclause specifies conditioning requirements when testing capacitors and RC units or discrete components serving as **safeguards** and provides selection criteria for capacitors and RC units that comply with IEC 60384-14.

G.15.2 Conditioning of capacitors and RC units

When required by 5.5.2.2 or 5.5.3.2, the following conditioning is applied when evaluating a capacitor or an RC unit to the requirements of IEC 60384-14.

The duration of the damp heat, steady-state test as specified in 4.12 of IEC 60384-14:2005, shall be 21 days at a temperature of $40\text{ }^{\circ}\text{C} \pm 2^{\circ}\text{C}$ and a relative humidity of $93\text{ \%} \pm 3\text{ \%}$.

Capacitors subjected to a duration that is longer than 21 days during the above test are considered acceptable.

G.15.3 Rules for selecting capacitors

The appropriate capacitor subclass shall be selected from those listed in Table G.7, according to the rules of application in the table.

Table G.7 – 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. test 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 this table.

- The voltage rating of the capacitor shall be at least equal to the **r.m.s. working voltage** across the insulation being bridged, determined according to 5.4.1.9.2.
- For a single capacitor (X type) serving as **functional insulation**, failure of the capacitor shall not result in the failure of a **safeguard** and the **type test** impulse voltage shall be at least equal to the **required withstand voltage**.
- For a single capacitor serving as a **basic safeguard** or **supplementary safeguard**, the rated peak impulse test voltage of the capacitor shall be at least equal to the **required withstand voltage**.
- For a single capacitor serving as a **double safeguard** or **reinforced safeguard**, the rated peak impulse test voltage of the capacitor shall be at least equal to twice the **required withstand voltage**.
- For a single capacitor serving as a **basic safeguard**, **supplementary safeguard** or **reinforced safeguard** the peak a.c. value of the r.m.s. test voltage shall not be smaller than the highest of the test voltages in Table 31, Table 32 and Table 33.
- A higher grade capacitor than the one specified may be used, 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.
- Two or more capacitors may be used 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.
- If two or more capacitors are used in series they shall comply with 5.5.2.2 and 5.5.3.2 as applicable and 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.

G.15.4 Informative examples of the application of capacitors

Table G.8 gives informative examples for the number of Y capacitors required bridging **basic insulation**, **supplementary insulation** or **reinforced insulation** based on the **required withstand voltage**. Table G.9 gives the maximum voltage that can appear across a Y capacitor based on the **peak working voltage**.

Table G.10 gives examples for the number of Y capacitors required bridging **basic insulation** and **reinforced insulation** based on the temporary overvoltages. Table G.11 gives a number of informative examples of the application of X capacitors selected in accordance with Table G.7. Other examples are possible.

**Table G.8 – Informative examples of the application of Y capacitors
based on required withstand voltage**

AC mains supply voltage up to and including V r.m.s.	Overvoltage category	Mains transient voltage kV	Bridged insulation	Capacitor type	Required number of capacitors
150	II	1,5	B or S	Y2	1
	II	1,5	D or R	Y2	2
	II	1,5	D or R	Y1	1
	III	2,5	B or S	Y2	2
	III	2,5	D or R	Y1	1
	IV	4,0	B or S	Y1	1
	IV	4,0	D or R	Y1	2
300	II	2,5	B or S	Y2	2
	II	2,5	D or R	Y1	1
	II	2,5	D or R	Y2	2
	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	3
	IV	6,0	B or S	Y1	2
	IV	6,0	D or R	Y1	2
500	II	4,0	B or S	Y1	1
	II	4,0	D or R	Y1	2
	III	6,0	B or S	Y1	2
	III	6,0	D or R	Y1	2
	IV	8,0	B or S	Y1	2
	IV	8,0	D or R	Y1	3
B basic insulation S supplementary insulation			D double insulation R reinforced insulation		

Table G.9 – Informative examples of the application of Y capacitors based on peak working voltage

Capacitor type	Bridged insulation	Peak working voltage across the capacitor not to exceed kV
Any type ^a	B	Capacitors located in circuits isolated from the mains ^b , shall comply with the electric strength test of 5.4.11.1
Y4	B or S	0,978
Y4	D or R	0,795
Y2	B or S	1,631
Y2	D or R	1,325
Y1	B or S	4,350
Y1	D or R	3,535
^a For capacitors that bridge basic insulation and are located in circuits isolated from the mains , see 5.5.3.2. ^b For application of Y capacitor located in circuits connected to the mains , see Table G.8 and Table G.10.		
B basic insulation S supplementary insulation		D double insulation R reinforced insulation

Table G.10 – Informative examples of the application of Y capacitors based on temporary overvoltages

Nominal mains voltage V r.m.s.	Bridged insulation	Capacitor type	No. of capacitors
120	B	Y4	2
	R	Y4	3
	B	Y2	1
	R	Y2	2
	B	Y1	1
	R	Y1	1
230	B	Y2	1
	R	Y2	2
	B	Y1	1
	R	Y1	1
600	B	Y2	2
	R	Y2	3
	B	Y1	1
	R	Y1	1
B basic insulation R reinforced insulation			

Table G.11 – Informative examples of the application of X capacitors, line to line or line to neutral

AC mains supply voltage up to and including V r.m.s.	Overvoltage category	Mains transient voltage kV	Capacitor type	Required number of capacitors based on required withstand voltage
150	II	1,5	X2	1
	III	2,5	X2	1
	IV	4,0	X1	1
250	II	2,5	X2	1
	III	4,0	X1	1
	IV	6,0	X1	2
500	II	4,0	X1	1
	III	6,0	X1	2
	IV	8,0	X1	2

G.16 Optocouplers as safeguards

This subclause specifies compliance requirements for optocouplers serving as a **basic safeguard**, **supplementary safeguard** or a **reinforced safeguard**.

Optocouplers shall comply with the requirements of IEC 60747-5-5. In the application of IEC 60747-5-5,

- the voltage $V_{ini,a}$ for **type testing** as specified in 7.4.3 of IEC 60747-5-5:2007, and
- the voltage $V_{ini,b}$ for **routine testing** as specified in 7.4.1 of IEC 60747-5-5:2007

shall be the appropriate value of the test voltage in 5.4.11.1 of this standard.

NOTE 1 The above constructions may contain cemented joints, in which case 5.4.4.5 of this standard also applies.

NOTE 2 The previous version 60747-5-1, IEC 60747-5-2 and IEC 60747-3 must include their amendments to be considered adequate for compliance with the requirements and provisions of this subclause.

G.17 Relays

G.17.1 General

This subclause specifies requirements for relays that are located in PS2 or PS3 or in an **arcing PIS** or a **resistive PIS**.

G.17.2 Requirements for relays

The relay may be tested separately or in the equipment.

For resistance to heat and fire, see Clause 13 in IEC 61810-1:2008.

A relay shall comply with the requirements of IEC 61810-1, taking into account the following:

- 10 000 operating cycles for endurance (see 5.5 of IEC 61810-1:2008) and during the electric endurance test (see Clause 11 of IEC 61810-1:2008), no temporary malfunction shall occur;

NOTE A temporary malfunction is an event that has to be eliminated during the test at latest after one additional energization cycle without any external influence (see Clause 11 of IEC 61810-1:2008).

- the relay shall be suitable for use in the applicable pollution situation (see Clause 13 of IEC 61810-1:2008);
- for **mains** relays the speed of contact making and breaking shall be independent of the rate of rise of the coil voltage;
- characteristics of the relay with regard to the ratings and classification (see IEC 61810-1), shall be appropriate for the function of the relay under **normal operating condition** as given below:
 - rated coil voltage and rated coil voltage range (see 5.1 of IEC 61810-1:2008);
 - rated contact load and the type of load (see 5.7 of IEC 61810-1:2008);
 - a.c. or d.c. relay (see 5.3 of IEC 61810-1:2008);
 - the ambient air temperature and upper and lower limit of the temperature (see 5.8 of IEC 61810-1:2008);
 - only relay technology category RT IV and RT V shall be considered to meet **pollution degree** 1 environment; for example, the relay meets 5.4.8 of this standard (see 5.9 of IEC 61810-1:2008);
- electric strength (see 10.3 of IEC 61810-1:2008), except the test voltages shall be the highest of the voltages of Table 31, Table 32 and Table 33 of this standard;
- **clearances** in accordance with Table 17 of this standard, if the **required withstand voltage** (referred to as impulse withstand voltage in IEC 61810-1) exceeds 12 kV;
- **creepage distances** in accordance with Table 23 of this standard, if the **r.m.s. working voltage** (referred to as voltage r.m.s. in IEC 61810-1) exceeds 500 V;
- **solid insulation** in accordance with 13.3 of IEC 61810-1:2008 or with 5.4.4 of this standard.

Compliance is checked according to IEC 61810-1 and the requirements of this standard.

G.17.3 Overload test

Except as specified in G.17.1, a relay shall withstand the following test.

The contact of the 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 contact switches a motor load, the test is conducted with the rotor of the motor in a locked condition. After the test, the relay shall still be functional.

G.17.4 Electric strength test

*Except as specified in Table G.1, a relay shall withstand an electric strength test as specified in 5.4.11.1. The test may be conducted at room temperature. If the contact switches a voltage exceeding that of ES2, the test voltage is as specified for **reinforced insulation**. If the contact switches a voltage less than that of ES3, the test voltage is as specified for **basic insulation**.*

G.17.5 Relay controlling mains socket-outlets

A **mains** relay controlling **mains** socket-outlets shall withstand the endurance test with an additional load that is equal to the total marked load of the socket-outlets. The peak surge current of the additional load shall have a value as shown in Table G.1.

G.17.6 Test method

For **mains** relays, the tests of IEC 61810-1 and this standard shall be applied with the modifications shown in Clause G.17 of this standard.

G.17.7 Compliance

After the tests, the relay shall show no damage in the sense of this standard. In particular, it shall show no deterioration of its **enclosure**, no reduction of **clearances** and **creepage distances** and no loosening of electrical connections or mechanical fixings.

G.18 Printed boards

G.18.1 General

This subclause specifies the requirements for insulation on printed boards.

This subclause also applies to the windings of a planar transformer.

G.18.2 Uncoated printed boards

This subclause specifies the requirements for insulation on uncoated boards.

The insulation between conductors on the outer surfaces of an uncoated printed board shall comply with the minimum **clearance** requirements of 5.4.2 and the minimum **creepage distance** requirements of 5.4.3.

Compliance is checked by inspection and by measurement.

G.18.3 Coated printed boards

This subclause specifies the requirements for separation distances before the boards are coated.

An alternative method to qualify coated printed boards is given in IEC 60664-3:2003.

For printed boards whose outer surfaces are to be coated with a suitable coating material, the minimum separation distances of Table G.12 apply to conductive parts before they are coated.

Double insulation and **reinforced insulation** shall pass **routine tests** for electric strength of 5.4.11.1.

Either one or both conductive parts and the entire 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 5.4.2 and the minimum **creepage distances** of 5.4.3 shall 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 O.11 and

Figure O.12 into account, and by the tests of G.18.6.

Table G.12 – Minimum separation distances for coated printed boards

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	10
7 070	13	13
8 910	16	16
11 310	20	20
14 140	26	26
17 700	33	33
22 600	43	43
28 300	55	55
35 400	70	70
45 200	86	86
Linear interpolation may be used between the nearest two points, the calculated spacing being rounded up to the next higher 0,1 mm increment.		
^a The test of G.18.6 is not required.		

G.18.4 Insulation between conductors on the same inner surface

This subclause specifies the requirements for insulation on the same inner layer of a multilayer board.

On an inner surface of a multi-layer printed board (see Figure O.17), the path between any two conductors shall comply with the requirements for a cemented joint in 5.4.4.5.

G.18.5 Insulation between conductors on different surfaces

This subclause specifies the requirements for insulation on the different layers of a multilayer board.

For **basic insulation** there is no thickness requirement.

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 provided by a single layer or conform with one of the specifications and pass the relevant tests in Table G.13.

Table G.13 – 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 $\geq 500\text{ }^{\circ}\text{C}$	No	Yes
An insulation system, with two or more coatings other than ceramic over a metallic substrate, cured at $< 500\text{ }^{\circ}\text{C}$	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 IEC 60050-24 (IEC 60050-212).		
^a Thermal conditioning of G.18.6.2 followed by the electric strength test of 5.4.11.1.		
^b Layers are counted before curing.		
^c Electric strength testing is carried out on the finished printed board.		

G.18.6 Tests on coated printed boards

G.18.6.1 Sample preparation and preliminary inspection

Three sample printed boards (or, for coated components in Clause G.19, two components and one board) identified as samples 1, 2 and 3 are required. Either actual boards or specially produced samples with representative coating and minimum separations may be used. 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.

G.18.6.2 Thermal conditioning

Sample 1 is subjected to the thermal cycling sequence of 5.4.7.

Sample 2 is aged in a full draught oven at a temperature and for a time duration chosen from the graph shown in Figure G.2 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 $\pm 2\text{ }^{\circ}\text{C}$. The temperature used to determine the temperature index line is the highest temperature on the board where safety is involved.

When using Figure G.2, interpolation may be used between the nearest two temperature index lines.

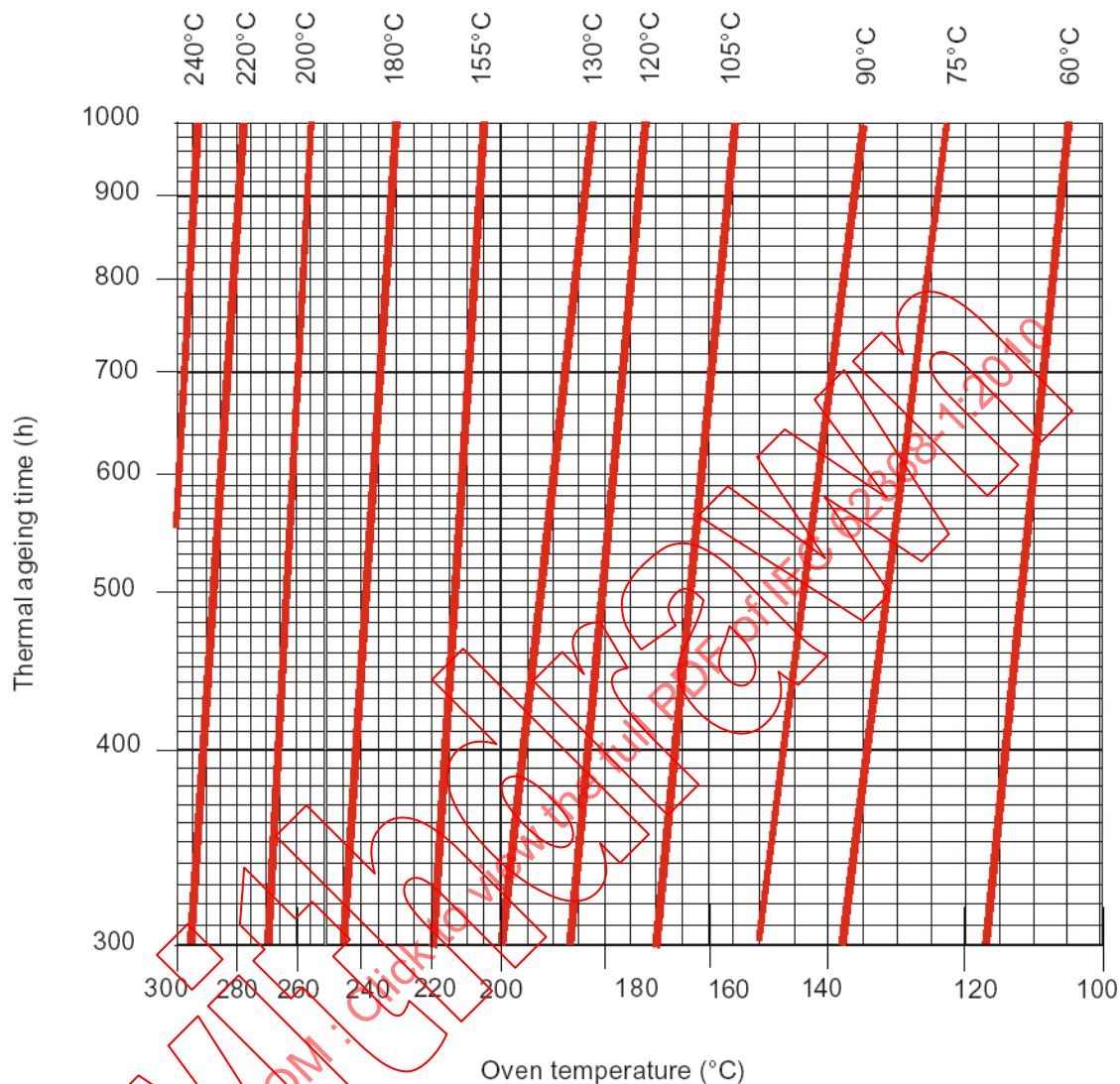


Figure G.2 – Thermal ageing time

G.18.6.3 Electric strength test

Samples 1 and 2 are then subjected to the humidity conditioning of 5.4.10 and shall withstand the electric strength test of 5.4.11.1 between conductors.

G.18.6.4 Abrasion resistance test

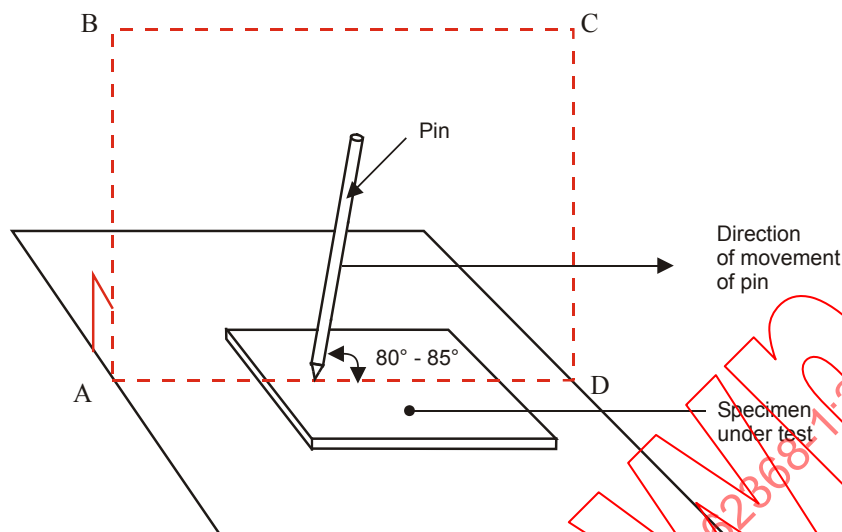
Sample board 3 is subjected to the following test.

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

The scratches are made by means of a hardened steel pin, the end of which has the form of a cone having a 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 G.3. The pin is so

loaded that the force exerted along its axis is $10\text{ N} \pm 0,5\text{ N}$. The scratches shall be at least 5 mm apart and at least 5 mm from the edge of the specimen.



NOTE The pin is in the plane ABCD that is perpendicular to the specimen under test.

Figure G.3 – Abrasion resistance test for coating layers

After the test, the coating layer shall neither have loosened nor have been pierced. The coating shall withstand an electric strength test as specified in 5.4.11.1 between conductors. In the case of metal core printed boards, the substrate is one of the conductors.

NOTE If mechanical stress or bending is applied to the board, additional tests to identify cracking may be needed (see IEC 60664-3).

G.19 Coatings on component terminals

G.19.1 Requirements

This subclause specifies the requirements for coatings on component terminals and the like.

Coatings may be used over external terminations of components to increase effective **clearances** and **creepage distances** (see Figure O.11). The minimum separation distances of Table G.12 apply to the component before coating, and the coating shall meet all the requirements of G.18.3. 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 G.12 (see G.18.3).

G.19.2 Compliance and test method

Compliance is checked by inspection taking into account Figure O.11 and by applying the sequence of tests covered by G.18.6.1, G.18.6.2 and G.18.6.3. These tests are carried out on a completed assembly including the component(s).

The abrasion resistance test of G.18.6.4 is carried out on a specially prepared sample printed board as described for sample 3 in G.18.6.1, except that the separation between the conductive parts shall be representative of the minimum separations and maximum potential gradients used in the assembly.

G.20 Mains connectors

Mains connectors that are listed in IEC/TR 60083 or that comply with one of the following standards IEC 60309-1, IEC 60320-1, IEC 60906-1 or IEC 60906-2, are considered acceptable without further evaluation.

G.21 Liquid filled components

G.21.1 General

This subclause provides construction and test requirements for LFCs used inside the equipment to avoid injury due to leaks of the liquid in the LFC within the meaning of this standard.

This subclause does not apply to components containing small amounts of liquids not likely to cause any chemical hazard (for example, liquid crystal displays, electrolytic capacitors, liquid cooling heat pipes, etc.).

For wet cell batteries, see Annex M.

G.21.2 Requirements

An LFC located internal to the equipment shall comply with all of the following requirements:

NOTE 1 Additional requirements need to be applied if located outside the equipment **enclosure**.

- flammable or conductive liquid shall be stored in a container, and the LFC shall comply with the tests of G.21.3.3, G.21.3.4, G.21.3.5 and G.21.3.6;
- the liquid shall be provided with protection in accordance with Clause 7 (chemical hazards);
- non-metallic parts of the container system shall withstand the tests of G.21.3.1 and G.21.3.2;

NOTE 2 Additional requirements of this standard may apply to the end product using an LFC if the LFC is evaluated as a component or subassembly.

- the LFC shall be mounted within the equipment in such a way that the tubing shall not come into contact with sharp edges or any other surface that could damage the tubing and if the LFC bursts or relieves its pressure, the fluid cannot come in contact with ES3 parts.

The order of tests is not specified. The tests may be performed on separate samples, except after the test of G.21.3.2, the test of G.21.3.1 is conducted.

G.21.3 Compliance and test methods

G.21.3.1 Hydrostatic pressure test

Compliance is checked by evaluation of the available data or by the following test. An LFC that is open to the atmosphere is not subjected to this test.

One sample of the LFC is subjected to a hydrostatic pressure test for 2 min at room temperature and at a pressure that is the highest of the following:

- *five times the maximum working pressure measured at the maximum temperature reached during **normal operating conditions**; and*
- *three times the maximum measured working pressure at the maximum temperature reached during application of the **abnormal operating conditions** of Clause B.3 and **single fault conditions** of Clause B.4.*

G.21.3.2 Creep resistance test

Two samples of the LFC, of which one or more parts are made of non-metallic materials, shall be conditioned for 14 days at a temperature of 87 °C and placed in a full draft air-circulating oven. Following the conditioning, the system shall comply with the test of G.21.3.1 and non-metallic parts shall show no sign of deterioration such as cracking and embrittlement.

G.21.3.3 Tubing and fittings compatibility test

Three samples of tubing and associated fittings of the LFC, of which one or more parts are made of non-metallic materials, shall be tested for tensile strength in accordance with the ISO 527 series before and after a conditioning test for 40 days at 38 °C in a full draft air-circulating oven or a water bath maintained at 38 °C. The internal pressure of the assemblies is maintained at atmospheric pressure. The tensile strength after conditioning shall not be less than 60 % of the tensile strength before the test.

G.21.3.4 Vibration test

One sample of the LFC, or the equipment containing the LFC, is fastened to the vibration generator in its normal position of use, as specified in IEC 60068-2-6, by means of screws, clamps or straps round the component. The direction of vibration is vertical, and the severity is:

- duration: 30 min;
- amplitude: 0,35 mm;
- frequency range: 10 Hz, 55 Hz, 10 Hz;
- sweep rate: approximately one octave per minute.

G.21.3.5 Thermal cycling test

One sample of the LFC is subjected to three cycles of conditioning for 7 h at a temperature that is 10 °C above the maximum temperature obtained during **normal operating conditions**, **abnormal operating conditions** of Clause B.3 and **single fault conditions** of Clause B.4, followed by room temperature for 1 h.

NOTE The LFC is not energized during the above test.

G.21.3.6 Force test

One sample of the LFC is subjected to the tests of Clause T.2 (10 N test applied to fittings **accessible to a skilled person**) and Clause T.3 (30 N test applied to fittings **accessible to an instructed person** or to an **ordinary person**).

G.21.4 Compliance

Compliance is checked by inspection and evaluation of the available data or by the tests of G.21.3. During and after these tests, there shall be no rupture, no leaks and no loosening of any connection or part.

G.22 Connectors other than mains connectors

Connectors other than for connecting **mains** power shall be so designed that the plug has such a shape that insertion into a **mains** socket-outlet or appliance coupler is unlikely to occur.

NOTE Examples of connectors meeting this requirement are those constructed according to IEC 60130-2, IEC 60130-9, IEC 60169-2 or IEC 60169-3, when used as prescribed. An example of a connector not meeting the requirements of this subclause is the so-called "banana" plug.

Compliance is checked by inspection.

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Annex H (normative)

Criteria for telephone ringing signals

H.1 General

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.

H.2 Method A

This method requires that the currents I_{TS1} and I_{TS2} flowing through a 5 000 Ω resistor, between any two conductors or between one conductor and protective earth do not exceed the limits specified, as follows.

- a) For **normal operating conditions**, I_{TS1} , the current determined from the calculated or measured current for any single active ringing period t_1 (as defined in Figure H.1), does not exceed:

- for cadenced ringing ($t_1 < \infty$), the current given by the curve of Figure H.2 at t_1 ;
- for continuous ringing ($t_1 = \infty$), 16 mA.

I_{TS1} , in mA, is as given by

$$I_{TS1} = \frac{I_p}{\sqrt{2}} \quad \text{for } (t_1 \leq 600 \text{ ms})$$

$$I_{TS1} = \frac{t_1 - 600}{600} \times \frac{I_{pp}}{2\sqrt{2}} + \frac{1200 - t_1}{600} \times \frac{I_p}{\sqrt{2}} \quad \text{for } (600 \text{ ms} < t_1 < 1200 \text{ ms})$$

$$I_{TS1} = \frac{I_{pp}}{2\sqrt{2}} \quad \text{for } (t_1 \geq 1200 \text{ ms})$$

where

- I_p is the peak current, in mA, of the relevant waveform given in Figure H.3;
- I_{pp} is the peak-to-peak current, in mA, of the relevant waveform given in Figure H.3;
- t_1 is expressed in ms.

- b) For **normal operating conditions**, 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 H.1), does not exceed 16 mA r.m.s.

I_{TS2} in mA is as given by

$$I_{TS2} = \left[\frac{t_1}{t_2} \times I_{TS1}^2 + \frac{t_2 - t_1}{t_2} \times \frac{I_{dc}^2}{3,75^2} \right]^{1/2}$$

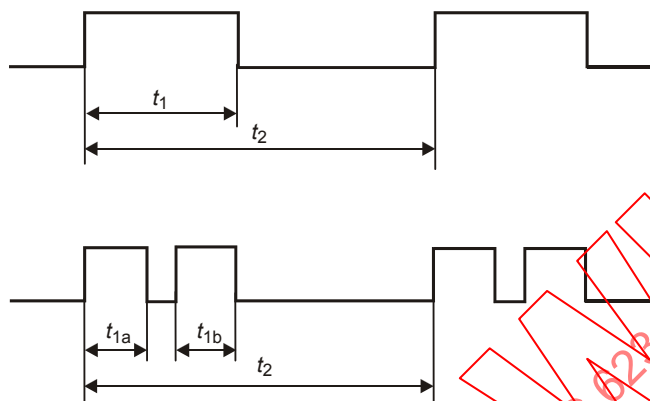
where

- I_{TS1} in mA, is as given by H.2 a);
- 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 ms.

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_{TS1} shall not exceed the current given by the curve of Figure H.2, or 20 mA, whichever is greater; and
- I_{TS2} shall not exceed a limit of 20 mA.



where

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 H.1 – Definition of ringing period and cadence cycle

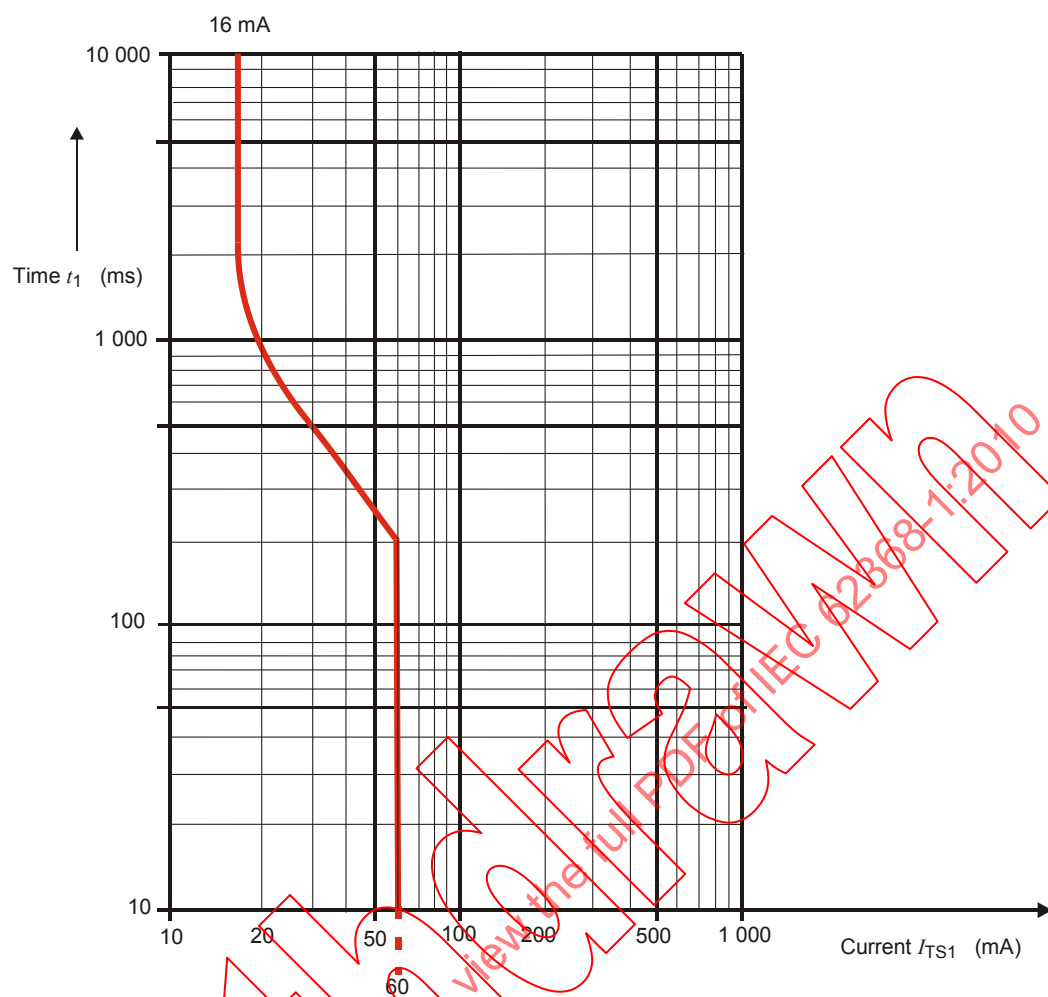


Figure H.2 – I_{TS1} limit curve for cadenced ringing signal

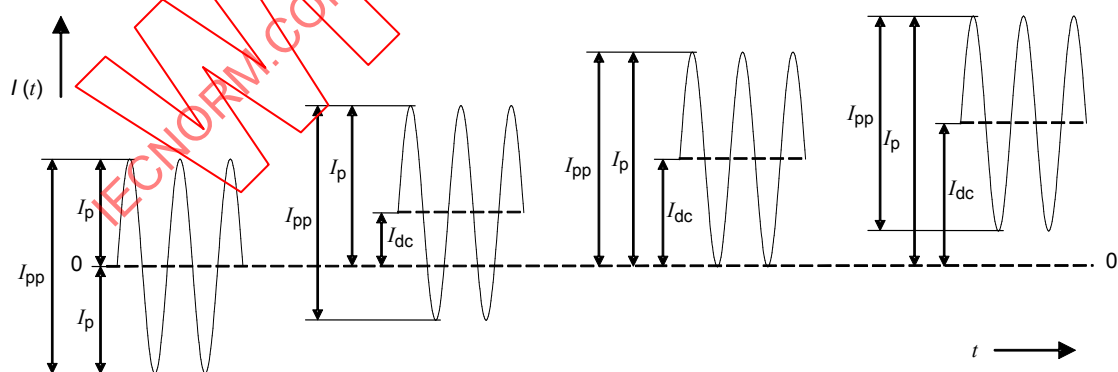


Figure H.3 – Peak and peak-to-peak currents

H.3 Method B

H.3.1 Ringing signal

H.3.1.1 Frequency

The ringing signal shall use only frequencies whose fundamental component is equal to or less than 70 Hz.

H.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 M Ω .

H.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.

H.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 H.3.

H.3.2 Tripping device and monitoring voltage

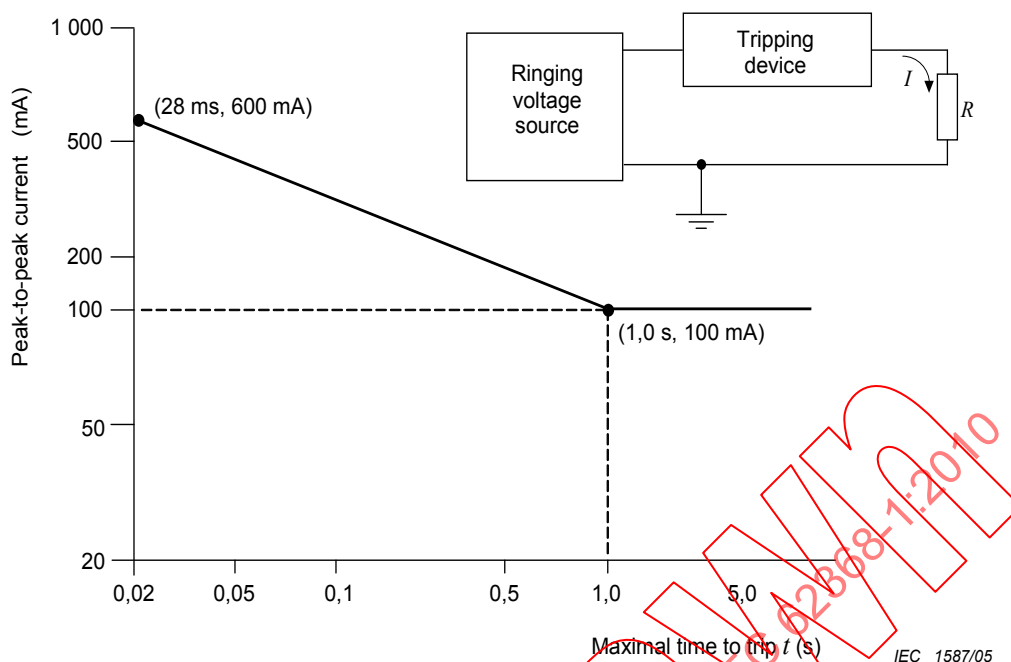
H.3.2.1 Conditions for use of a tripping device or a monitoring voltage

A ringing signal circuit shall include a tripping device as specified in H.3.2.2, or provide a monitoring voltage as specified in H.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 a 500 Ω or greater resistor does not exceed 100 mA peak-to-peak, neither a tripping device nor a monitoring voltage is required;
- if the current through a 1 500 Ω or greater resistor exceeds 100 mA peak-to-peak, a tripping device shall be included. If the tripping device meets the trip criteria specified in Figure H.4 with $R \geq 500 \Omega$, no monitoring voltage is required. If, however, the tripping device only meets the trip criteria with $R \geq 1 500 \Omega$, a monitoring voltage shall also be provided;
- if the current through a 500 Ω or greater resistor exceeds 100 mA peak-to-peak, but the current through a 1 500 Ω or greater resistor does not exceed this value, either:
 - a tripping device shall be provided, meeting the trip criteria specified in Figure H.4 with $R \geq 500 \Omega$, 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 H.4 – Ringing voltage trip criteria

H.3.2.2 Tripping device

A series current-sensitive tripping device in the ringlead that will trip ringing as specified in Figure H.

H.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 I (informative)

Overvoltage categories (see IEC 60364-4-44)

The largest transient voltage likely to be experienced at the power input interface of equipment connected to the **mains** is known as the **mains transient voltage**. In this standard, minimum **clearances** for insulation in circuits connected to the **mains** are based on the **mains transient voltage**.

According to IEC 60664-1, the value of the **mains transient voltage** is allocated to the **mains** voltage and the overvoltage category, I to IV (see Table 15 of this standard).

The overvoltage category therefore has to be identified for each equipment intended to be connected to the **mains** (see Table I.1).

The concept of overvoltage categories is used for equipment energized directly from the a.c. **mains**.

The overvoltage categories have a probabilistic implication rather than the meaning of physical attenuation of the transient voltage downstream in the installation.

NOTE 1 This concept of overvoltage categories is used in IEC 60364-4-44:2007, section 443.

NOTE 2 The term overvoltage category in this standard is synonymous with impulse withstand category used in IEC 60364-4-44:2007, section 443.

The term overvoltage category is not used in connection with d.c. power distribution systems in this standard.

Table I.1 – Overvoltage categories

Overvoltage category	Equipment and its point of connection to the a.c. mains	Examples of equipment
IV	Equipment that will be connected to the point where the mains supply enters the building	- Electricity meters - Communications ITE 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 ITE used in the building
I	Equipment that will be connected to a special mains in which measures have been taken to reduce transients	ITE supplied via an external filter or a motor driven generator

Annex J (normative)

Insulated winding wires for use without interleaved insulation

J.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 covers round solid winding wires having diameters between 0,05 mm and 5,0 mm and stranded winding wires with equivalent cross-sectional areas.

J.2 Sampling tests

J.2.1 General

The 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.

J.2.2 Electric strength

The test sample is prepared according to 4.4.1 of IEC 60851-5:2008 (for a twisted pair). The sample is then subjected to the electric strength test of 5.4.11.1 with a test voltage not less than twice the highest of the appropriate voltages of Table 31, Table 32 and Table 33, 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**.

J.2.3 Flexibility and adherence

Test 8 in 5.1.1 of IEC 60851-3:2009 shall be used, using the mandrel diameters of Table J.1.

The test sample is then examined in accordance with 5.1.1.4 of IEC 60851-3:2009, followed by the electric strength test of 5.4.11.1 in this standard. The test voltage shall be not less than the highest of the appropriate voltages in Table 31, Table 32 and Table 33, 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**.

Table J.1 – Mandrel diameter

Nominal conductor diameter mm	Mandrel diameter mm
0,05 up to and including 0,35	4,0 ± 0,2
over 0,35 up to and including 0,50	6,0 ± 0,2
over 0,50 up to and including 0,75	8,0 ± 0,2
over 0,75 up to and including 2,50	10,0 ± 0,2
over 2,50 up to and including 5,00	Four times the 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 $118 \text{ MPa} \pm 10 \%$ ($118 \text{ N/mm}^2 \pm 10 \%$).

J.2.4 Heat shock

Test 9 of IEC 60851-6:1996, followed by the electric strength test 5.4.11.1 except that the test voltage is applied between the wire and the mandrel. The test voltage shall be not less than the highest of the appropriate voltages in Table 31, Table 32 and Table 33, 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**.

The oven temperature is the relevant temperature of the thermal class of insulation in Table J.2. The mandrel diameter and tension applied to the wire during winding on the mandrel are as in Table J.1. The electric strength test is conducted at room temperature after removal from the oven.

Table J.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 $\pm 5^\circ$ 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.								

J.2.5 Retention of electric strength after bending

Five samples are prepared as in J.2.3 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, now withdrawn. It is not included in the fourth edition (2008) of that standard.

The test voltage shall be not less than the highest of the appropriate voltages in Table 31, Table 32 and Table 33, 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**.

The mandrel diameter and tension applied to the wire during winding on the mandrel are as in Clause J.2.

J.3 Testing during manufacturing

J.3.1 General

The wire shall be subjected by the wire manufacturer to electric strength tests during manufacture as specified in J.3.2 and J.3.3.

J.3.2 Routine test

The test voltage for **routine test** shall be the highest of the appropriate voltages in Table 31, Table 32 and Table 33 of this standard, 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**.

J.3.3 Sampling test

Twisted pair samples shall be tested in accordance with 4.4.1 of IEC 60851-5:2008. The test voltage for the **sampling test** shall be the highest of the appropriate voltages in Table 31, Table 32 and Table 33 of this standard, but not less than:

- 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**.

Annex K (normative)

Safety interlocks

K.1 General

K.1.1 General requirements

Safety interlocks shall be so designed that, for an **ordinary person**, the class 2 energy sources and class 3 energy sources will be removed before the cover, door, etc. is in a position that those parts become **accessible** as a class 1 energy source.

Safety interlocks shall be so designed that, for an **instructed person**, the class 3 energy sources will be removed before the cover, door, etc. is in a position that this part becomes **accessible** as a class 2 energy source or less.

The interlock shall either:

- necessitate previous de-energisation of such parts, or
- automatically initiate disconnection of the supply to such parts, and to reduce to a:
 - class 1 energy source within 2 s for an **ordinary person**; and
 - class 2 energy source within 2 s for an **instructed person**.

For hot parts and for moving parts, reduction of the energy source may be longer than 2 s if an **instructional safeguard** is provided in accordance with Clause F.5 indicating the time when the energy source will be reduced to the required class. The **instructional safeguard** shall be placed on the door, cover or other part that initiates the interlock action and is opened or removed to gain access. An additional **instructional safeguard** in accordance with Clause F.5 shall be placed on or beside the part that was a class 2 or 3 energy source before the interlock action was initiated.

K.1.2 Compliance and test method

The energy level of class 2 or class 3 energy source parts are monitored.

Compliance is checked by inspection, measurement and use of the rigid test finger according to Annex V.

K.2 Components of the safety interlock safeguard mechanism

The components comprising the **safety interlock** mechanism shall be considered **safeguards**, and shall comply with applicable **safeguard** requirements and shall be subject to applicable requirements of Annex G.

Compliance is checked in accordance with Annex G and by inspection.

K.3 Inadvertent change of operating mode

A **safety interlock** shall not be operable by means of probes specified in Annex V so as to change the energy class within the area, space or access point being controlled to a class 3 energy source for an **instructed person**, or to a class 2 energy source or a class 3 energy source for an **ordinary person**.

Compliance is checked in accordance with Annex V and by inspection.

K.4 Interlock safeguard override

A **safety interlock** may be overridden by a **skilled person**. The **safety interlock** override system:

- shall require an intentional effort to operate; and
- shall reset automatically to normal operation when servicing is complete, or prevent normal operation unless the **skilled person** has carried out restoration; and
- if located in an area **accessible** to an **ordinary person** or, if applicable, an **instructed person**, shall not be operable by means of probes specified in Annex V, and shall require a **tool** for operation.

Compliance is checked in accordance with Annex V and by inspection.

K.5 Fail-safe

K.5.1 Requirement

In the event of any **single fault condition** in the **safety interlock** system, the space controlled by the **safety interlock** shall

- revert to a class 1 energy source for an **ordinary person** or a class 2 energy source for an **instructed person**, or
- be locked in the **normal operating condition** and comply with applicable requirements for a class 3 energy source.

K.5.2 Compliance and test method

*Compliance is checked by introduction of electrical, electro-mechanical, and mechanical component faults, one at a time. **Single fault conditions** are described in Clause B.4. For each fault, the space controlled by the **safety interlock** shall comply with the applicable requirements for **single fault conditions** for the respective energy source. Fixed separation distances in **safety interlock** circuits (for example, those associated with printed boards) are not subjected to simulated **single fault conditions** if the separation distances comply with K.7.1.*

K.6 Mechanically operated safety interlocks

K.6.1 Endurance requirement

Moving mechanical parts in mechanical and electromechanical **safety interlock** systems shall have adequate endurance.

K.6.2 Compliance and test method

*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. In the event of any fault during or after the 10 000 operating cycles in the **safety interlock** system, the space controlled by the **safety interlock** shall:*

- *revert to a class 1 energy source for an **ordinary person** or a class 2 energy source for an **instructed person**, or*
- *be locked in the **normal operating condition** and comply with applicable requirements for a class 3 energy source.*

NOTE The above test is conducted to check the endurance of moving parts other than those in **safety interlock** systems, switches and relays. **Safety interlock** systems, switches and relays, if any, are subject to Annex G.

K.7 Interlock circuit isolation

K.7.1 Separation distances for contact gaps and interlock circuit elements

If the switch or relay disconnects a circuit conductor in a circuit connected to the **mains**, the separation distances for contact gaps and their related circuits shall be not less than that for a **disconnect device** (see Annex L).

If the switch or relay is in a circuit isolated from the **mains**, the separation distances for contact gaps shall be not less than the relevant minimum **clearance** value for **basic insulation** for isolation of class 2 energy sources. Interlock circuit elements, the failure of which can defeat the interlock system, shall have **basic insulation**.

If the switch or relay is in a circuit isolated from the **mains**, the separation distances for contact gaps shall be not less than the relevant minimum **clearance** value for **reinforced insulation** for isolation of class 3 energy sources. Interlock circuit elements, the failure of which can defeat the interlock system, shall have **reinforced insulation**.

Two independent interlock systems employing **basic insulation** may be used as an alternative to the provision of **reinforced insulation**.

Alternatively, the separation gap between contacts in the off position shall withstand the electric strength test of 5.4.2.8 at a test voltage required for **basic insulation**. The contact gap shall comply with the above requirements before and after the 10 000 cycle endurance test of K.6.2. The endurance test condition shall represent the maximum **normal operating condition** within the equipment with respect to voltage and current that the contacts interrupt.

The contact gap **clearance** may be the required distance for a homogeneous field according to Table 20 provided the switch or relay complies with K.7.2, K.7.3 and K.7.4.

The above requirements do not apply to switches complying with Clause G.1 and relays complying with Clause G.17.

K.7.2 Overload test

*The contact of a switch or relay in the **safety interlock** system 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.*

K.7.3 Endurance test

*The contact of a switch or relay in the **safety interlock** system 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 may be used if requested by the manufacturer.*

*For reed switches used in a **safety interlock** system in ES1 or ES2, the test is 100 000 operating cycles. For other switches and relays in a **safety interlock** system, the test is 10 000 operating cycles.*

After the test, the **safety interlock** system, including the switch or relay, shall still be functional.

K.7.4 Electric strength test

Except for reed switches in ES1 or ES2, an electric strength test as specified in 5.4.11.1 is applied between the contacts after the tests of K.7.3. If the contact is in a circuit connected to the **mains**, the test voltage is as specified for **reinforced insulation**. If the contact is in a circuit isolated from the **mains**, the test voltage is as specified for **basic insulation** in a circuit connected to the **mains**.

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Annex L (normative)

Disconnect devices

L.1 General requirements

L.1.1 General

A **disconnect device** shall be provided to disconnect the equipment from the supply. If a **disconnect device** interrupts the neutral conductor, it shall simultaneously interrupt all phase conductors.

A **disconnect device** may be:

- the plug on the power supply cord;
- an appliance coupler;
- an isolating switch;
- a circuit breaker; or
- any equivalent means for disconnection.

NOTE The following requirements do not apply to functional switches where a **disconnect device** is also provided.

For equipment intended to be powered from an a.c. **mains** that is Overvoltage Category I, Overvoltage Category II or Overvoltage Category III, or from a d.c. **mains** that is ES3, a **disconnect device** shall have a contact separation of at least 3 mm. For an a.c. **mains** that is Overvoltage Category IV, see IEC 60947-1. When incorporated in the equipment, the **disconnect device** shall be connected as closely as practicable to the incoming supply.

For equipment intended to be powered from a d.c. **mains** that is not at ES3,

- a **disconnect device** shall have a contact separation at least equal to the minimum **clearance** for **basic insulation**;
- a removable fuse may be used as a **disconnect device**, provided that it is **accessible** only to an **instructed person** or to a **skilled person**.

L.1.2 Permanently connected equipment

For **permanently connected equipment** the **disconnect device** shall be incorporated in the equipment, unless the equipment is accompanied by installation instructions stating that an appropriate **disconnect device** shall be provided as part of the building installation.

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

L.1.3 Parts that remain energised

Parts on the supply side of a **disconnect device** in the equipment, that remain energised when the **disconnect device** is switched off, shall be guarded to reduce the risk of accidental contact by **skilled persons**.

As an alternative, instructions shall be provided in the service manual.

L.1.4 Single phase equipment

For single-phase equipment, the **disconnect device** shall disconnect both poles simultaneously, except that a single-pole **disconnect device** can be used to disconnect the phase conductor when it is possible to rely on the identification of the neutral in the **mains**. If only a single pole disconnect device is provided in the equipment, instructions shall be given for the provision of an additional two-pole **disconnect device** in the building installation when the equipment is used where identification of the neutral in the **mains** is not possible.

NOTE Examples of cases where a two-pole **disconnect device** is required are:

- on equipment supplied from an IT power system;
- on pluggable equipment supplied through a reversible appliance coupler or a reversible plug (unless the appliance coupler or plug itself is used as the **disconnect device**;
- on equipment supplied from a socket-outlet with indeterminate polarity.

L.1.5 Three-phase equipment

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

L.1.6 Switches as disconnect devices

Where the **disconnect device** is a switch incorporated in the equipment, the on and off positions shall be marked in accordance with F.3.5.2.

L.1.7 Plugs as disconnect devices

Where a plug on the power supply cord is used as the **disconnect device**, the installation instructions shall state that for pluggable equipment, the socket-outlet shall be easily **accessible**. For pluggable equipment intended for installation by an **ordinary person**, the installation instructions shall be made available to the **ordinary person**.

L.1.8 Multiple power sources

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

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

Equipment incorporating an internal UPS shall have provisions for reliably disabling the UPS and disconnecting its output prior to servicing the equipment. Instructions for disconnection of the UPS shall be provided. The internal energy source of the UPS shall be marked appropriately and guarded against accidental contact by a **skilled person**.

L.2 Compliance

Compliance is checked by inspection.

Annex M (normative)

Batteries and fuel cells

M.1 General requirements

This annex provides additional requirements for equipment that contains batteries. Use of batteries in the equipment may require **safeguards** that have not been addressed in other parts of the standard. This annex does not cover requirements for external batteries, installation of external batteries or battery maintenance other than battery replacement by an **ordinary person** or an **instructed person**. Also, this annex does not cover equipment that charges external batteries.

NOTE Additional requirements for use of fuel cells in equipment covered under the scope of this standard are under consideration.

M.2 Safety of battery cells and batteries

M.2.1 Requirements

Battery cells and batteries shall be provided with **safeguards** that are effective, during **normal operating conditions**, **abnormal operating conditions**, **single fault conditions**, installation conditions and transportation conditions.

Battery cells and batteries shall comply with the relevant IEC standards for batteries as listed below. The complete battery pack/assembly shall pass the additional tests in this annex, as applicable.

IEC 60086-4, IEC 60896-11, IEC 60896-21, IEC 60896-22, IEC 61056-1 and IEC 61056-2, IEC 61427, IEC/TS 61430, IEC 61434, IEC 61959, IEC 61960, IEC 62133, IEC 62282-2, IEC/TS 62393 and IEC 62485-2.

NOTE 1 A battery cell is a basic manufactured unit providing a source of electrical energy by direct conversion of chemical energy, that consists of electrodes, separators, electrolyte, container and terminals.

NOTE 2 A battery is an assembly of cell(s) ready for use as a source of electrical energy characterized by its voltage, size, terminal arrangement, capacity and rate capability. Batteries may contain multiple cells.

M.2.2 Compliance and test method

Compliance is checked by:

- *inspection; or*
- *evaluation based on data provided by the manufacturer; or*
- *testing according to Annex B under **normal operating conditions**, **abnormal operating conditions** and **single fault conditions**.*

M.3 Protection in battery circuits

M.3.1 Requirements

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
- batteries in **hand-held equipment**, **direct plug-in equipment** and **transportable equipment** that are replaceable by an **ordinary person** shall either:
 - have contacts that cannot be shorted with the test probes of Annex V; or
 - be inherently protected to avoid creating a class 2 energy source or a class 3 energy source; or
 - contain a **basic safeguard** and a **supplementary safeguard** in a high energy battery containing any amount of aggregate lithium contents (or aggregate lithium equivalent contents) of lithium (or lithium-ion).

NOTE Reversed charging of a rechargeable battery occurs when the polarity of the charging circuit is reversed, aiding the discharge of the battery.

M.3.2 Test method

Batteries circuits are checked by inspection and by evaluation of the data provided by the equipment manufacturer and battery manufacturer for charging and discharging rates.

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.*
 - *For adjustable battery charging circuits, 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.*
 - *With the battery charging circuit operating at the rated output voltage of the charger, 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 highest overcharging current. The battery is then charged for a single period of 7 h 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 the simulated failure in place.*
- *Reverse charging of a rechargeable battery. The battery is installed in the reverse orientation and then the charging circuit is subject to simulation of any single component failure. 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 the 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 component in the load circuit of the battery under test (one component at a time).*

Where more than one cell is provided in a battery pack, all cells in the pack shall be tested as a unit.

NOTE Some of the tests specified can be hazardous to the persons performing the tests; all appropriate measures to protect such persons against possible chemical or **explosion** hazards should be taken.

M.3.3 Compliance

These tests shall not result in any of the following:

- *chemical leakage 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 an **ordinary person** or an **instructed person**; or*
- ***explosion** of the battery, if such **explosion** could result in injury to an **ordinary person** or an **instructed person**; or*
- *emission of flame or expulsion of molten metal to the outside of the equipment **enclosure**.*

After completion of the tests, the equipment shall pass the electric strength tests of 5.4.11.1.

M.4 Endurance of a battery and its enclosure

M.4.1 Requirements

A battery and its **enclosure** shall endure the mechanical stresses during use or transport, such as:

- dropping onto the floor, or
- unintentional impact of the battery (for example, against furniture), or
- increase in internal pressure from a high temperature (for example, inside an automobile in sunshine),
- vibration.

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 **accessible** to an **ordinary person** or an **instructed person**, an **instructional safeguard** shall be provided in accordance with Clause F.5. There shall be a marking close to the battery and a statement provided in the instructions;
- if the battery is not **accessible** to an **ordinary person** or an **instructed person**, an **instructional safeguard** shall be provided in accordance with Clause F.5. There shall be a marking close to the battery or a statement provided in the instructions.

The instructions shall state the following or equivalent wording:

CAUTION

Risk of explosion if battery is replaced by an incorrect type.
Dispose of used batteries according to the instructions.

M.4.2 Compliance and test method

*If the equipment and the battery are subject to handling or transporting by an **ordinary person** or an **instructed person**, the battery installed in the equipment shall be tested according to the relevant **enclosure** tests of Annex T.*

The compliance criteria of M.3.3 apply.

M.5 Risk of burn due to short circuit during carrying

M.5.1 Requirements

Battery terminals shall be protected from the possible burn that may occur to an **ordinary person** or an **instructed person** during the carrying of a battery with exposed bare conductive terminals (such as in the user's carrying bag) due to a short circuit caused by metal objects, such as clips, keys and necklaces.

M.5.2 Compliance and test method

If the battery is designed to be carried with bare conductive terminals, the battery shall comply with the test of P.2.2.3.

The compliance criteria of M.3.3 apply.

M.6 Prevention of short circuits and protection from other effects of electric current

M.6.1 Short circuits

M.6.1.1 General requirements

The electric energy stored in cells or batteries may be released in an inadvertent and uncontrolled manner due to external short-circuiting of the terminals or an internal **safeguard** failure, such as a metal contaminant bridging the insulation. As a result, the considerable amount of energy, heat and pressure generated by the high current can produce molten metal, sparks, **explosion** and vaporisation of electrolyte.

To address external faults, the main connections from the battery terminals shall either:

- be provided with the sufficient overcurrent protection device to prevent any accidental short circuit inducing conditions as mentioned above; or
- the battery connections up to the first overcurrent protection device shall be constructed so that a short circuit is not likely to occur and connections shall be designed to withstand the electromagnetic forces experienced during a short circuit.

NOTE The insulation should be resistant against the effects of ambient influences like temperature, dampness, dust, gasses, steam, and mechanical stress. Where terminals and conductors are not insulated, by design or for maintenance purposes, only insulated **tools** should be used in that area.

Internal faults within the cell can occur during the lifetime of the battery. It shall be assumed any cells requiring a pressure relief device may fail from this cause, except for those exempted from the test of this subclause, where other requirements apply. Each cell type in a pack shall be faulted so that each vents safely without introducing an **explosion** or fire. Where a battery cell is incorporated into a battery pack or the equipment, sufficient spacing shall be allowed for the proper vent operation of each cell.

M.6.1.2 Test method to simulate an internal fault

The test sample cell shall not contain an extra foil winding of non-coated electrode substrate around the spiral wound electrodes (jelly roll). At ambient room temperature, a fully charged fresh battery pack shall be placed on a wooden board that is 10 mm or more in thickness. The battery pack shall be pierced with a nail at a driving speed of 150 mm/s in the vertical axis across the centre of electrode surface until the tip of the nail has penetrated to a depth of 3 mm inside of the cell case. The nail is 3 mm in diameter and the tip angle is 17°. The nail

shall be held firmly in place at this depth to prevent an alternative internal pressure release point in case of thermal run away. The test shall be continued for 6 h.

M.6.1.3 Compliance

The sample shall not explode or emit molten material at any time during the test. Following the test, the test sample cell construction shall be inspected to ensure extra foil winding of non-coated substrate was not used.

For external faults, compliance may be checked by inspection.

As an alternative to the tests of M.6.1.2, the requirements of IEEE 1625, Clause 11 may be applied.

NOTE Cells exceeding an energy level above 2,6 A/h may have difficulties passing the test of M.6.1.2 and should be considered to comply with IEEE 1625, Clause 11.

M.6.2 Leakage currents

To be resistant against effects of ambient influences like temperature, dampness, dust, gasses, steam, mechanical stress, and to avoid the risk of fire or corrosion, batteries shall be kept clean and dry.

Compliance is checked by measuring the insulation resistance between the battery's circuit and other local conductive parts. The insulation resistance shall be greater than 100 Ω per volt (of battery nominal voltage), corresponding to a leakage current less than 10 mA.

NOTE The battery system should be isolated from the fixed installation before this test is carried out. Before carrying out any test check for ES2 or ES3 voltage between the battery and the associated rack or **enclosure**.

M.7 Risk of explosion from lead acid and NiCd batteries

M.7.1 Ventilation preventing explosive gas concentration

Where batteries are provided within an equipment such that emitted gases may concentrate in a confined equipment space, the battery construction, air flow or ventilation shall be such that the atmosphere within the equipment does not reach an **explosive** concentration.

M.7.2 Compliance and test method

*The purpose of ventilating a battery location or **enclosure** is to maintain the hydrogen concentration below the **explosive** 4 %_{vol} hydrogen LEL threshold. The hydrogen concentration in the battery location shall not exceed 1 %_{vol} hydrogen.*

NOTE 1 When a cell reaches its fully charged state, water electrolysis occurs according to the Faraday's law.

Under standard conditions of normal temperature and pressure where $T = 273\text{ K}$, $P = 1\,013\text{ hPa}$:

- 1 Ah decomposes H_2O into 0,42 l H_2 + 0,21 l O_2 ,
- decomposition of 1 cm³ (1 g) H_2O requires 3 Ah,
- 26,8 Ah decomposes H_2O into 1 g H_2 + 8 g O_2 .

When the charging operation is stopped, the emission of gas from the cells can be regarded as having come to an end 1 h after having switched off the charging current.

The minimum air flow rate for ventilation of a battery location or compartment shall be calculated by the following formula:

$$Q = v \times q \times s \times n \times I_{\text{gas}} \times C_{\text{rt}} \times 10^{-3} \left[\text{m}^3 / \text{h} \right]$$

where

Q is the ventilation air flow in m^3/h ;

v is the necessary dilution of hydrogen:

$$\frac{(100 \% - 4 \%)}{4 \%} = 24$$

$q = 0,42 \times 10^{-3} \left[\text{m}^3/\text{Ah} \right]$ generated hydrogen;

$s = 5$, general safety factor;

n is the number of cells;

I_{gas} is the current producing gas in mA /Ah rated capacity for the float charge current I_{float} or the boost charge current I_{boost} ;

C_{rt} is the capacity C_{10} for lead acid cells (Ah) or capacity C_5 for NiCd cells (Ah).

NOTE C_{10} is the 10 h rate with current I_{10} for lead acid cells: (Ah) to $U_{\text{final}} = 1,80 \text{ V/cell}$ at 20°C .

C_5 is the 5 h rate with current I_5 for NiCd cells: (Ah) to $U_{\text{final}} = 1,00 \text{ V/cell}$ at 20°C .

with $v \times q \times s = 0,05 \text{ m}^3/\text{Ah}$ the ventilation air flow calculation formula is:

$$Q = 0,05 \times n \times I_{\text{gas}} \times C_{\text{rt}} \times 10^{-3} \left[\text{m}^3 / \text{h} \right]$$

The current I_{gas} in mA producing gas is determined by one of the following formulas:

$$I_{\text{gas}} = I_{\text{float}} \times f_g \times f_s \left[\text{mA/Ah} \right] \text{ or}$$

$$I_{\text{gas}} = I_{\text{boost}} \times f_g \times f_s \left[\text{mA/Ah} \right]$$

where

I_{gas} is the current producing gas in mA /Ah rated capacity for the float charge current I_{float} or the boost charge current I_{boost} ;

I_{float} is the float charge current under fully charged condition at a defined float charge voltage at 20°C ;

I_{boost} is the boost charge current under fully charged condition at a defined boost charge voltage at 20°C ;

f_g is the gas emission factor, proportion of current at fully charged state producing hydrogen (see Table M.1);

f_s is the safety factor, to accommodate faulty cells in a battery string and an aged battery (see Table M.1).

Table M.1 – Values of f_g and f_s

	Lead-acid batteries vented cells Sb < 3 %	Lead-acid batteries VRLA cells	NiCd batteries vented cells
gas emission factor f_g	1	0,2	1
gas emission safety factor f_s (including 10 % faulty cells and ageing)	5	5	5

NOTE 2 For outdoor equipment, see Clause 11 of IEC 60950-22:2005.

M.8 Protection against internal ignition from external spark sources of lead acid batteries

M.8.1 General

This subclause applies for the rechargeable battery providing venting system.

NOTE For example, a battery used in an UPS.

The level of air ventilation rate shall ensure that a risk of **explosion** does not exist by keeping the hydrogen content in air below 1 %_{vol} at the **PIS**.

The use of an effective flame arrester in the battery venting system will prevent an external **explosion** propagating into the battery.

M.8.2 Test method

M.8.2.1 General

The test shall be carried out according to IEC 60896-21:2004, 6.4.

NOTE 1 This test is designed to reveal the protection afforded by the valve unit against the ignition of the gases within a cell by an external ignition source. In this test, proper precautions should be taken to **safeguard** persons and equipment from **explosion** and burns.

Where batteries form an integral part of a power supply system (for example, in a UPS system), the distance d , where d is the minimum distance (**clearance**) between the ventile of the battery and the electronic equipment that may exhibit flames, sparks, arcs or glowing devices (maximum surface temperature 300 °C), may be reduced according to the equipment manufacturer's calculations or measurements. The level of air ventilation rate should ensure that a risk of **explosion** does not exist by keeping the hydrogen content in air below 1%_{vol} plus a margin at the **PIS**.

A minimum distance d extending through air shall be maintained within which a maximum surface temperature of 300 °C shall not be exceeded (no flames, sparks, arcs or glowing devices).

NOTE 2 When calculating the minimum distance d to protect against **explosion** in close proximity to the source of release of a cell or battery, the dilution of **explosive** gases is not always ensured. The dispersion of **explosive** gas depends on the gas release rate and the ventilation characteristics close to the source of release.

*The minimum distance d can be estimated by calculating the dimensions of a hypothetical volume V_z of potentially **explosive** gas around the source of release, outside of which the concentration of hydrogen is below the safe concentration of the LEL.*

$$d = 28,8 \times \sqrt[3]{I_{\text{gas}} \times \sqrt[3]{C_{\text{rt}}}} \quad [\text{mm}] \quad (\text{see IEC 60079-10-1, chapter B4})$$

where

I_{gas} is the current producing gas [mA / Ah];

C_{rt} is the rated capacity [Ah].

NOTE 3 The required distance d can be achieved by the use of a partition wall between the battery and sparking device.

M.8.2.2 Estimation of hypothetical volume V_z

The theoretical minimum ventilation flow rate to dilute the flammable gas (hydrogen) to a concentration below the LEL can be calculated by means of the formula:

$$\left(\frac{dV}{dt} \right)_{\min} = \frac{(dG/dt)_{\max}}{k \times \text{LEL}} \times \frac{T}{293}$$

where

$dV/dt_{\min}$ is the minimum volumetric flow rate of fresh air required to dilute the gas (m^3/s);

$dG/dt_{\max}$ is the maximum gas release rate (kg/s);

LEL is 4 %_{vol} for hydrogen (kg/m^3);

k is the factor applied to the LEL; $k = 0,25$ is chosen for dilution of hydrogen gas;

T is the ambient temperature in K (293 Kelvin = 20 °C).

The volume V_z represents the volume over which the mean concentration of flammable gas will be 0,25 times the LEL. This means that at the extremities of the hypothetical volume, the concentration of gas will be significantly below the LEL (for example, the hypothetical volume where the concentration is above LEL would be less than V_z).

M.8.2.3 Correction factors

With a given number of air changes per unit time, c , related to the general ventilation the hypothetical volume V_z of potentially **explosive** atmosphere around the source of release can be estimated as follows:

$$V_z = \left(\frac{dV}{dt} \right)_{\min} / c$$

where c is the number of fresh air changes per unit time (s^{-1}).

The above formula holds for an instantaneous and homogenous mixing at the source of release given ideal flow conditions of fresh air. In practice, ideal conditions rarely exist. Therefore a correction factor f is introduced to denote the effectiveness of the ventilation.

$$V_z = f \times \left(\frac{dV}{dt} \right)_{\min} / c$$

where f is the ventilation effectiveness factor, denoting the efficiency of the ventilation in terms of its effectiveness in diluting the **explosive** atmosphere, f ranging from 1 (ideal) to typically 5 (impeded air flow). For battery installations the ventilation effectiveness factor is $f = 1,25$.

M.8.2.4 Calculation of distance d

The term $\left(\frac{dV}{dt}\right)_{\min}$

including all factors corresponds with the hourly ventilation air flow Q (in m³/h) for secondary batteries calculated under

$$Q = f \times \left(\frac{dV}{dt}\right)$$

$$Q = 0,05 \times (N)^* \times I_{\text{gas}} \times C_{\text{rt}} \times 10^{-3} [\text{m}^3/\text{h}]$$

This hourly ventilation air flow Q can be used to define a hypothetical volume. Assuming a hemispherical dispersal of gas, a volume of a hemisphere $V_z = 2/3 \pi d^3$ can be defined, where d is the distance from the source of release.

This results in the calculation formula for the distance d , with $\epsilon = 1$ air change per hour within the hemisphere:

$$d^3 = \frac{3}{2\pi} \times 0,05 \times 10^6 \times (N) \times I_{\text{gas}} \times C_{\text{rt}} [\text{mm}^3]^*$$

$$d = 26,8 \times \left(\frac{1}{N}\right)^* \times \sqrt[3]{I_{\text{gas}}} \times \sqrt[3]{C_{\text{rt}}} [\text{mm}]^*$$

* Depending on the source of gas release, the number of cells per monobloc battery (N) or vent openings per cell involved ($1/N$) shall be taken into consideration (for example, by the factor $\sqrt[3]{N}$, respectively $\sqrt[3]{1/N}$).

Distance d as a function of the rated capacity for various charge currents I (mA/Ah) is shown in Figure M.1.

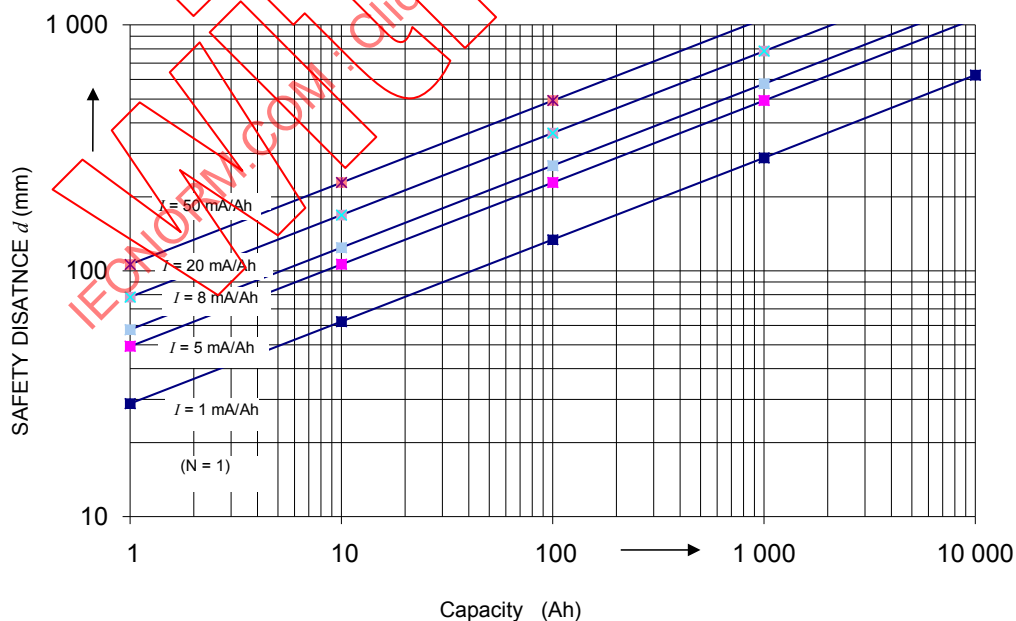


Figure M.1 – Distance d as a function of the rated capacity for various charge currents I (mA/Ah)

M.9 Preventing electrolyte spillage

M.9.1 Protection from electrolyte spillage

Equipment shall be constructed so that spillage of electrolyte from batteries, that may have an adverse effect on skin, eye and other human body parts, other **safeguards** or the premises, is unlikely. All possible operating modes during maintenance should be taken into account, including replacement of the battery or a fuel cartridge and refilling of consumed material or fuel.

Compliance is checked by inspection.

M.9.2 Tray for preventing electrolyte spillage

If cell failure could result in the spillage of electrolyte, the spillage shall be contained (for example, by use of a retaining tray adequate to contain the electrolyte) taking into account the maximum possible spillage amount.

This requirement is applicable to **stationary equipment** and does not apply if the construction of the battery is such that leakage of the electrolyte from the battery is unlikely, or if spillage of electrolyte does not adversely affect required insulation.

NOTE An example of a battery construction where leakage of the electrolyte is considered to be unlikely is the sealed cell valve-regulated type.

Compliance is checked by inspection.

M.10 Instructions to prevent reasonably foreseeable misuse

A battery incorporated in the equipment and a battery together with its associated components (including battery cells, fuel containers and electric power generators) shall be so constructed that an electric shock or fire **safeguard** failure (for example, flammable chemical leakage causing fire or insulation damage) is unlikely, taking all foreseeable conditions into account. If applicable, this shall include extreme conditions as specified by the manufacturer, such as:

- high or low extreme temperatures that a battery can be subjected to during use, storage or transportation; and
- low air pressure at high altitude.

Where providing safety devices or design in a battery or equipment is not reasonably practical considering the functional nature of the battery or equipment containing a battery, instructions according to Clause F.4 shall be provided to protect the battery from extreme conditions or user's abuse. Examples that shall be considered include:

- replacement of a battery with an incorrect type that can defeat a **safeguard** (for example, in the case of some lithium battery types);
- disposal of a battery into fire or a hot oven, or mechanically crushing or cutting of a battery, that can result in an **explosion**;
- leaving a battery in an extremely high temperature surrounding environment that can result in an **explosion** or the leakage of flammable liquid or gas;
- a battery subjected to extremely low air pressure that may result in an **explosion** or the leakage of flammable liquid or gas.

*Compliance is checked by inspection, by evaluation of available data provided by the manufacturer, and, if required, by **abnormal operating condition** tests according to Clause B.3.6 considering all possible installation, transportation and use conditions.*

Annex N (normative)

Electrochemical potentials

Table N.1 – Electrochemical potentials (V)

Magnesium, magnesium alloys	Zinc, zinc alloys	80 tin/20 zinc on steel, zinc on iron or steel I	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	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
	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
		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
			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
				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
					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
						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
							0	0,05	0,1	0,15	0,25	0,35	0,4	0,45	0,6	0,65	0,7	0,75
								0	0,05	0,1	0,2	0,3	0,35	0,4	0,55	0,6	0,66	0,7
									0	0,05	0,15	0,25	0,3	0,35	0,5	0,55	0,6	0,65
										0	0,1	0,2	0,25	0,3	0,45	0,5	0,55	0,6
											0	0,1	0,15	0,2	0,35	0,4	0,45	0,5
												0	0,05	0,1	0,25	0,3	0,35	0,4
													0	0,05	0,2	0,25	0,3	0,35
														0	0,15	0,2	0,25	0,3
															0	0,05	0,1	0,15
																0	0,05	0,1
																	0	0,05
																		0

Cr = Chromium
Ni = Nickel

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.

Annex O (normative)

Measurement of creepage distances and clearances

In the following figures, the value of X is given in Table O.1. Where the distance shown is less than X , the depth of the gap or groove is disregarded when measuring a **creepage distance**.

If the required minimum **clearance** is more than 3 mm, the value of X is given in Table O.1.

If the required minimum **clearance** is less than 3 mm, the value of X is the smaller of:

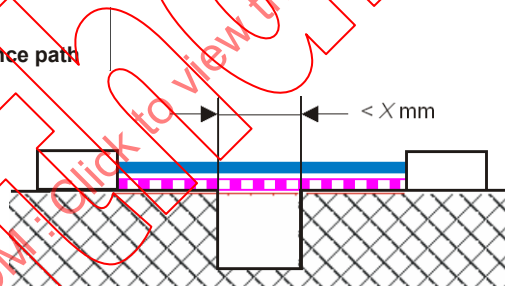
- the relevant value in Table O.1; or
- one third of the required minimum **clearance**.

Table O.1 – Value of X

Pollution degree (see 5.4.1.6)	X mm
1	0,25
2	1,00
3	1,50

NOTE Throughout this annex, the following convention is used:

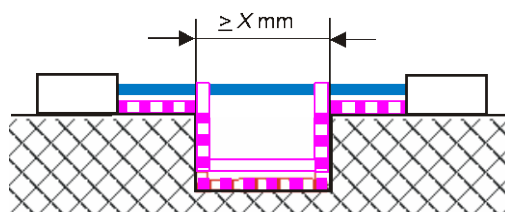
 **clearance**
 **creepage distance path**



Condition: Path under consideration includes a parallel or converging-sided groove of any depth with width less than X mm.

Rule: **Creepage distance** and **clearance** are measured directly across the groove.

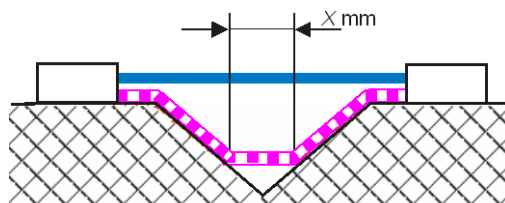
Figure O.1 – Narrow groove



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.

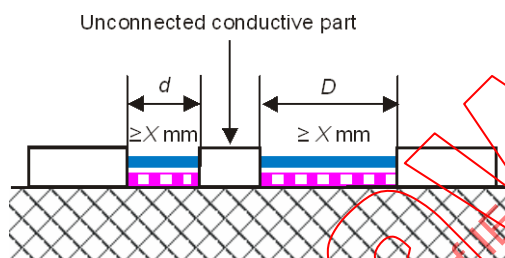
Figure O.2 – Wide groove



Condition: Path under consideration includes a V-shaped groove with an internal angle of less than 80° and a width greater than X mm.

Rule: **Clearance** is the "line of sight" distance. **Creepage distance** path follows the contour of the groove but "short-circuits" the bottom of the groove by X mm link.

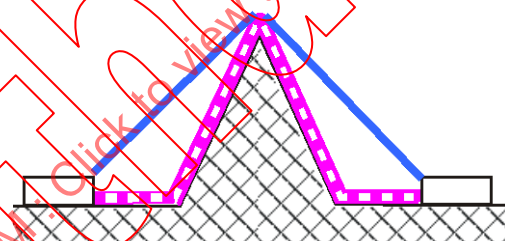
Figure O.3 – V-shaped groove



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 mm it shall be considered as zero.

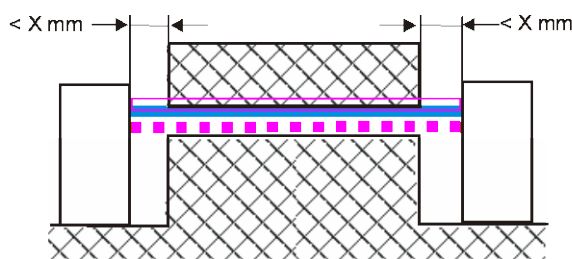
Figure O.4 – Intervening unconnected conductive part



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.

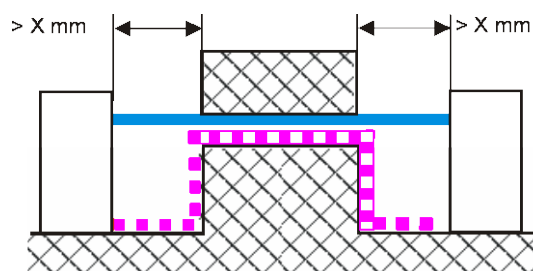
Figure O.5 – Rib



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.

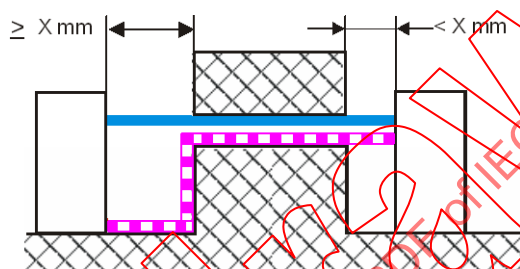
Figure O.6 – Uncemented joint with narrow groove



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.

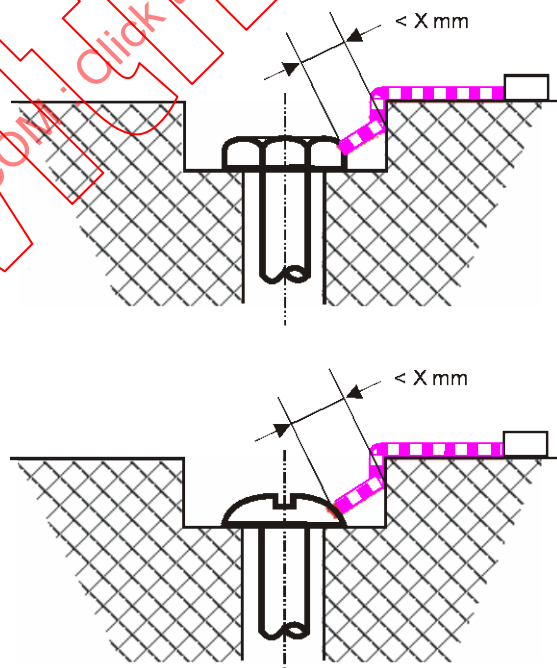
Figure O.7 – Uncemented joint with wide groove



Condition: Path under consideration includes an uncemented joint with grooves 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.

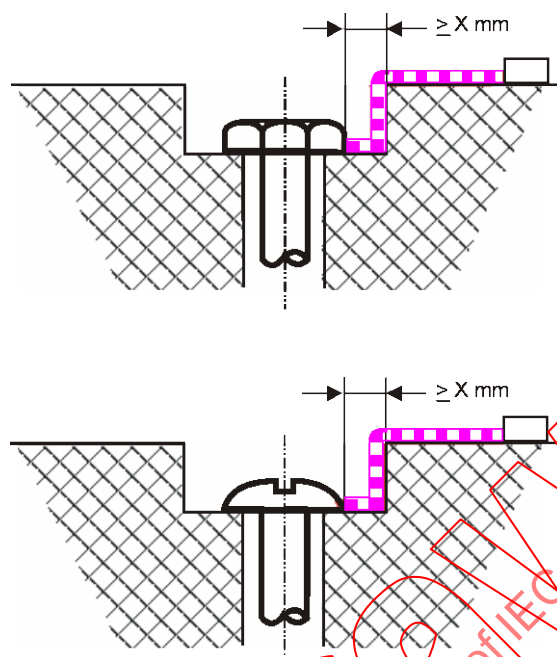
Figure O.8 – Uncemented joint with narrow and wide grooves



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 when the distance is equal to X mm.

Figure O.9 – Narrow recess



Gap between head of screw and wall of recess wide enough to be taken into account.

Figure Q.10 – Wide recess

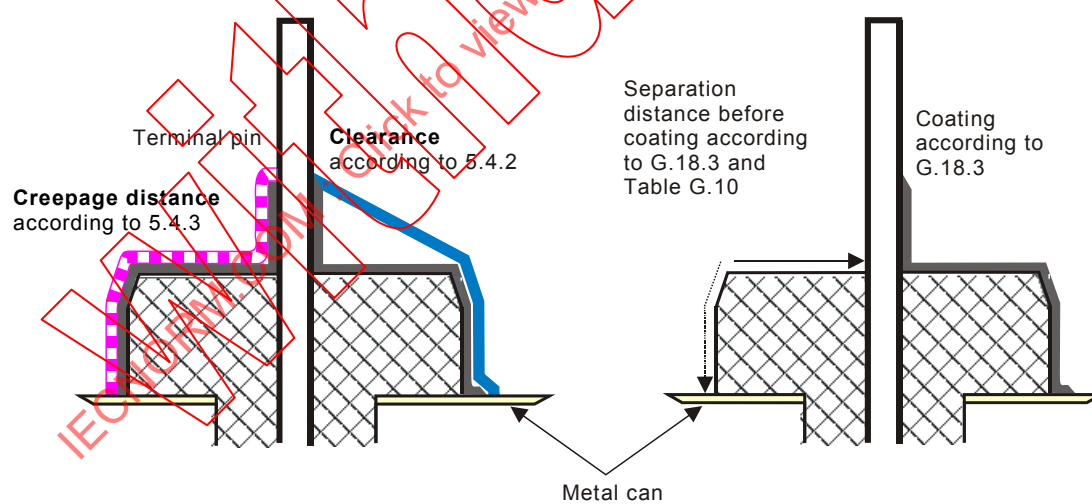


Figure O.11 – Coating around terminals

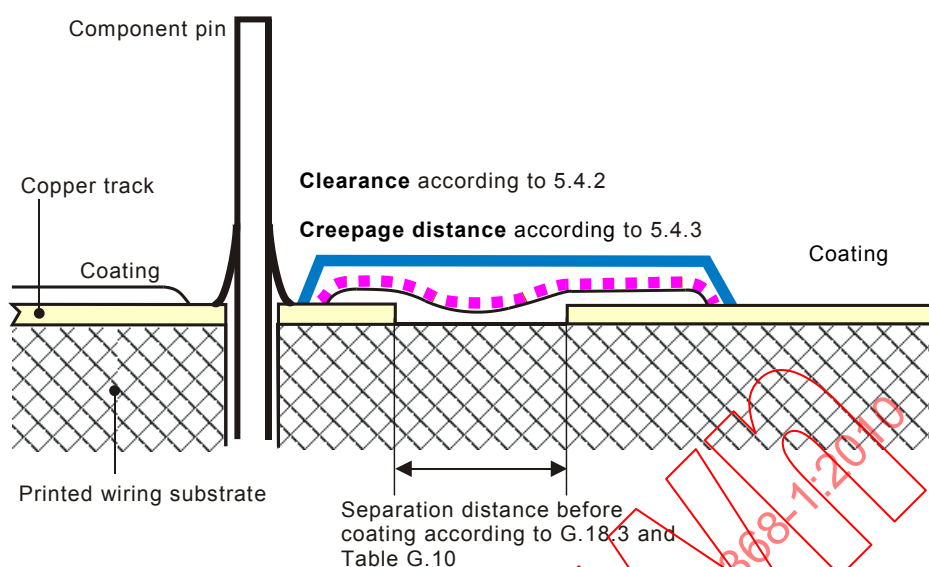
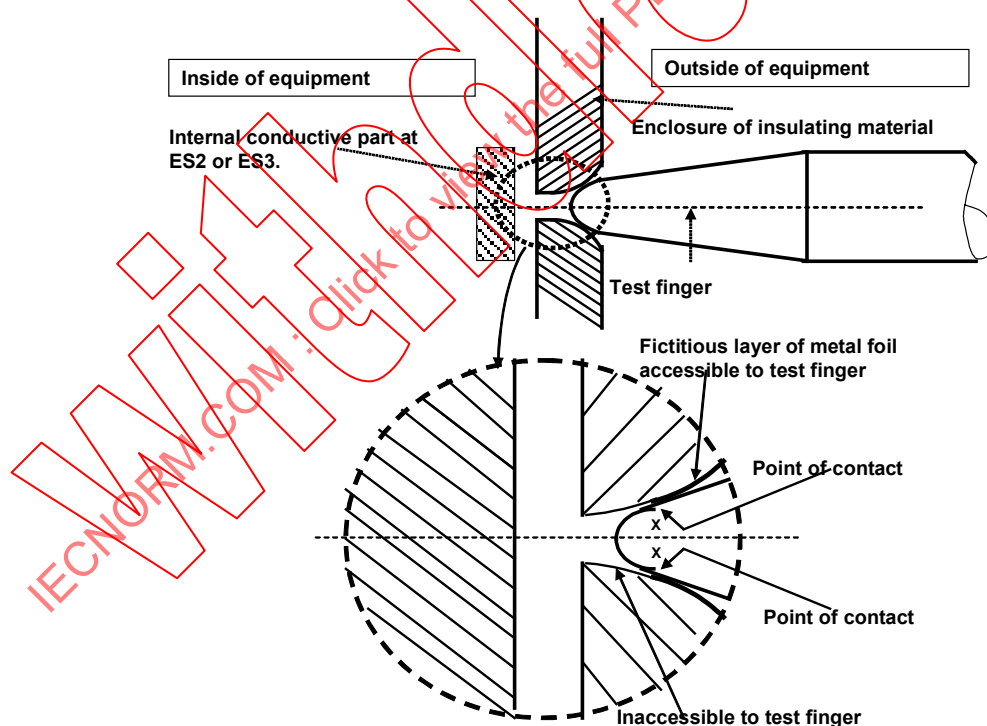


Figure O.12 – Coating over printed wiring



Point X is used for measurements of clearances and creepage distances from the outer surface of an enclosure of insulating material to an internal conductive part at ES2 or ES3.

Figure O.13 – Example of measurements in an enclosure of insulating material

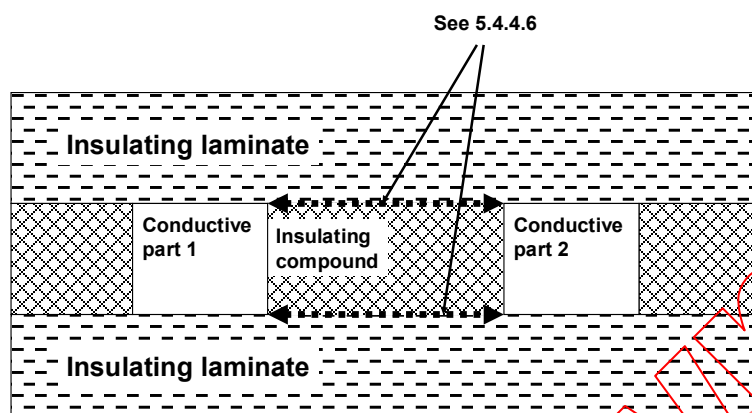


Figure O.14 – Cemented joints in multi-layer printed boards

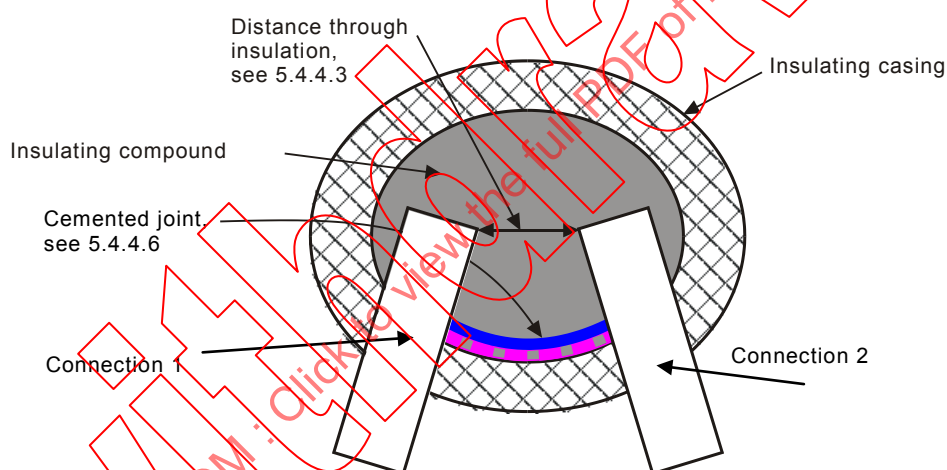


Figure O.15 – Device filled with insulating compound

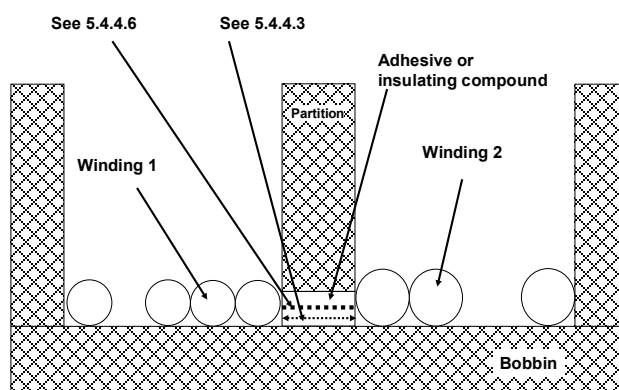
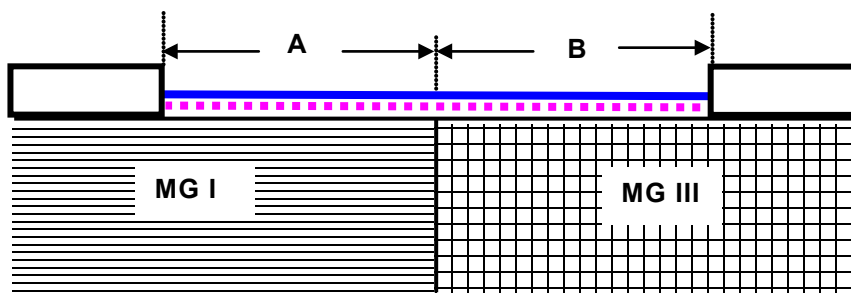


Figure O.16 – Partitioned bobbin

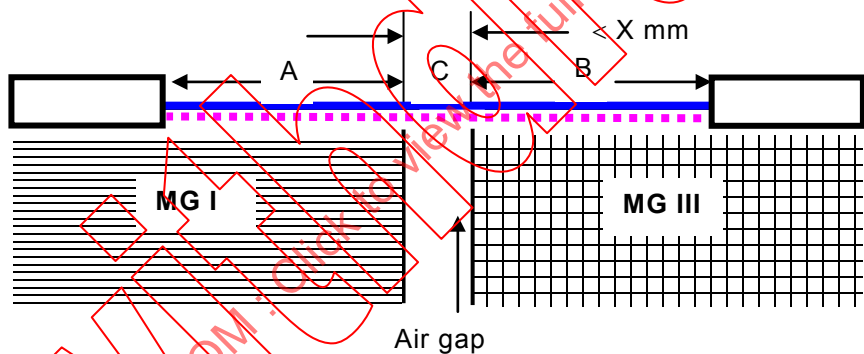


Condition: Path under consideration is along two materials having different CTI values.

Rule: **Creepage distance** is calculated as follows:

$$\frac{A}{\text{Required creepage for MG I}} + \frac{B}{\text{Required creepage for MG III}} \geq 1$$

Figure O.17 – Materials with different CTI values

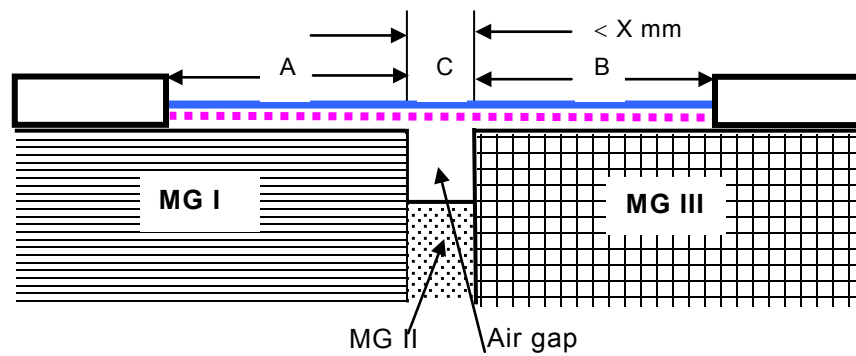


Condition: Path under consideration includes a parallel or converging-sided air gap having a width of less than X mm and two different materials on each side.

Rule: **Creepage distance** is calculated as follows:

$$\frac{A}{\text{Required creepage for MG I}} + \frac{B + C}{\text{Required creepage for MG III}} \geq 1$$

Figure O.18 – Materials with different CTI values having an air gap of less than X mm

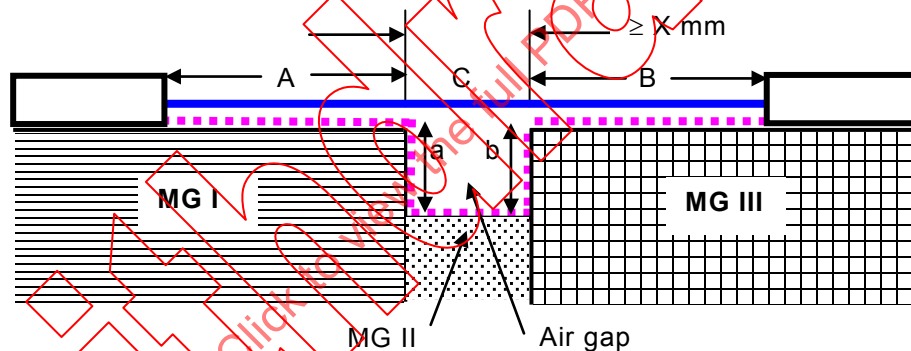


Condition: Path under consideration includes a parallel or converging-sided groove having a width of less than X mm and two different materials on each side and a different material below the groove.

Rule: **Creepage distance** is calculated as follows:

$$\frac{A}{\text{Required creepage for MG I}} + \frac{B + C}{\text{Required creepage for MG III}} \geq 1$$

Figure O.19 – Materials with different CTI values having an air groove of less than X mm



Condition: Path under consideration includes a parallel or converging-sided groove having a width greater than or equal to X mm and two different materials on each side and a different material below the groove.

Rule: **Creepage distance** is calculated as follows:

$$\frac{A + a}{\text{Required creepage for MG I}} + \frac{C}{\text{Required creepage for MG II}} + \frac{B + b}{\text{Required creepage for MG III}} \geq 1$$

Figure O.20 – Materials with different CTI values having an air groove not smaller than X mm

Annex P (normative)

Safeguards against entry of foreign objects, foreign liquids, and spillage of internal liquids

P.1 General

This clause specifies **safeguards** to reduce the likelihood of fire, electric shock, chemical reaction, and burn due to the entry of foreign metallic objects or foreign liquids through openings in the equipment, or due to spillage of internal liquids.

Under **normal operating conditions** and **abnormal operating conditions**, persons are not expected to insert foreign metallic objects into the equipment.

Such preventive actions comprise a **basic safeguard** (behavioural **safeguard**). If entry of a foreign metallic object could result in a **single fault condition**, then an equipment **supplementary safeguard** against the consequences of entry of a foreign metallic object is required.

For equipment intended, according to the manufacturer's instructions, to be used in more than one orientation, the **safeguards** shall be effective for each such orientation.

The requirements in Clause P.2 only apply to bare conductive parts. Conductive parts covered with conformal or other similar coatings are not considered to be bare conductive parts.

P.2 Safeguards against entry of solid foreign objects

P.2.1 Top and side openings

This subclause does not apply to **transportable equipment** provided with energy storage devices, such as batteries (see P.2.2.1).

Except for Figure P.3, this subclause also applies to **transportable equipment** with **accessible** parts and circuits that are connected to protective bonding in accordance with 5.6.6.4.2 in all orientations.

NOTE For **transportable equipment** where such parts and circuits are not connected to protective bonding in accordance with 5.6.6.4.2, see P.2.2.2.

Openings in the top and sides of outer **enclosures** shall be so located or constructed to reduce the likelihood that foreign metallic objects will enter the openings.

This requirement does not apply to openings located behind doors, panels, covers, etc., that can be opened or removed by a person, provided that the equipment openings comply with this requirement when the doors, panels and covers, etc., are closed or in place.

Supplementary safeguards that reduce the likelihood of entry of foreign conductive objects include the following:

- openings that do not exceed 5 mm in any dimension or the equipment has a rating of IP3X or better;

- openings that do not exceed 1 mm in width regardless of length or the equipment has a rating of IP4X or better;
- top openings in which vertical entry is prevented (see Figure P.1 for examples);
- side openings provided with louvers that are shaped to deflect outwards an external vertically falling object (see Figure P.2 for examples);
- side openings without louvers where the **enclosure** thickness at the opening is not less than the vertical dimension of the opening;
- top or side openings, as shown in Figure P.3, 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 ES3 or PS3;
- internal barriers.

NOTE The examples of Figure P.1, Figure P.2 and Figure P.3 are not intended to be used as engineering drawings but are only shown to illustrate the intent of these requirements.



Figure P.1 – Examples of cross-sections of designs of openings preventing vertical access

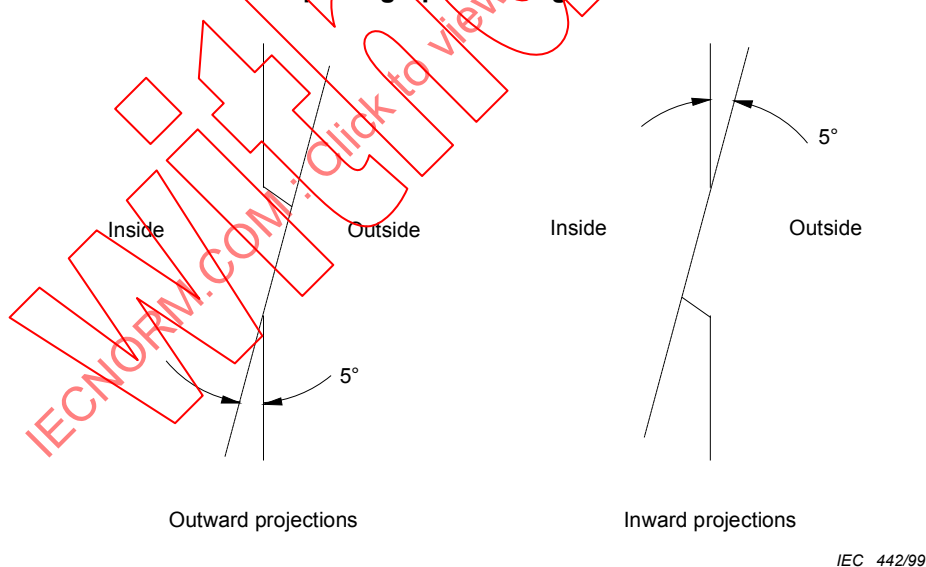
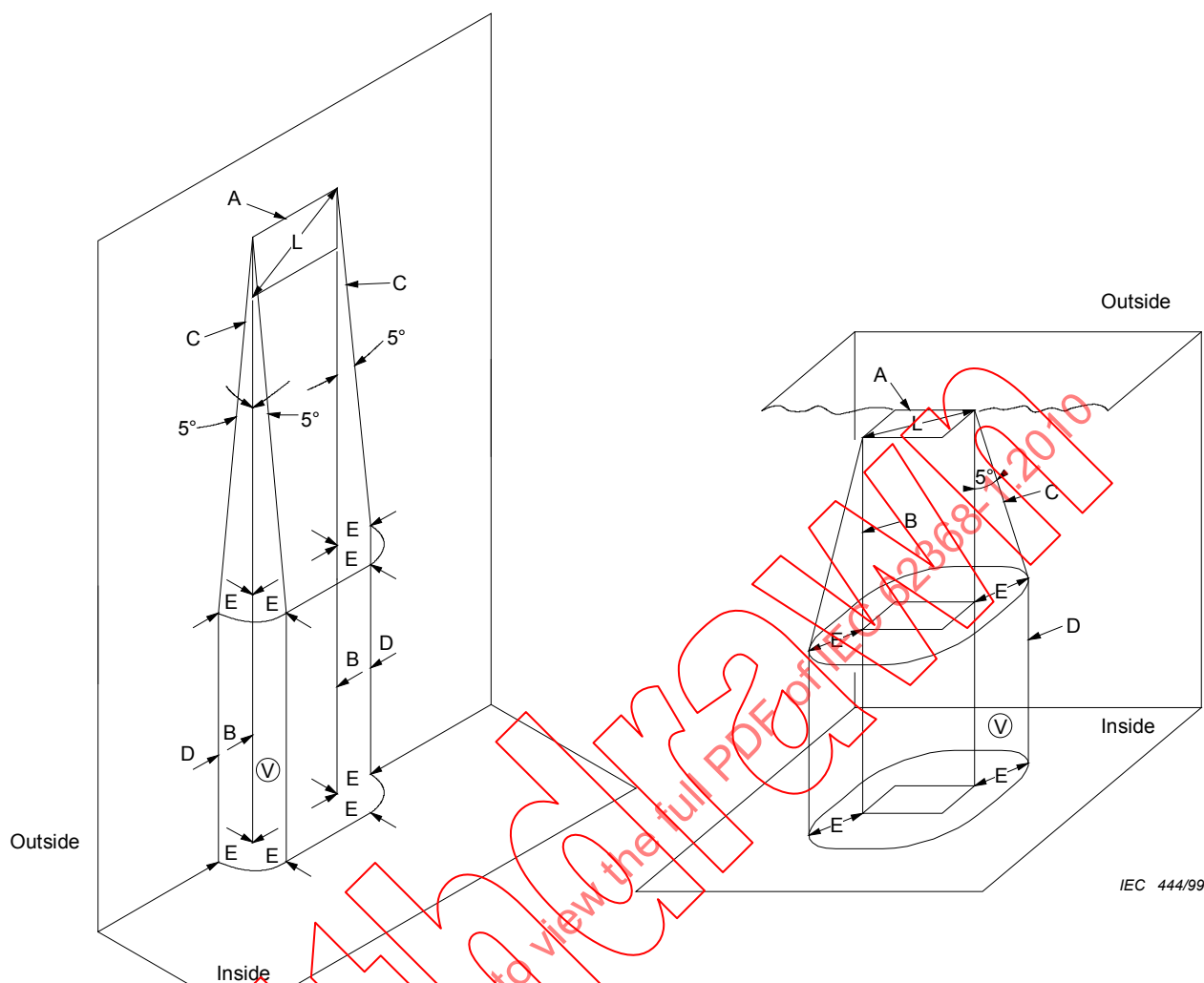


Figure P.2 – Examples of louver design



IEC 443/99

Key

- 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 ES3 or PS3 air insulation (**clearance**) **safeguards** are not located.

Figure P.3 – Enclosure openings

Compliance is checked by inspection, measurement and where necessary by simulated fault testing.

*If the openings are larger than specified above, then all bare conductive parts of ES3 or PS3 within the inclusive periphery of E, Figure P.3, shall be shorted to simulate a fault by bridging along a direct straight path to all other bare conductive parts within a 13 mm radius. Bridging is simulated by means of a straight metal object, 1 mm in diameter and having any length up to 13 mm, applied without appreciable force. During the tests, the **single fault conditions** of B.4.8 shall be met.*

P.2.2 Transportable equipment

P.2.2.1 Openings in transportable equipment provided with energy storage devices, such as batteries

This subclause specifies how to reduce the likelihood of small foreign metallic objects entering **transportable equipment** provided with energy storage devices, such as batteries, and bridging PS2 and PS3 parts. With all doors or covers closed or in place and peripheral devices or assemblies, such as disk drives, batteries, etc., installed as intended, openings in the outer **enclosures** shall be so located or constructed to reduce the likelihood of foreign metallic objects entering the equipment during transportation.

Supplementary safeguards that reduce the likelihood of entry of foreign metallic objects include the following:

- openings that do not exceed 1 mm in width regardless of length; or
- a metal 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
- internal barriers.

Compliance is checked by inspection and measurement.

P.2.2.2 Transportable equipment without batteries and having accessible floating conductive parts

This subclause specifies how to reduce the likelihood of small foreign metallic objects entering **transportable equipment** and bridging ES3 to ES1 or ES3 to ES2.

Transportable equipment without batteries and having **accessible** parts that do not comply with the requirements for protective bonding in accordance with 5.6.6.4.2 shall:

- comply with P.2.1, or
- have a minimum distance of 13 mm from ES3 to any parts that do not comply with the requirements for protective bonding in accordance with 5.6.6.4.2.

Compliance is checked by inspection and measurement.

P.2.2.3 Openings in transportable equipment in relation to metallized plastic parts of a barrier or enclosure

This subclause specifies how to reduce the likelihood of small foreign metallic objects entering **transportable equipment** and bridging PS2 or PS3 parts to metallized plastic parts, such as barriers and **enclosures**.

Openings in **transportable equipment** shall be so located or constructed to reduce the likelihood of foreign metallic objects entering the equipment and shorting a PS2 or PS3 to a metallized plastic part.

Supplementary safeguards that reduce the likelihood of entry of a conductive foreign metallic object and shorting to a metallized plastic part include the following:

- openings that are in accordance with P.2.2.1, as applicable; or
- a non-metallized barrier provided between the bare conductive parts of PS2 or PS3 within 13 mm of the metallized plastic parts of the barrier or **enclosure**.

Alternatively, ES3, PS2 or PS3 shall be shorted along a direct straight path to all metallized plastic parts within a 13 mm radius of the ES3, PS2, or PS3 conductive parts.

NOTE Examples of metallized barriers or metallized **enclosures** include those made of conductive composite materials or materials that are electroplated, vacuum-deposited, foil lined or painted with metallic paint.

Compliance is checked in accordance with P.2.1, P.2.2.1, or P.2.2.2, as applicable.

P.3 Safeguards against spillage of internal liquids

P.3.1 General

This subclause does not apply to liquids that are non-conductive, non-flammable, non-toxic, and non-corrosive, and are not in a pressurized container. This subclause does not apply to

- electrolytic capacitors;
- liquids with viscosity of 1 000 centipoise or more;
- batteries (see Annex M).

NOTE Viscosity of 1 000 centipoise is approximately equivalent to 60 weight motor oil.

P.3.2 Determination of spillage consequences

If the equipment is not **transportable equipment**, the equipment shall be energized, and the liquid shall be allowed to leak from piping connectors and similar joints in the liquid system.

If the equipment is **transportable equipment**, then, following introduction of the leak, the equipment shall be moved to all possible positions and then energized.

If the spillage results in a **single fault condition** not covered by Clause B.4, then:

- the containment vessel shall be considered a **basic safeguard**, and the means for limiting the spread of the spillage (for example, by a barrier or drip pan or supplementary containment vessel, etc.) shall be considered a **supplementary safeguard**; or
- the liquid shall be contained in a vessel comprising a **reinforced safeguard**; or
- the containment vessel **safeguard** shall comprise a **double safeguard** or a **reinforced safeguard**.

If the liquid is conductive, flammable, toxic, or corrosive, then, following the spillage, the liquid shall not be **accessible to ordinary persons or instructed persons**.

Annex Q (normative)

Interconnection with building wiring

Q.1 Limited power source

A limited power source shall comply with one of the following:

- the output is inherently limited in compliance with Table Q.1; or
- linear or non-linear impedance limits the output in compliance with Table Q.1. If a PTC device is used, it shall:
 - pass the tests specified in Clauses 15, 17, J.15 and J.17 of IEC 60730-1:1999; or
 - meet the requirements of IEC 60730-1 for a device providing Type 2 AL action;
- a regulating network limits the output in compliance with Table Q.1, both with and without a simulated single fault (see Clause B.4), in the regulating network (open circuit or short circuit); or
- an overcurrent protective device is used and the output is limited in compliance with Table Q.2; or
- an IC current limiter complying with Clause G.13 that limits the output current in accordance with Table Q.1.

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

Q.2 Compliance and test method

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 Table Q.1 and Table Q.2.

The non-capacitive load referenced in footnotes b) and c) of Table Q.1 and Table Q.2 is adjusted to develop maximum current and power transfer respectively. Single faults in a regulating network according to the third dash in Clause Q.1 are applied under these maximum current and power conditions.

Table Q.1 – Limits for inherently limited power sources

Output voltage ^a U_{oc}		Output current ^{b d} I_{sc}	Apparent power ^{c d} S
V a.c.	V d.c.	A	VA
$U_{oc} \leq 30$	$U_{oc} \leq 30$	$\leq 8,0$	≤ 100
–	$30 < U_{oc} \leq 60$	$\leq 150/U_{oc}$	≤ 100
^a U_{oc} : Output voltage measured in accordance with B.2.3 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 or a PTC device, and 60 s in other cases.			

**Table Q.2 – Limits for power sources not inherently limited
(overcurrent protective device required)**

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	≤1 000/ U_{oc}	≤250	≤5,0
20 < U_{oc} ≤ 30	20 < U_{oc} ≤ 30			≤100/ U_{oc}
–	30 < U_{oc} ≤ 60			≤100/ U_{oc}

^a U_{oc} : Output voltage measured in accordance with B.2.3 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 in the equipment remain in the circuit during measurement, but overcurrent protective devices are bypassed.

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.

Q.3 Test for external circuits – paired conductor cable

Equipment supplying power to an **external circuit** paired conductor cable shall be 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
- 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 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 all load circuits disconnected.

Annex R (normative)

Limited short-circuit test

R.1 General

This annex documents the test procedure and compliance criteria for the limited short-circuit test specified in 5.6.6.4. This test demonstrates that the **protective bonding conductor** is suitable for the fault current permitted by the overcurrent protective device, and in doing so, tests the integrity of a **supplementary safeguard**.

If required by 5.6.6.4, the limited short-circuit test is conducted as given below.

R.2 Determination of the overcurrent protective device and circuit

The source used to conduct the limited short-circuit test shall be short-circuited at its output terminals and the current measured to ensure that it can supply at least 1 500 A. This can be an a.c. wall socket, generator, power supply or battery. A suitable overcurrent protective device shall be chosen if there is not one present in the source. This overcurrent protective device shall be such that it does not interrupt the fault current before half a cycle has passed.

If the equipment under test has no overcurrent protective device provided, then the overcurrent protective device in the building installation for d.c. sources, or that specified to be provided externally to the equipment for d.c. sources, is used for the test. The manufacturer shall then specify the device used to conduct the test in the equipment safety instructions. The rating of this overcurrent protective device shall not exceed 20 A.

If the overcurrent protective device is provided in the equipment, then this is used for the test. For a.c. sources where only one device is provided in the equipment and the plug is non-polarised, the protective device in the building installation is used for the test and the internal overcurrent protection device is by-passed. The manufacturer shall specify the device used for the test in the equipment safety instructions.

The source shall be applied to the equipment under test via the cable supplied or specified by the equipment manufacturer. Where there is no cable supplied or specified, a 1 m length of 2,5 mm² or 12 AWG shall be used. For d.c. sources, the cable shall be sized for the maximum rated input current of the equipment.

To conduct this test an earth fault shall be introduced. The point at which this is done is subject to the equipment concerned. There may also be more than one point at which this should be conducted to determine the worst case. To decide where this should be carried out examine the construction of the equipment concerned and determine the point nearest to the input of the source to the equipment, thereby establishing the lowest impedance point to the source. This is where the fault shall be applied.

R.3 Test method

*The **protective bonding conductor** is connected to a source capable of supplying an a.c. or d.c. current, as appropriate to the equipment under test, of 1 500 A under short-circuit conditions, and using a source voltage equal to the **rated voltage** or any voltage within the **rated voltage range** of the equipment. In cases where the prospective short-circuit current seen by the equipment is known, then the source used for test shall be able to supply that current under short-circuit conditions. The manufacturer shall state the prospective short-circuit current that has been used in the evaluation in the safety instructions. The*

overcurrent protective device protecting the circuit under consideration (in accordance with Clause R.2) is kept in series with the **protective bonding conductor**. The power supply cord, if provided or specified, is kept in when conducting the test.

The limited short-circuit test for **protective bonding conductors** in a potted or conformally coated assembly is conducted on a potted or coated sample.

The test is conducted two more times (for a total of three times, on a different sample unless the manufacturer agrees to conduct the test on the same sample). The test is continued until the overcurrent protective device operates.

R.4 Compliance

At the conclusion of the test, compliance is checked by inspection as follows.

There shall be

- no damage to the **protective bonding conductor**,
- no damage to any **basic insulation, supplementary insulation, or reinforced insulation**,
- no reduction of spacings,
- no delamination of the printed board.

Annex S

(normative)

Tests for resistance to heat and fire

NOTE Toxic fumes are given off during the tests. The tests should be carried out either under a ventilated hood or in a well-ventilated room, but free from draughts that could invalidate the tests.

S.1 Flammability test for fire enclosure and fire barrier materials of equipment where the steady-state power does not exceed 4 000 W

Fire enclosure and fire barrier materials are tested according to IEC 60695-11-5:2004.

The following additional requirements apply to the specified clauses of IEC 60695-11-5:2004.

Clause 6 – Test specimen

*For **fire enclosures** and fire barriers, each test specimen consists of either a complete **fire enclosure** or fire barrier or a section of the **fire enclosure** or fire barrier representing the thinnest significant wall thickness and including any ventilation opening.*

Clause 7 – Severities

The values of duration of application of the test flame are as follows:

- the test flame is applied for 10 s;*
- if flaming does not exceed 30 s, the test flame is immediately reapplied for 1 min at the same point;*
- if again flaming does not exceed 30 s, the test flame is immediately reapplied for 2 min at the same point.*

Clause 8 – Conditioning of test specimen

Prior to being tested, the samples are conditioned in a circulating air oven for a period of 7 days (168 h), at a temperature 10 K higher than the maximum temperature of the part measured during the test of 5.4.1.5 or 70 °C, whichever is the higher, and then cooled to room temperature.

For printed boards, a preconditioning of 24 h at a temperature of 125 °C ± 2 °C in an air circulating oven and a subsequent cooling period of 4 h at room temperature in a desiccator over anhydrous calcium chloride is to be applied.

Subclause 9.2 – Application of needle flame

The test flame is applied to an inside surface of the test specimen at a point 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 45° 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 test specimen.

The test is repeated on the remaining two test specimens. If any part being tested is near a source of ignition at more than one point, each test specimen is tested with the flame applied to a different point that is near a source of ignition.

Clause 11 – Evaluation of test results

The existing text is replaced by the following.

The test specimens shall comply with all of the following:

- *after every application of the test flame, the test specimen shall not be consumed completely; and*
- *after any application of the test flame, any self-sustaining flame shall extinguish within 30 s; and*
- *no burning of the specified layer or **wrapping tissue** shall occur.*

S.2 Flammability test for fire enclosure and fire barrier integrity

*Compliance of **fire enclosure** and fire barrier integrity is checked according to IEC 60695-11-5:2004.*

For the purpose of this standard, the following additional requirements apply to the stated clauses of IEC 60695-11-5:2004.

Clause 6 – Test specimen

*For **fire enclosures** and fire barriers, each test specimen consists of either a complete **fire enclosure** and fire barrier or a section of the **fire enclosure** and fire barrier representing the thinnest significant wall thickness and including any ventilation opening.*

Clause 7 – Severities

The value of duration of application of the test flame is as follows:

- *the test flame is applied for 60 s.*

Clause 8 – Conditioning of test specimen

Prior to being tested, the samples are conditioned in a circulating air oven for a period of 7 days (168 h), at a temperature 10 K higher than the maximum temperature of the part measured during the test of 5.4.1.5 or 70 °C, whichever is the higher, and then cooled to room temperature.

For printed boards, a preconditioning of 24 h at a temperature of 125 °C ± 2 °C in an air circulating oven and a subsequent cooling period of 4 h at room temperature in a desiccator over anhydrous calcium chloride is to be applied.

Subclause 9.2 – Application of needle flame

The test flame is applied to an inside surface of the test specimen at a point 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 45° 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 test specimen.

The test is repeated on the remaining two test specimens. If any part being tested is near a source of ignition at more than one point, each test specimen is tested with the flame applied to a different point that is near a source of ignition.

Clause 11 – Evaluation of test results

The existing text is replaced by the following.

The test specimens shall comply with the following:

After application of the test flame, the test specimen shall not show any additional holes.

S.3 Flammability tests for the bottom of a fire enclosure

S.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 **enclosure** surrounding the test area is recommended.

S.3.2 Compliance and test method

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 $0,845 \text{ g/ml}$ and $0,865 \text{ g/ml}$, a flash point between $43,5^\circ\text{C}$ and $93,5^\circ\text{C}$ and an average calorific value of 38 MJ/l . The ladle containing the oil is heated and the oil ignited and allowed 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**.*

*During these tests the **cheesecloth** shall not ignite.*

S.4 Flammability classification of materials

Materials are classified according to the burning behaviour and their ability to extinguish, if ignited. Tests are made with the material in the thinnest significant thickness used.

Table S.1 – Foamed materials

Material flammability class	ISO standard
HF-1 regarded better than HF-2	9772
HF-2 regarded better than HBF	9772
HBF	9772

Table S.2 – Rigid materials

Material flammability class	IEC standard
5VA regarded better than 5VB	60695-11-20
5VB regarded better than V-0	60695-11-20
V-0 regarded better than V-1	60695-11-10
V-1 regarded better than V-2	60695-11-10
V-2 regarded better than HB40	60695-11-10
HB40 regarded better than HB75	60695-11-10
HB75	60695-11-10

Table S.3 – Very thin materials

Material flammability class	ISO standard
VTM-0 regarded better than VTM-1	9773
VTM-1 regarded better than VTM-2	9773
VTM-2	9773

NOTE 1 When VTM materials are used, relevant electrical and mechanical requirements should also be considered.

Wood and wood-based material with a thickness of at least 6 mm is considered to fulfil the V-1 requirement. Wood-based material is material in which the main ingredient is machined natural wood, coupled with a binder.

NOTE 2 Examples of wood-based material are materials incorporating ground or chipped wood, such as hard fibre board or chip board.

S.5 Flammability test for fire enclosure materials of equipment with a steady-state power exceeding 4 000 W

Fire enclosure materials are tested according to IEC 60695-11-20:1999, using the plate procedure (see 8.3).

For the purpose of this standard, the following additional requirements apply to the specified IEC 60695-11-20:1999.

Clause 7 – Specimen, end product testing

For fire enclosures, each test specimen 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 (plate procedure).

Subclause 8.1 – Conditioning

Prior to being tested, the samples are conditioned in a circulating air oven for a period of 7 days (168 h), at a temperature 10 K higher than the maximum temperature of the part measured during the test of 5.4.1.5 or 70 °C, whichever is the higher, and then cooled to room temperature.

Subclause 8.3 – Procedure – plates

The test flame is applied to an inside surface of the test specimen at a point 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 flame is to be in contact with the test specimen.

The values of duration of application of the test flame are as follows:

- *the test flame is applied for 5 s and removed for 5 s;*
- *the test flame application and removal is repeated four more times at the same location (total of five flame applications).*

Subclause 8.4 – Classification

The existing text is replaced by the following.

The test specimens shall comply with all of the following:

- *after every application of the test flame, the test specimen shall not be consumed completely; and*
- *after the fifth application of the test flame, any flame shall extinguish within 1 min.*

NOTE No burning of the specified cotton indicator or **wrapping tissue** should occur.

Annex T (normative)

Mechanical strength tests

T.1 General

In general, this annex describes a number of tests that are invoked by different clauses. Compliance criteria are specified in the clause that invokes a particular test.

No tests are applied to handles, levers, knobs, the face of CRTs or to transparent or translucent covers of indicating or measuring devices, unless parts at ES3 are **accessible** when the handle, lever, knob or cover is removed.

T.2 Steady force test, 10 N

A steady force of $10\text{ N} \pm 1\text{ N}$ is applied to the component or part under consideration.

T.3 Steady force test, 30 N

*Where an **enclosure** or barrier is used as a **safeguard**, it is subjected to the tests of V.1.3.*

T.4 Steady force test, 100 N

*External **enclosures** of:*

- ***transportable equipment**; and*
- ***hand-held equipment**; and*
- ***direct plug-in equipment**;*

are subjected to a steady force of $100\text{ N} \pm 10\text{ N}$ over a circular plane surface 30 mm in diameter for a period of 5 s, applied in turn to the top, bottom and sides.

T.5 Steady force test, 250 N

*External **enclosures** of equipment, except those covered in Clause T.4, are subjected to a steady force of $250\text{ N} \pm 10\text{ N}$ over a circular plane surface 30 mm in diameter for a period of 5 s, applied in turn to the top, bottom and sides. However, this test is not applied to the bottom of equipment having a mass of more than 18 kg.*

T.6 Enclosure impact test

*External surfaces of **enclosures** whose failure would allow class 3 energy sources to be **accessible**, such as rotating or otherwise moving 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 sphere, approximately 50 mm in diameter and with a mass of $500\text{ g} \pm 25\text{ g}$, is used to perform the following tests:

- on horizontal surfaces, the sphere is to fall freely from rest through a vertical distance of 1 300 mm onto the sample (see Figure T.1);
- on vertical surfaces, the sphere is suspended by a cord and swung as a pendulum in order to apply a horizontal impact, dropping through a vertical distance of 1 300 mm onto the sample (see Figure T.1).

Alternatively horizontal impacts may be simulated on vertical or sloping surfaces by mounting the sample at 90° to its normal position and applying the vertical impact test instead of the pendulum test.

This test does not apply to **enclosures** of **direct plug-in equipment**, **transportable equipment** and **hand-held equipment**.

The test is not applied to the following:

- the bottom of an **enclosure**;
- the face of a CRT;
- the platen glass of equipment (for example, contrast filter panels in front of displays or on a copying machine);
- the surface of the **enclosure** of **stationary equipment**, including equipment for building-in, that is not **accessible** and protected after installation;
- **movable equipment** requiring lifting or handling by the **ordinary person** 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.

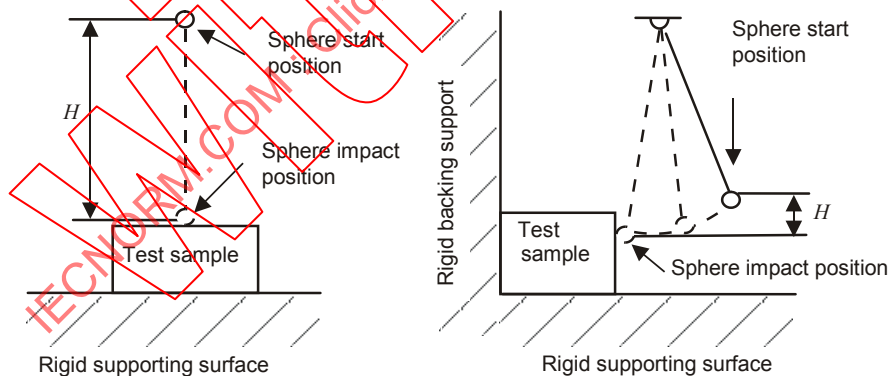


Figure T.1 – Impact test using sphere

T.7 Drop test

The following equipment is subjected to a drop test:

- **hand-held equipment**;
- **direct plug-in equipment**;
- **transportable equipment**;

- **movable equipment** requiring lifting or handling by an **ordinary person** 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.

- **desk-top equipment** having a mass of 7 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.

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 $\pm$ 10 mm for desk-top equipment and **moveable equipment** as described above;
- 1 000 mm $\pm$ 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 18 mm $\pm$ 2 mm thick, all supported on a concrete or equivalent non-resilient floor.

T.8 Stress relief test

Stress relief 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 at a temperature 10 K higher than the maximum temperature observed on the sample during the heating test of 5.4.1.5.2, but not less than 70 °C, for a period of 7 h, then cooled to room temperature.

For large equipment where it is impractical to condition a complete **enclosure**, a portion of the **enclosure** representative of the complete assembly with regard to thickness and shape, including any mechanical support members, may be used.

NOTE Relative humidity need not be maintained at a specific value during this test.

T.9 Glass breakage

T.9.1 General

In an area **accessible** to an **ordinary person** or **instructed person**, glass with a surface area exceeding 0,1 m² or with a major dimension exceeding 450 mm, shall not:

- be shattered in a manner likely to result in MS2 or MS3 skin-lacerating injury; or
- expose these persons to class 3 energy sources.

This requirement does not apply to platen glass.

Glass breakage is checked by the test of T.9.2.

If the glass breaks or cracks, an additional fragmentation test according to T.9.3 is made on a separate test sample. The fragmentation test does not apply to CRTs, tempered glass and laminated glass or any construction that keeps the particles together in the event of glass breakage.

NOTE Laminated glass includes constructions such as plastic film affixed to a single side of a glass.

T.9.2 Impact test and compliance

The test sample is supported over its whole area and shall be subjected to a single impact, specified in Table T.1.

The impact specified shall be caused by allowing a solid, smooth, steel ball of 50 mm in diameter and with the mass of approximately 500 g to fall freely from rest through a vertical distance, as shown in Figure T.1, and strike the glass with the specified impact in a direction perpendicular to the glass surface.

Table T.1 – Impact on glass part

Glass part	Result	Impact J ± 1 %
Glass on portable equipment, table-top equipment and on fixed mounted equipment	Skin-lacerations	2
Glass on floor standing equipment	Skin-lacerations	3,5
Any glass exceeding T.9.1 dimensions	Class 3 energy sources	7,0

To apply the required impact, the correct height is calculated by $h = E/(g \times m)$

where

h is the vertical distance in metres;

E is the impact energy in Joules;

g is the gravitational acceleration of 9,81 m/s²;

m is the mass of the steel ball in kilograms.

*After the test of Annex V, class 3 energy source parts shall not be **accessible**.*

T.9.3 Fragmentation test and compliance

The test sample is supported over its whole area and precautions shall be taken to ensure that particles will not be scattered upon fragmentation. Then the test sample is shattered with a centre punch placed approximately 15 mm in from the midpoint of one of the longer edges of the test sample. After a maximum of 5 min of fracture, and without using any aid to vision, except spectacles if normally worn, the particles are counted in a square of 50 mm side located approximately at the centre of the area of coarsest fracture and excluding any area within 15 mm of any edge or hole.

The test sample shall fragment in such a way that the number of particles counted in a square of 50 mm side shall not be less than 45.

NOTE A suitable method of counting the particles is to place a square of 50 mm side of transparent material over the test sample and mark a spot of ink as each particle within the square is counted. To count particles at the edges of the square, select any two adjacent sides of the square and count all the particles intersected by these, and exclude all other intersected particles.

T.10 Test for telescoping or rod antennas

The end piece of telescoping or rod antennas shall be subjected to a 20 N force along the major axis of the antenna for a period of 1 min. In addition, if the end piece is attached by screw threads, a loosening torque is to be applied to the end pieces of five additional samples. The torque is to be gradually applied with the rod fixed. When the specific torque is reached, it is to be maintained for no more than 15 s. The holding time for any one sample shall be not less than 5 s and the average holding time of the five samples shall be not less than 8 s.

The value of torque is given in Table T.2.

Table T.2 – Torque values for end-piece test

End-piece diameter mm	Torque Nm
<8,0	0,3
≥8,0	0,6

Annex U (normative)

Mechanical strength of CRTs and protection against the effects of implosion

U.1 General

This annex specifies mechanical strength of CRTs, how to protect against the effects of implosion and how a protective screen can withstand mechanical forces.

CRTs with a maximum face dimension exceeding 160 mm shall be either intrinsically protected with respect to effects of implosion and to mechanical impact, or the **enclosure** of the equipment shall provide adequate protection against the effects of an implosion of the CRT.

The face of a non-intrinsically protected CRT shall be provided with an effective screen that cannot be removed by hand. If a separate screen of glass is used, it shall not contact the surface of the CRT.

The CRT, other than the face of an intrinsically protected CRT, shall not be **accessible** to an **ordinary person**.

A protective film attached to the faceplate of the picture tube as part of the implosion protection system shall be covered on all edges by the **enclosure** of the equipment.

If the equipment is provided with a CRT with protective film attached to the faceplate as part of the safety implosion system, the following **instructional safeguard** or wording with a similar meaning in accordance with Clause F.5, shall be given in the instructions:

WARNING

The CRT in this equipment employs a protective film on the face.
This film shall not be removed as it serves a safety function and
removal will increase the risk of injury.

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

- *IEC 61965 for intrinsically protected CRTs, including those having integral protective screens;*
- *Clauses U.2 and U.3 for equipment having non-intrinsically protected CRTs;*
- *Annex V for application of probes for the **enclosure**.*

NOTE 1 A picture tube CRT is considered to be intrinsically protected with respect to the effects of implosion if, when it is correctly mounted, no additional protection is necessary.

NOTE 2 To facilitate the tests, the CRT manufacturer may indicate the most vulnerable area on the CRTs to be tested.

U.2 Compliance and test method for non-intrinsically protected CRTs

The equipment, with the CRT and the protective screen in position, is placed on a horizontal support at a height of (750 ± 50) mm above the floor, or directly on the floor if the equipment is obviously intended to be positioned on the floor.

*The CRT is imploded inside the **enclosure** of the equipment by the following method.*

Cracks are propagated in the envelope of each CRT. An area on the side or on the face of each CRT is scratched with a diamond stylus and this area is repeatedly cooled with liquid nitrogen or the like until a fracture occurs. To prevent the cooling liquid from flowing away from the test area, a dam of modelling clay or the like should be used.

NOTE Suitable scratch patterns are found in Figure 6 of IEC 61965:2003.

After this test, within 5 s of the initial fracture, no particle (a single piece of glass having a mass greater than 0,025 g) shall have passed a 250 mm high barrier, placed on the floor, 500 mm from the projection of the front of the equipment.

U.3 Protective screen

A protective screen shall be adequately secured and resistant to mechanical forces.

Compliance is checked by the tests of Clause T.3, without cracking of the protective screen or loosening of its mounting.

Annex V (normative)

Determination of accessible parts

V.1 Accessible parts of equipment

V.1.1 General

An **accessible** part of an equipment is a part that can be touched by a body part. For the purposes of determining an **accessible** part, a body part is represented by one or more of the specified probes.

Accessible parts of an equipment may include parts behind a door, panel, removable cover, etc. that can be opened without the use of a **tool**.

Accessible parts do not include those that become **accessible** when floor standing equipment having a mass exceeding 40 kg is tilted.

For equipment intended for building-in or rack-mounting, or for subassemblies and the like for incorporation in larger equipment, **accessible** parts do not include those that are not **accessible** when the equipment or subassembly is installed according to the method of mounting or installation specified in the installation instructions.

If a part is declared **accessible** by the manufacturer (for example, by means of instructions or markings) with or without the use of a **tool**, then the part is deemed **accessible** without test.

V.1.2 Test method 1 – Surfaces and openings tested with jointed test probes

For surfaces and openings, the following jointed test probe is applied, without appreciable force and in any possible position, to the surfaces and openings of the equipment:

- *the test probe of Figure V.1 for equipment that is likely to be **accessible** to children;*

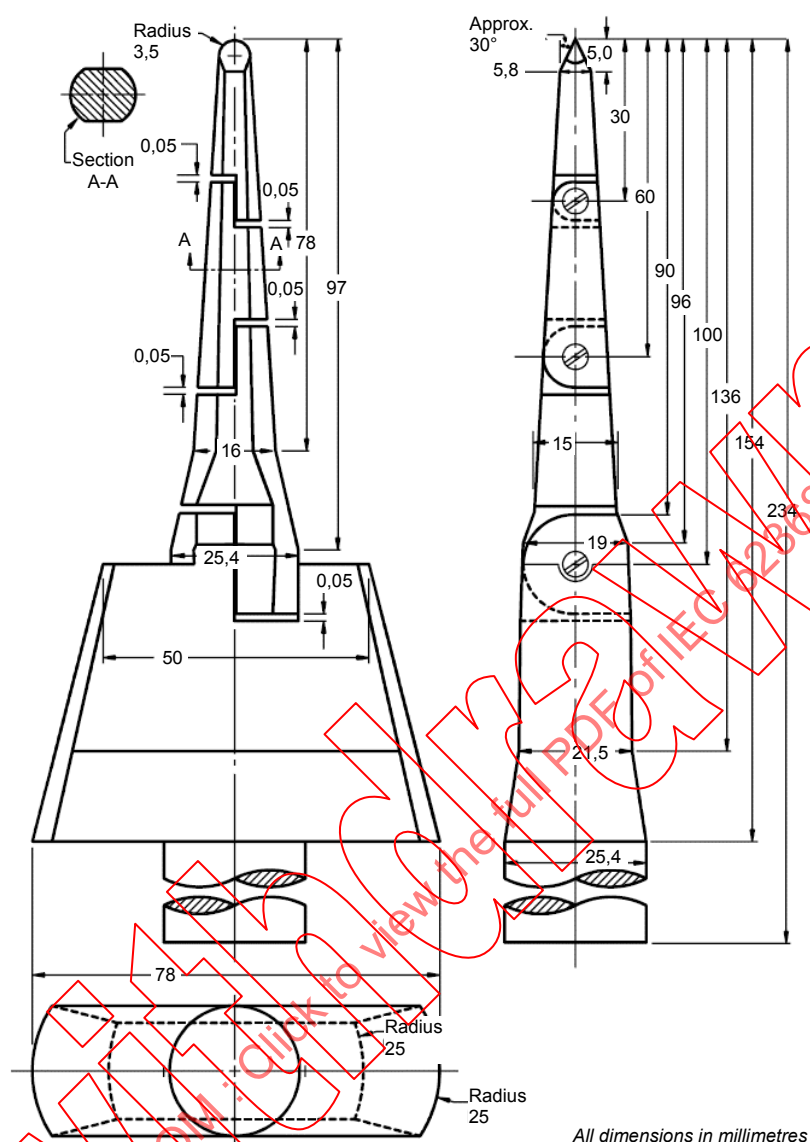
NOTE Equipment intended for use in homes, schools, public and similar locations is equipment generally considered to be **accessible** to children.

- *the test probe of Figure V.2 for equipment that is not likely to be **accessible** to children.*

*Where entry behind a door, panel, removable cover, etc. is possible without the use of a **tool**, or entry is directed by manufacturer instructions or marking, with or without the use of a **tool**, the test probe is applied to surfaces and openings in those areas.*

V.1.3 Test method 2 – Openings tested with straight unjointed test probes

Openings preventing access to a part by the jointed test probe are further tested by means of a straight unjointed version of the respective test probe applied with a force of 30 N. If the unjointed probe enters the openings, test method 1 is repeated, except that the appropriate jointed version of the test probe is pushed through the opening using any necessary force up to 30 N.



Linear dimensions in millimetres

Tolerances on dimensions without specific tolerances:

angles: $\pm 15'$

on radii: $\pm 0,1$ mm

Tolerances on linear dimensions without specific tolerances:

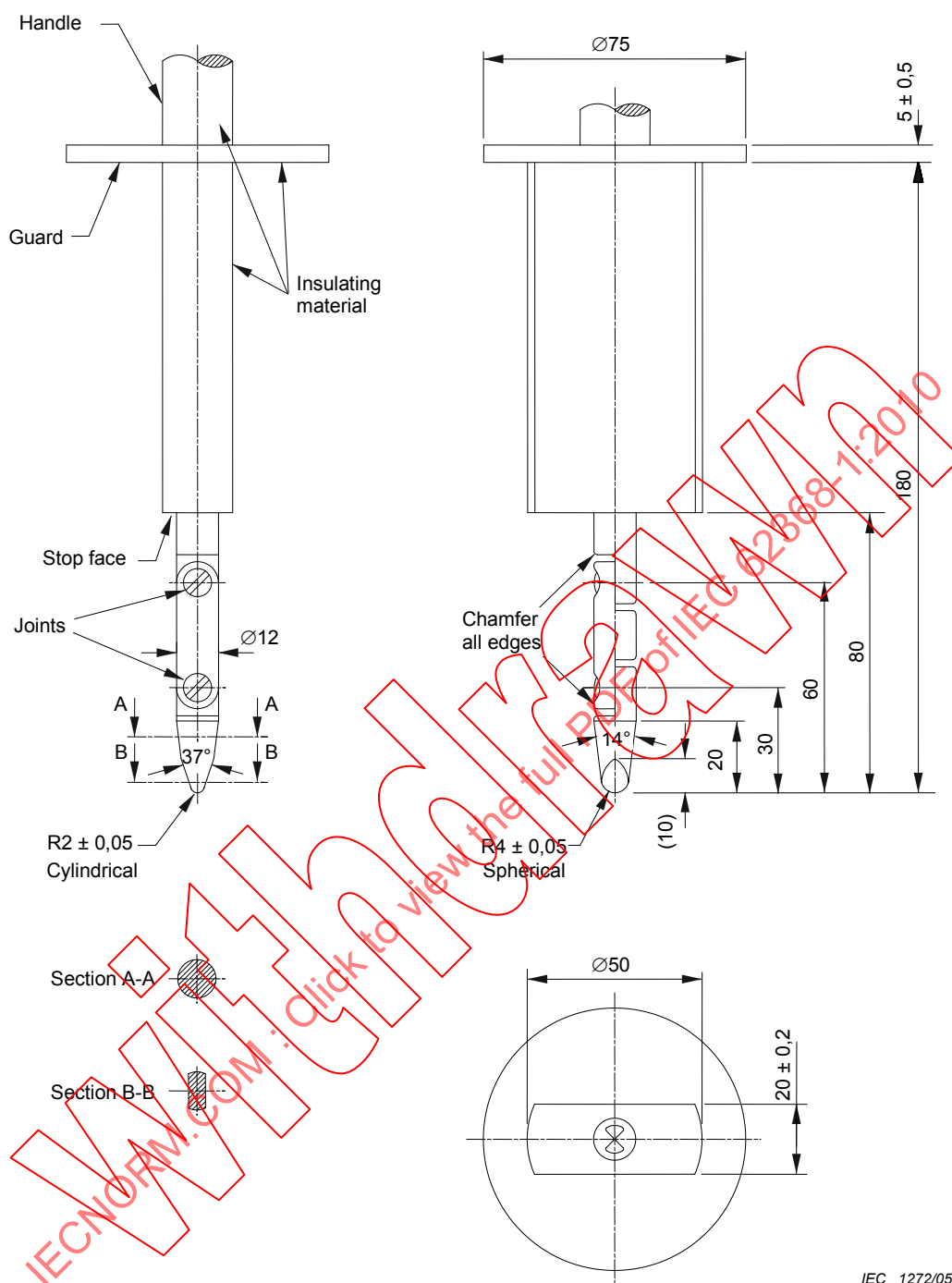
≤ 15 mm: $\begin{matrix} 0 \\ -0,1 \end{matrix}$ mm

> 15 mm ≤ 25 mm: $\pm 0,1$ mm

> 25 mm: $\pm 0,3$ mm

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

Figure V.1 – Jointed test probe for equipment likely to be accessible to children



IEC 1272/05

Tolerances on dimensions without specific tolerances:

- 14° and 37° angles: ±15'
- on radii: ±0,1 mm
- on linear dimensions:

≤15 mm: $\begin{matrix} 0 \\ -0,1 \end{matrix}$ mm

>15 mm ≤ 25 mm: ±0,1 mm

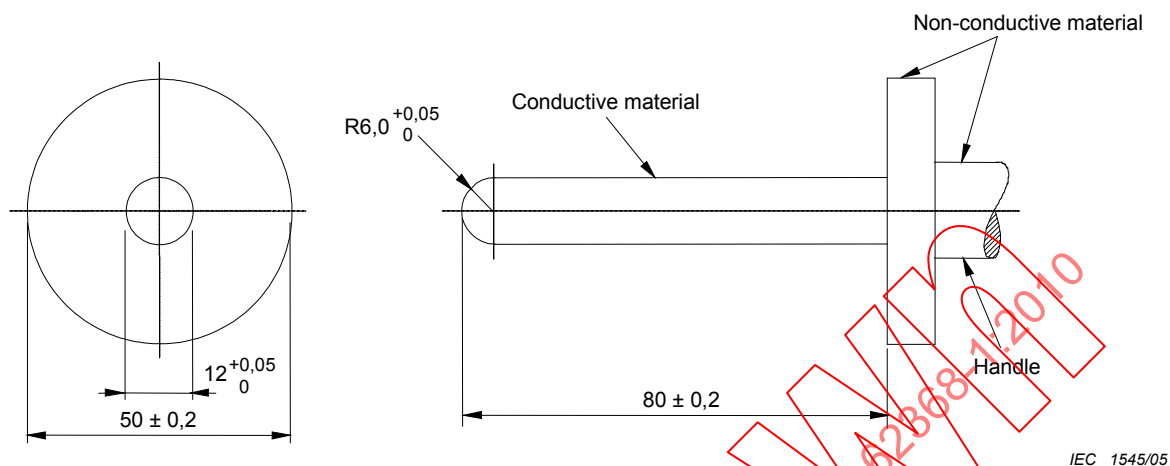
>25 mm: ±0,3 mm

NOTE This jointed test probe is taken from Figure 2, test probe B of IEC 61032:1997.

Figure V.2 – Jointed test probe for equipment not likely to be accessible to children

V.1.4 Test method 3 – Plugs, jacks, connectors

For a plug, jack, or connector, the blunt probe of Figure V.3 is applied without appreciable force and in any possible position to the plug, jack, or connector.



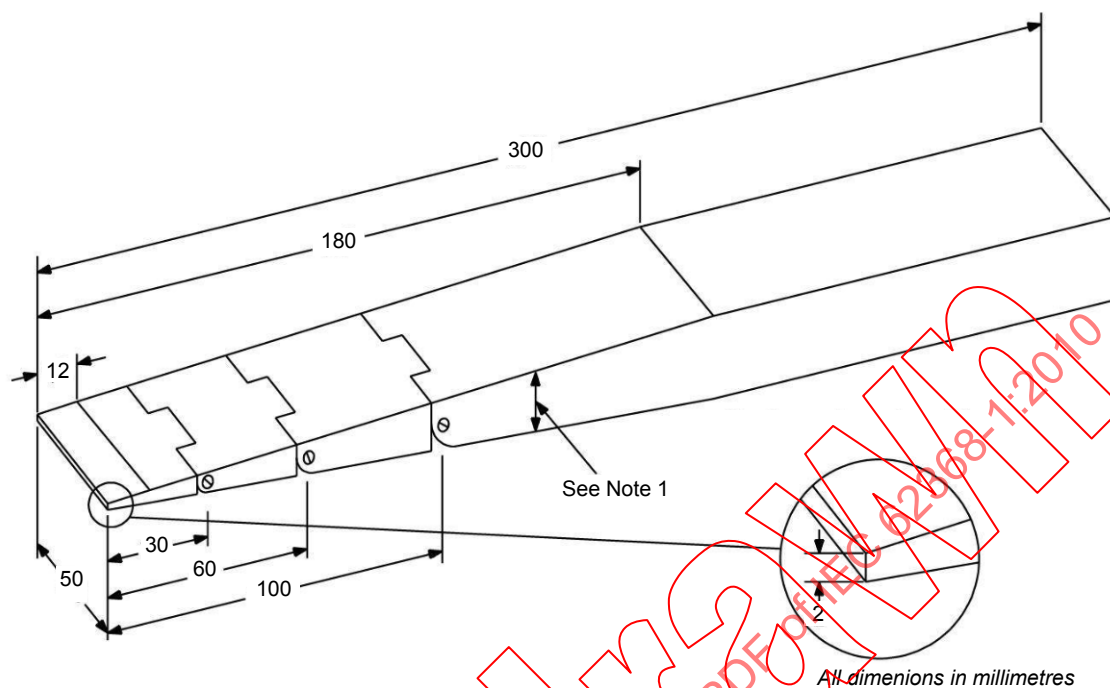
Dimensions in millimetres

NOTE This test probe is taken from Figure 2c, IEC 60950-1:2005.

Figure V.3 – Blunt probe

V.1.5 Test method 4 – Slot openings

For slot openings exceeding 50 mm, the wedge probe of Figure V.4 is applied with a force of 30 N to the openings of the equipment. This requirement also applies where entry behind a door, panel, removable cover, etc. is possible without the use of a **tool**.



Tolerances on linear dimensions without specific tolerances:

≤ 25 mm: $\pm 0,13$ mm

> 25 mm: $\pm 0,3$ mm

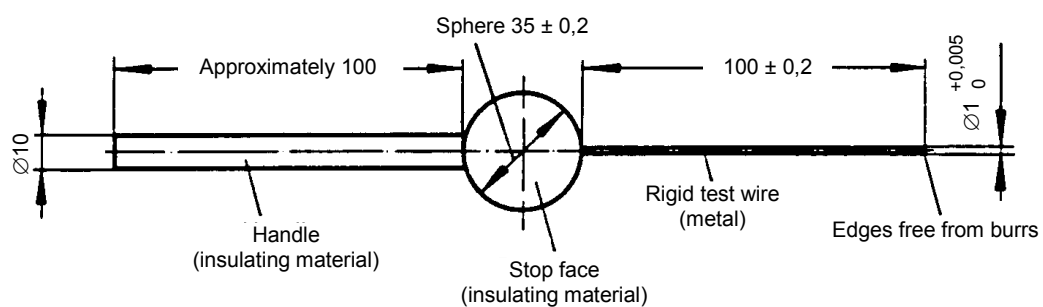
The thickness of the probe varies linearly, with slope changes at the following points along the probe:

Distance from probe tip mm	Probe thickness mm
0	2
12	4
180	24

Figure V.4 – Wedge probe

V.1.6 Test method 5 – Terminals intended to be used by an ordinary person

Each terminal is tested with the straight test probe of Figure V.5 with a force of $1\text{ N} \pm 0,1\text{ N}$ and with the length limited to $20\text{ mm} \pm 0,2\text{ mm}$.



NOTE This probe is taken from Figure 4, IEC 61032:1997.

Figure V.5 – Terminal probe

V.2 Accessible part criterion

*If a part can be touched by the specified probe, then the part is **accessible**.*

Annex W (informative)

Comparison of terms introduced in this standard

W.1 General

This standard introduces new safety terms associated with the new safety concepts.

This annex identifies the relevant terms in this standard and, where different, compare them to the equivalent IEC/TC 64² basic safety publications and other relevant safety publications.

Terms not in Table W.1 are either the same or substantially the same as in other IEC standards.

W.2 Comparison of terms

In Table W.1 below, the text quoted from an IEC standard is in normal font. Remarks about IEC 62368-1 are in *italic font*.

Table W.1 – Comparison of terms

IEC 60664-1:2007 terms	IEC 62368-1 terms
3.2 clearance shortest distance in air between two conductive parts	3.3.12.1 clearance shortest distance in air between two conductive parts
3.3 creepage distance shortest distance along the surface of a solid insulating material between two conductive parts	3.3.12.2 creepage distance shortest distance along the surface of an insulating material between two conductive parts
3.4 solid insulation solid insulating material interposed between two conductive parts	3.3.5.5 solid insulation solid insulating material interposed between two conductive parts or between a conductive part and a body part
3.5 working voltage highest r.m.s. value of the a.c. or d.c. voltage across any particular insulation which can occur when the equipment is supplied at rated voltage	3.3.14.7 working voltage highest voltage across any particular insulation that can occur when the equipment is supplied at rated voltage or any voltage in the rated voltage range under normal operating conditions
3.9 rated voltage value of voltage assigned by the manufacturer, to a component, device or equipment and to which operation and performance characteristics are referred	3.3.10.4 rated voltage value of voltage assigned by the manufacturer to a component, device or equipment and to which operation and performance characteristics are referred

² IEC/TC 64: Electrical installations and protection against electric shock. Click on the IEC website for a list of publications issued by TC 64.

IEC 60664-1:2007 terms	IEC 62368-1 terms
3.13 pollution degree numeral characterizing the expected pollution of the micro-environment	3.3.6.4 pollution degree numeral characterising the expected pollution of the micro-environment
3.19.1 type test test of one or more devices made to a certain design to show that the design meets certain specifications	3.3.6.10 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
3.9.2 rated impulse voltage impulse withstand voltage value assigned by the manufacturer to the equipment or to a part of it, characterizing the specified withstand capability of its insulation against transient overvoltages	3.3.14.2 mains transient voltage highest peak voltage expected at the power input to the equipment arising from external transients on the mains
3.17.1 functional insulation insulation between conductive parts which is necessary only for the proper functioning of the equipment	3.3.5.3 functional insulation insulation between conductive parts which is necessary only for the proper functioning of the equipment
3.17.2 basic insulation insulation of hazardous-live-parts which provides basic protection	3.3.5.1 basic insulation insulation to provide basic safeguard against electric shock
3.17.3 supplementary insulation independent insulation applied in addition to basic insulation for fault protection	3.3.5.6 supplementary insulation independent insulation applied in addition to basic insulation to provide supplementary safeguard for fault protection against electric shock
3.17.4 double insulation insulation comprising both basic insulation and supplementary insulation	3.3.5.2 double insulation insulation comprising both basic insulation and supplementary insulation
3.17.5 reinforced insulation insulation of hazardous-live-parts which provides a degree of protection against electric shock equivalent to double insulation	3.3.5.4 reinforced insulation single insulation system that provides a degree of protection against electric shock equivalent to double insulation
3.19.2 routine test test to which each individual device is subjected during or after manufacture to ascertain whether it complies with certain criteria	3.3.6.6 routine test test to which each individual device is subjected during or after manufacture to ascertain whether it complies with certain criteria
3.19.3 sampling test test on a number of devices taken at random from a batch	3.3.6.7 sampling test test on a number of devices taken at random from a batch

IEC 61140:2001 terms	IEC 62368-1 terms
3.1.1 basic protection protection against electric shock under fault-free conditions [IEV 195-06-01]	<i>For consistency throughout the standard the term "safeguard" is used to describe the device or scheme that provides protection against an energy source.</i> 3.3.11.1 basic safeguard safeguard that provides protection under normal operating conditions and under abnormal operating conditions whenever an energy source capable of causing pain or injury is present in the equipment
3.10.2 supplementary insulation Independent insulation applied in addition to basic insulation, for fault protection [IEV 195-06-07]	3.3.11.17 supplementary safeguard safeguard applied in addition to the basic safeguard that is or becomes operational in the event of failure of the basic safeguard
3.4 live part conductor or conductive part intended to be energized in normal operation, including a neutral conductor, but by convention not a PEN conductor or PEM conductor or PEL conductor [IEV 195-02-19] NOTE 1 This concept does not necessarily imply a risk of electric shock. NOTE 2 For definitions of PEM and PEL see IEC 195-02-13 and 195-02-14.	<i>The term live part is not used.</i> <i>In accordance with the IEC 61140 definition, ES1, ES2 and ES3 are all live parts</i>
3.5 hazardous-live-part live part that, under certain conditions, can give a harmful electric shock [IEV 195-06-05] NOTE In case of high voltage, a hazardous voltage may be present on the surface of solid insulation. In such a case the surface is considered to be a hazardous-live-part.	<i>The term hazardous-live-part is not used.</i> <i>In accordance with the IEC 61140 definition, an ES3 source is a hazardous-live-part.</i>
3.26 extra-low-voltage (ELV) any voltage not exceeding the relevant voltage limit specified in IEC/TS 61201	<i>No equivalent term. See ES1.</i>
3.26.1 SELV system an electrical system in which the voltage cannot exceed ELV: – under normal conditions; and – under single-fault conditions, including earth faults in other circuits	ES1 <i>ES1 is a voltage not exceeding the relevant voltage limit specified in IEC/TS 61201 or a current not exceeding the relevant current limit specified in IEC/TS 60479-1</i> – under normal conditions; and – under single-fault conditions

IEC 61140:2001 terms	IEC 62368-1 terms
3.28 limited-current-source device supplying electrical energy in an electric circuit – with protective-separation from hazardous-live-parts, and – that ensures that the steady-state touch current and charge are limited to non-hazardous levels, under normal and fault conditions	ES1 <i>ES1 is a voltage not exceeding the relevant voltage limit specified in IEC/TS 61201 or a current not exceeding the relevant current limit specified in IEC/TS 60479-1</i> – under normal conditions; and – under single-fault conditions.
5.1.6 Limitation of steady-state touch current and charge Limitation of steady-state touch current and charge shall prevent persons or animals from being subjected to values of steady-state touch current and charge liable to be hazardous or perceptible. NOTE For persons, the following values (a.c. values for frequencies up to 100 Hz) are given as guidance: – A steady-state current flowing between simultaneously accessible conductive parts through a pure resistance of 2 000 Ω not exceeding the threshold of perception, a.c. 0,5 mA or d.c. 2 mA are recommended. – Values not exceeding the threshold of pain a.c. 3,5 mA or d.c. 10 mA may be specified.	<i>ES1 current limit is 0,5 mA a.c. and 2 mA d.c.</i> <i>ES2 current limit is 5 mA a.c., 25 mA d.c. (these values are taken from IEC/TS 60479-1)</i>
<i>No equivalent term</i>	3.3.11.14 safeguard physical part or system or instruction specifically provided to reduce the likelihood of injury, or, for fire, to reduce the likelihood of ignition or spread of fire
<i>No equivalent term. Based on double insulation</i>	3.3.11.3 double safeguard safeguard comprising both a basic safeguard and a supplementary safeguard
<i>No equivalent term. Based on reinforced insulation</i>	3.3.11.13 reinforced safeguard single safeguard that is operational under – normal operating conditions, – abnormal operating conditions, and – single fault conditions
<i>No equivalent term. Roughly equivalent to a warning</i>	3.3.11.6 instructional safeguard an instruction invoking specified behaviour to avoid contact with or exposure to a class 2 or class 3 energy source

IEC 61140:2001 terms	IEC 62368-1 terms
<i>No equivalent term</i>	3.3.11.8 precautionary safeguard instructed person behaviour to avoid contact with or exposure to a class 2 energy source based on supervision or instructions given by a skilled person
<i>No equivalent term</i>	3.3.11.16 skill safeguard skilled person behaviour to avoid contact with or exposure to a class 2 or class 3 energy source based on education and experience
<i>The term normal condition is used in IEC 61140, but not defined</i>	3.3.7.4 normal operating condition mode of operation that represents as closely as possible the most severe conditions of normal use that can reasonably be expected
<i>No equivalent term</i>	3.3.7.1 abnormal operating condition temporary operating condition that is not a normal operating condition and is not a single fault condition of the equipment itself
<i>The term single fault is used in IEC 61140, but not defined</i>	3.3.7.10 single fault condition fault under normal operating condition of a single safeguard (but not a reinforced safeguard) or of a single component or a device

IEC 60950-1:2005 terms	IEC 62368-1 terms
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	5.2.1.1 ES1 ES1 is a class 1 electrical energy source with levels not exceeding ES1 limits under normal operating conditions and abnormal operating conditions that do not lead to a single fault conditions and not exceeding ES2 limits under single fault conditions. NOTE ES1 may be accessible to an ordinary person.
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 of IEC 60950-1:2005), the voltages do not exceed specified limit values. A TNV CIRCUIT is considered to be a SECONDARY CIRCUIT in the meaning of this standard	5.2.1.2 ES2 ES2 is a class 2 electrical energy source with levels not exceeding ES2 limits under normal operating conditions, abnormal operating conditions, and single fault conditions, but is not ES1. NOTE ES2 may be accessible to an instructed person.
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	ES 1 on which transients according to Table 16, ID numbers 4, 6, 7 , 9, 12, 13, 14 and 15 are possible NOTE The electrical characteristics are not identical to TNV circuits but will give equivalent level of safety.
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	ES2 NOTE The electrical characteristics are not identical to TNV circuits but will give equivalent level of safety.

IEC 60950-1:2005 terms	IEC 62368-1 terms
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	ES 2 on which transients according to Table 16, ID numbers 4, 6, 7, 9, 12, 13, 14 and 15 are possible NOTE The electrical characteristics are not identical to TNV circuits but will give equivalent level of safety.
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	3.3.8.2 ordinary person person who is neither a skilled person nor an instructed person
1.2.13.7 OPERATOR see USER (1.2.13.6 of IEC 60950-1:2005)	See 3.3.8.2
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:	3.3.1.1 external circuit electrical circuit that is external to the equipment and is not mains NOTE The relevant external circuits are identified in Table 16

IEC 60950-1:2005 terms	IEC 62368-1 terms
– an Integrated Services Digital Network (ISDN); – a private network with electrical interface characteristics similar to the above.	
None	3.3.8.1 instructed person a person instructed or supervised by a skilled person as energy sources and who can responsibly employ equipment and precautionary safeguards with respect to those energy sources
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	3.3.8.3 skilled person person with relevant education or experience to enable him or her to avoid dangers and to reduce the likelihood of risks that may be created by the equipment
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.	3.3.1.1 external circuit electrical circuit that is external to the equipment and is not mains NOTE The relevant external circuits are identified in Table 16.

IEC 60728-11 terms	IEC 62368-1 terms
3.1.3 cable networks (for television signals, sound signals and interactive services) general overall term used to define CATV-networks, MATV-networks. SMATV-networks and individual receiving networks; these networks can be used in downstream and upstream directions 3.1.4 CATV network or community antenna television network network designed to provide sound and television signals as well as signals for interactive services to communities 3.1.20 MATV network or master antenna television network network designed to provide sound and television signals as well as signals for interactive services to households in one or more buildings 3.1.31 SMATV network or satellite master antenna television network network designed to provide sound and television signals as well as signals for interactive services, received by satellite receiving antenna eventually combined with terrestrial TV and/or radio signals, to households in one or more buildings	3.3.1.1 external circuit electrical circuit that is external to the equipment and is not mains NOTE The relevant external circuits are identified in Table 16.

IEC 62151 terms	IEC 62368-1 terms
3.1.3 telecommunication network a metallicallly terminated transmission medium intended for communication between equipments that may be located in separate buildings, excluding: – the mains systems for supply, transmission and distribution of electrical power, if used as a telecommunication transmission medium; – television distribution systems using cable. 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 a TNV CIRCUIT. Only the circuits in 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 permanent 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 ISDN network; – a private network with electrical interface characteristics similar to the above.	3.3.1.1 external circuit electrical circuit that is external to the equipment and is not mains NOTE The relevant external circuits are identified in Table 16.
3.5.4 TNV-0 circuit a TNV CIRCUIT: – whose normal operating voltages do not exceed a safe value under normal operating conditions and under single fault conditions; – which is not subject to overvoltages from TELECOMMUNICATION NETWORKS NOTE The limiting values of voltage under normal operating and single fault conditions are specified in 4.1.	5.2.1.1 ES1 ES1 is a class 1 electrical energy source with levels not exceeding ES1 limits under normal operating conditions and abnormal operating conditions and not exceeding ES2 limits under single fault conditions. NOTE 1 ES1 may be accessible to an ordinary person. NOTE 2 The electrical characteristics are not identical but will give equivalent level of safety

IEC 62151 terms	IEC 62368-1 terms
3.5.3 TNV circuit a circuit which is in the equipment and to which the ACCESSIBLE area of contact is limited (except for a TNV-0 CIRCUIT) and that is so designed and protected that, under normal operating and single fault conditions, the voltages do not exceed specified limiting values A TNV CIRCUIT is considered to be a SECONDARY CIRCUIT in the meaning of this standard. NOTE The voltage relationships between TNV CIRCUITS are shown in table 1.	5.2.1.2 ES2 ES2 is a class 2 electrical energy source with levels not exceeding ES2 limits under normal operating conditions, abnormal operating conditions, or single fault conditions, but is not ES1. NOTE 1 ES2 may be accessible to an instructed person. NOTE 2 The electrical characteristics are not identical to TNV circuits but will give an equivalent level of safety.

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COMMISSION ELECTROTECHNIQUE INTERNATIONALE

ÉQUIPEMENTS DES TECHNOLOGIES DE L'AUDIO/VIDÉO, DE L'INFORMATION ET DE LA COMMUNICATION –

Partie 1: Exigences de sécurité

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- 9) L'attention est attirée sur le fait que certains des éléments de la présente Publication de la CEI peuvent faire l'objet de droits de brevet. La CEI ne saurait être tenue pour responsable de ne pas avoir identifié de tels droits de brevets et de ne pas avoir signalé leur existence.

La Norme internationale CEI 62368-1 a été établie par le Comité d'études 108: 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 présente version bilingue, correspond à la version anglaise monolingue publiée en 2010-01. Elle inclut le Corrigendum 1 (2010-06).

Le texte anglais de cette norme est issu des documents 108/325/FDIS et 108/355/RVD.

Le rapport de vote 108/355/RVD donne toute information sur le vote ayant abouti à l'approbation de cette norme.

La version française de cette norme n'a pas été soumise au vote.

Cette publication a été rédigée selon les Directives ISO/CEI, Partie 2.

À l'exception du texte précédé par « Note », l'ensemble du texte apparaissant dans une figure normative, ou dans un cadre se trouvant sous un tableau normatif, est également normatif. Le texte présentant une référence en exposant est lié à un élément précis dans le tableau. Le reste du texte figurant dans un cadre sous un tableau s'applique à l'ensemble du tableau.

Les annexes informatives et le texte suivant le mot « NOTE » ne sont pas normatifs. Ils sont fournis uniquement à titre d'information supplémentaire.

Les notes « dans certains pays » concernant les différentes pratiques nationales figurent dans les paragraphes suivants:

0.2.1, 4.1.15, 5.4.2.4.3, 5.4.2.9, 5.4.5.1, 5.5.2.2, 5.5.2.7, 5.7.7, 10.3.2, 10.3.3.3, 10.3.3.4, 10.4.1, F.3.3.5, Tableau 15 et Tableau 16.

Dans la présente norme, les caractères d'imprimerie ou formats suivants sont utilisés:

- exigences proprement dites et annexes normatives: caractères romains;
- déclarations de conformité et modalités d'essais: *caractères italiques*;
- notes/rapport explicatif: petits caractères romains;
- conditions normatives dans les tableaux: petits caractères romains;
- termes définis en 3.3: **gras**.

Le comité a décidé que le contenu de cette publication 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,
- supprimée,
- remplacée par une édition révisée, ou
- amendée.

NOTE 1 L'attention des Comités nationaux et des organismes nationaux qui établissent les normes nationales est attirée sur le fait que les fabricants d'équipements et les organisations d'essai peuvent avoir besoin d'une période de transition après la publication d'une publication CEI nouvelle, amendée ou révisée selon laquelle ils sont tenus de fabriquer leurs produits conformément aux nouvelles exigences et de s'équiper pour réaliser des essais nouveaux ou révisés. Il est recommandé par le TC108 que le contenu de cette publication soit adopté pour une mise en œuvre obligatoire à l'échelon national pas avant cinq ans à partir de la date de publication de la présente norme.

NOTE 2 La CEI 62368-1 est fondée sur les principes de la construction technique basée sur le danger, qui représente une manière différente de développer et de spécifier des considérations relatives à la sécurité par rapport à la pratique actuelle. Tandis que cette norme diffère des normes traditionnelles de la CEI relatives à la sécurité dans son approche et alors que la CEI 62368-1 est considérée apporter plusieurs avantages, son introduction et son évolution ne sont pas prévues pour entraîner des changements significatifs de la philosophie de sécurité existante qui a conduit au développement des exigences en matière de sécurité contenues dans la CEI 60065 et la CEI 60950-1. La philosophie émergeant derrière la création de la CEI 62368-1 consiste à simplifier les problèmes créés par la fusion des technologies de l'ITE et de la CE. Les techniques utilisées sont nouvelles et requièrent par ailleurs un processus d'apprentissage. Une certaine expérience est également nécessaire dans leur application. En conséquence, le TC108 de la CEI recommande que la première édition de la présente norme soit considérée comme une alternative à la CEI 60065 ou à la CEI 60950-1 au moins pendant la période de transition recommandée.

NOTE 3 Les informations explicatives relatives à la CEI 62368-1 seront publiées comme CEI/TR 62368-2. Celle-ci comportera les justifications, ainsi que les informations explicatives relatives à la présente norme.

IMPORTANT – Le logo “en couleur” apparaissant sur la première page de la présente publication indique qu'elle contient des couleurs considérées utiles pour la bonne compréhension de son contenu. Il convient par conséquent que les utilisateurs impriment le présent document à l'aide d'une imprimante couleur.

INTRODUCTION

0 Principes de la présente norme relative à la sécurité des produits

0.1 Objectif

La présente Norme internationale est une norme relative à la sécurité des produits qui classe les sources d'énergie, prescrit des **protections** contre ces sources d'énergie, et fournit des recommandations concernant leur application et leurs exigences.

Les **protections** prescrites sont prévues pour réduire la probabilité de douleur, blessure et, en cas d'incendie, de dommage matériel.

L'INTRODUCTION a pour objectif de permettre aux concepteurs de comprendre les principes de sécurité sous-jacents pour concevoir des équipements sûrs. Ces principes sont informatifs et ne constituent pas une alternative aux exigences détaillées de la présente norme.

0.2 Personnes

0.2.1 Généralités

La présente norme décrit des **protections** pour trois types de personnes: les **personnes ordinaires**, les **personnes averties**, et les **personnes qualifiées**. La présente norme part du principe qu'une personne ne crée jamais volontairement des conditions ou des situations susceptibles de provoquer une douleur ou une blessure.

NOTE En Australie, les opérations effectuées par une **personne avertie** ou par une **personne qualifiée** peuvent nécessiter une licence formelle de la part des autorités de réglementation.

0.2.2 Personne ordinaire

Personne ordinaire est le terme appliqué à toutes les personnes qui ne sont ni des **personnes averties** ni des **personnes qualifiées**. **Personnes ordinaires** comprend non seulement les utilisateurs de l'équipement, mais également toutes les personnes qui peuvent avoir accès à l'équipement ou se trouver à proximité de l'équipement. Dans les **conditions normales de fonctionnement** ou des **conditions anormales de fonctionnement**, il convient que les **personnes ordinaires** ne soient pas exposées aux parties comprenant des sources d'énergie pouvant provoquer des douleurs ou des blessures. Dans une **condition de premier défaut**, il convient que les **personnes ordinaires** ne soient pas exposées aux parties comprenant des sources d'énergie pouvant provoquer des blessures.

0.2.3 Personne avertie

Personne avertie est un terme appliqué aux personnes qui ont été formées et entraînées par une **personne qualifiée**, ou qui ont été encadrées par une **personne qualifiée**, pour identifier les sources d'énergie pouvant provoquer des douleurs (voir le Tableau 1) et pour prendre des précautions afin d'éviter tout contact involontaire ou exposition à ces sources d'énergie. Dans les **conditions normales de fonctionnement**, des **conditions anormales de fonctionnement** ou des **conditions de premier défaut**, il convient que les **personnes averties** ne soient pas exposées aux parties comprenant des sources d'énergie pouvant provoquer des blessures.

0.2.4 Personne qualifiée

Personne qualifiée est un terme appliqué aux personnes qui disposent d'une formation ou d'une expérience dans les technologies d'équipement, notamment dans la connaissance des différentes énergies et des amplitudes d'énergie utilisées dans l'équipement. Une **personne qualifiée** utilise sa formation et son expérience pour reconnaître les sources d'énergie pouvant provoquer des douleurs ou des blessures et pour mettre en œuvre une action de protection contre les blessures dues à ces énergies. Il convient que les **personnes qualifiées**

soient également protégées contre le contact involontaire ou l'exposition aux sources d'énergie pouvant provoquer des blessures.

0.3 Modèle à suivre pour les douleurs et les blessures

Le présent paragraphe présente un modèle fondé sur la technologie de construction pour les douleurs et les blessures et leur lien avec une source d'énergie donnée.

Une source d'énergies qui provoque une douleur ou une blessure le fait par l'intermédiaire du transfert d'une forme d'énergie depuis ou vers une partie du corps.

Ce concept est représenté par un modèle en trois blocs (voir la Figure 1).

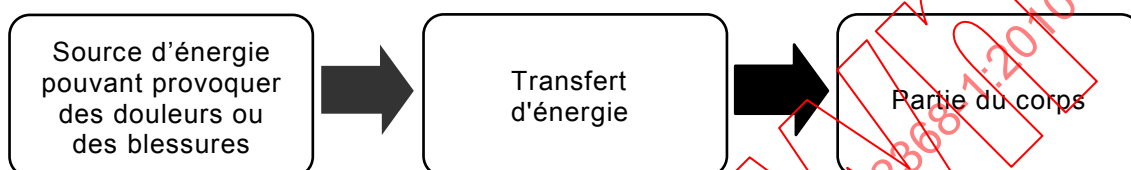


Figure 1 – Modèle en trois blocs pour les douleurs et les blessures

Cette norme relative à la sécurité spécifie trois classes de sources d'énergie définies par des amplitudes et paramétrées par la durée de contact relatif soit au corps soit à la réponse des **matériaux combustibles** à ces sources d'alimentation. Chaque classe d'énergie (voir 4.2) est fonction de la sensibilité de la partie du corps ou du **matériau combustible** à cette amplitude d'énergie (voir le Tableau 1).

Tableau 1 – Réponse à la classe d'énergie

Source d'énergie	Effet sur le corps	Effets sur les matériaux combustibles
Classe 1	Non douloureux, mais peut être détectable	Inflammation non probable
Classe 2	Douloureux, mais ne constitue pas une blessure	Inflammation possible, mais développement et propagation du feu limités
Classe 3	Blessure	Inflammation probable, développement et propagation rapides du feu

Le seuil d'énergie pour la douleur ou les blessures n'est pas constant au sein de la population. Par exemple, pour certaines sources d'énergie, le seuil est fonction de la masse du corps; plus la masse est légère, plus le seuil est bas, et inversement. D'autres variables du corps sont l'âge, l'état de santé, les émotions, les effets de médicaments, les caractéristiques de la peau, etc. De plus, même lorsque les apparences extérieures semblent identiques, les individus ne présentent pas le même seuil de sensibilité à la même source d'énergie.

L'effet de la durée du transfert d'énergie dépend de la forme d'énergie spécifique. Par exemple, la durée d'une douleur ou d'une blessure due à une énergie thermique peut être très courte (1 s) sur une peau à température élevée, ou très longue (plusieurs heures) sur une peau à basse température.

En outre, une douleur ou une blessure peut survenir longtemps après le transfert d'énergie vers une partie du corps. Par exemple, une douleur ou une blessure due à une réaction chimique peut ne pas se manifester pendant des jours, des semaines, des mois ou des années.

0.4 Sources d'alimentation

Le présent paragraphe identifie les sources d'énergie traitées par la présente norme, et les douleurs ou les blessures qui découlent d'un transfert de ces énergies vers le corps, ainsi que la probabilité de dommage matériel provoqué par le feu s'échappant de l'équipement.

Un produit électrique est connecté à une source d'énergie électrique (par exemple, le **réseau d'alimentation**), une alimentation externe ou une batterie. Un produit électrique utilise l'énergie électrique pour remplir ses fonctions prévues.

Au cours du processus d'utilisation d'énergie électrique, le produit transforme l'énergie électrique en d'autres formes d'énergie, par exemple en énergie thermique, en énergie cinétique, en énergie optique, en énergie audio, en énergie électromagnétique, etc. Certaines transformations d'énergie peuvent constituer une part délibérée de la fonction du produit (par exemple, des parties mobiles d'une imprimante, des images sur un écran d'affichage visuel, du son provenant d'un haut-parleur, etc.). Certaines transformations d'énergie peuvent être un sous-produit de la fonction du produit (par exemple, de la chaleur dissipée par des circuits fonctionnels, un rayonnement x provenant d'un tube cathodique, etc.).

Certains produits peuvent utiliser des sources d'énergie non électriques telles que des batteries, des parties mobiles, ou chimiques, etc. L'énergie située dans ces autres sources peut être transférée vers ou depuis une partie du corps ou être transformée en d'autres formes d'énergie (par exemple, une batterie transforme l'énergie chimique en énergie électrique, ou une partie du corps mobile transfère son énergie cinétique vers une arête vive).

Des exemples des types de formes d'énergie et des blessures et dommages matériels associés traités dans la présente norme figurent dans le Tableau 2.

Tableau 2 – Exemples de réactions du corps humain ou de dommages matériels liés aux sources d'énergie

Formes d'énergie	Exemples de réactions du corps humain ou de dommages matériels	Article
Énergie électrique (par exemple, parties conductrices alimentées)	Douleur, fibrillation, arrêt cardiaque, arrêt respiratoire, brûlure de la peau, ou brûlure d'un organe interne	5
Énergie thermique (par exemple, inflammation électrique et propagation du feu)	Incendie d'origine électrique provoquant une douleur, une blessure ou un dommage matériel liés à une brûlure	6
Réaction chimique (par exemple, électrolyte, poison)	Endommagement de la peau, des poumons et d'autres organes, ou empoisonnement	7
Énergie cinétique (par exemple, parties mobiles de l'équipement, ou une partie du corps mobile contre une partie de l'équipement)	Lacération, perforation, abrasion, contusion, écrasement, amputation ou perte d'un membre, d'un œil, d'une oreille, etc.	8
Énergie thermique (par exemple, parties accessibles chaudes)	Brûlure de la peau	9
Énergie rayonnée (par exemple, énergie électromagnétique, énergie optique, énergie acoustique)	Perte de la vue, brûlure de la peau, ou perte de l'ouïe	10

0.5 Protections

0.5.1 Généralités

Le présent paragraphe introduit le modèle en trois blocs pour la sécurité, pour expliquer la fonction d'une **protection**, et décrit plusieurs manifestations de **protections**.

De nombreux produits utilisent systématiquement de l'énergie pouvant provoquer des douleurs ou des blessures. La conception de l'équipement ne peut pas empêcher l'utilisation de ce type d'énergie. En conséquence, il convient que ces produits suivent un plan qui réduit la probabilité que des énergies de ce type soient transférées vers une partie du corps. Le plan qui réduit la probabilité d'un transfert d'énergie vers une partie du corps s'appelle une **protection** (voir la Figure 2).

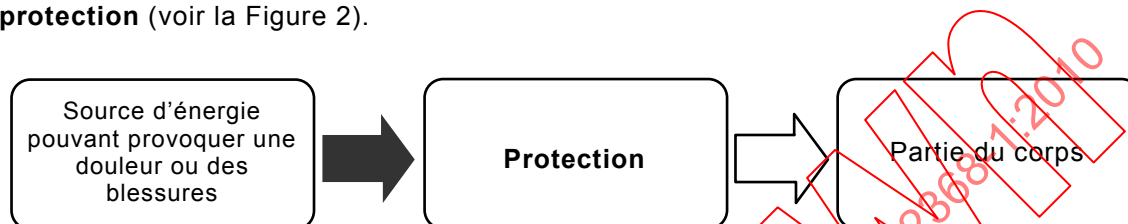


Figure 2 – Modèle en trois blocs pour la sécurité

Une **protection** est un dispositif, un plan ou un système qui

- est interposé entre une source d'énergie pouvant provoquer une douleur ou des blessures et une partie du corps, et
- réduit la probabilité d'un transfert d'énergie pouvant entraîner une douleur ou une blessure sur une partie du corps.

NOTE Les mécanismes de **protection** contre un transfert d'énergie pouvant entraîner une douleur ou une blessure consistent à

- atténuer l'énergie (limiter la valeur de l'énergie), ou
- freiner l'énergie (réduire le débit du transfert d'énergie), ou
- dévier l'énergie (changer la direction de l'énergie), ou
- déconnecter, suspendre ou désactiver la source d'énergie, ou
- envelopper la source d'alimentation (diminuer la probabilité que l'énergie s'échappe), ou
- interposer une barrière entre une partie du corps et la source d'alimentation.

Une **protection** peut s'appliquer à l'équipement, à l'installation locale, à une personne ou peut consister en un comportement appris ou dirigé (par exemple, dans le cas d'une **protection mise en place sous forme d'instructions**) visant à réduire la probabilité d'un transfert d'énergie pouvant provoquer une douleur ou des blessures. Une **protection** peut être un élément unique ou correspondre à un ensemble d'éléments.

Dans l'idéal, l'ordre de préférence pour présenter des **protections** est le suivant:

- **protections de l'équipement;**
- **protections de l'installation;**
- **protections mises en place sous forme d'instructions** impliquant un **équipement de protection individuelle**, ou un comportement préventif.

En pratique, le choix d'une **protection** prend en compte la nature de la source d'alimentation, l'utilisateur prévu, les exigences fonctionnelles de l'équipement, et des considérations du même ordre.

0.5.2 Protection de l'équipement

Une **protection de l'équipement** peut être une **protection principale**, une **protection supplémentaire**, une **protection double**, ou une **protection renforcée**.

0.5.3 Protection de l'installation

Les **protections de l'installation** ne sont pas contrôlées par le fabricant de l'équipement, bien que dans certains cas, des **protections de l'installation** puissent être spécifiées dans les instructions d'installation de l'équipement.

En général, pour l'équipement, une **protection d'installation** est une **protection supplémentaire**.

NOTE Par exemple, la **protection supplémentaire** de mise à la terre est située en partie dans l'équipement et en partie dans l'installation. La **protection supplémentaire** de mise à la terre n'est pas effective tant que l'équipement n'est pas connecté à l'installation.

Les exigences relatives aux **protections de l'installation** ne sont pas traitées dans la présente norme. Cependant, la présente norme part du principe que certaines **protections de l'installation**, comme la mise à la terre de protection, sont en place et effectives.

0.5.4 Protection mise en place sous forme d'instructions

Une **protection mise en place sous forme d'instructions** est une indication visuelle (symboles, mots ou les deux) ou un message sonore décrivant l'existence et l'emplacement d'une source d'énergie pouvant provoquer une douleur ou une blessure, et visant à solliciter un comportement spécifique de la part d'une personne afin de réduire la probabilité d'un transfert d'énergie vers une partie du corps (voir l'Annexe F).

Une **protection mise en place sous forme d'instructions** peut être une **protection principale** ou une **protection supplémentaire**.

Une **protection mise en place sous forme d'instructions** peut être considérée comme une protection acceptable pour contourner une **protection de l'équipement** lors de l'accès à des emplacements où l'unité nécessite d'être alimentée pour effectuer une activité d'entretien, de telle sorte que la personne sache comment éviter un contact avec la source d'énergie de classe 2.

Si les **protections de l'équipement** nuisent ou empêchent son fonctionnement, une **protection mise en place sous forme d'instructions** peut être une **protection renforcée**.

La mise à disposition d'une **protection mise en place sous forme d'instructions** ne fait pas d'une **personne ordinaire** une **personne avertie** (voir 0.5.8).

0.5.5 Protection individuelle

Une **protection individuelle** peut être une **protection principale**, une **protection supplémentaire** ou une **protection renforcée**.

Les exigences relatives aux **protections individuelles (équipement de protection individuelle)** ne sont pas traitées dans la présente norme. Cependant, cette norme part du principe que les **protections individuelles** sont disponibles pour une utilisation telle que spécifiée par le fabricant.

0.5.6 Protection dans des conditions d'entretien par une personne ordinaire ou avertie

Dans des conditions d'entretien par une **personne ordinaire** ou par une **personne avertie**, des **protections** pour ces personnes peuvent se révéler nécessaires. Ces **protections**

peuvent être des **protections de l'équipement**, des **protections individuelles**, ou des **protections mises en place sous forme d'instructions**. L'application de ces **protections** est spécifiée dans les articles correspondants.

0.5.7 Protections de l'équipement dans des conditions d'entretien par une personne qualifiée

Dans des conditions d'entretien par une **personne qualifiée**, il convient que des **protections de l'équipement** soient prévues contre les effets d'une réaction involontaire du corps (par exemple, un sursaut) susceptible d'entraîner un contact involontaire avec une source d'énergie de classe 3 située hors du champ de vision de la **personne qualifiée**.

NOTE Cette **protection** s'applique généralement aux équipements de grande taille, dans lesquels la **personne qualifiée** peut avoir besoin de s'introduire en partie ou entièrement, entre au moins deux emplacements de source d'énergie de classe 3, au cours de l'entretien.

0.5.8 Protection de précaution

Une **protection de précaution** consiste en la formation et l'expérience ou l'encadrement d'une **personne avertie** par une **personne qualifiée** en vue de l'utilisation de précautions pour protéger la **personne avertie** contre les sources d'énergie de classe 2. Les **protections de précaution** ne sont pas spécifiquement prescrites dans la présente norme mais sont considérées comme effectives lorsque le terme **personne avertie** est utilisé.

Pendant l'entretien de l'équipement, une **personne avertie** peut avoir besoin d'ôter ou de détruire une **protection de l'équipement**. Dans ce cas, une **personne avertie** doit alors appliquer une précaution comme **protection** pour éviter les blessures.

0.5.9 Protection mise en place grâce à l'expérience acquise

Une **protection mise en place grâce à l'expérience acquise** consiste en l'utilisation de l'éducation, de la formation, des connaissances et de l'expérience de la **personne qualifiée** pour protéger cette même personne contre les sources d'énergie de classe 2 et de classe 3. Les **protections mises en place grâce à l'expérience acquise** ne sont pas spécifiquement prescrites dans la présente norme mais sont considérées comme effectives lorsque le terme **personne qualifiée** est utilisé.

Pendant l'entretien de l'équipement, une **personne qualifiée** peut avoir besoin d'ôter ou de détruire une **protection de l'équipement**. Dans ce cas, une **personne qualifiée** doit alors utiliser son expérience comme **protection** pour éviter les blessures.

0.5.10 Exemples de caractéristiques de protection

Le Tableau 3 donne quelques exemples de caractéristiques de **protection**.

Tableau 3 – Exemples de caractéristiques de protection

Protection	Protection principale	Protection supplémentaire	Protection renforcée
Protection de l'équipement: partie physique d'un équipement	Effective dans les conditions normales de fonctionnement	Effective dans le cas d'un dysfonctionnement de la protection principale	Effective dans les conditions normales de fonctionnement et dans le cas d'une condition de premier défaut dans une autre partie de l'équipement
	Exemple: isolation principale	Exemple: isolation supplémentaire	Exemple: isolation renforcée
	Exemple: températures normales inférieures aux températures d'inflammation	Exemple: enveloppe ignifuge	Non applicable
Protection de l'installation: partie physique d'une installation réalisée par l'homme	Effective dans les conditions normales de fonctionnement	Effective dans le cas d'un dysfonctionnement d'une protection principale de l'équipement	Effective dans les conditions normales de fonctionnement et dans le cas d'une condition de premier défaut dans une autre partie de l'équipement
	Exemple: dimensions du fil	Exemple: dispositif de protection contre les surintensités	Exemple: socle de prise de courant
Protection individuelle: dispositif physique porté sur le corps	En l'absence de toute protection de l'équipement , effective dans les conditions normales de fonctionnement	Effective dans le cas d'un dysfonctionnement d'une protection principale de l'équipement	En l'absence de toute protection de l'équipement , effective dans les conditions normales de fonctionnement et dans le cas d'une condition de premier défaut dans une autre partie de l'équipement
	Exemple: gant	Exemple: tapis de sol isolant	Exemple: gant isolé électriquement permettant de manipuler des conducteurs alimentés
Protection mise en place sous forme d'instructions: comportement volontaire ou enseigné visant à réduire la probabilité d'un transfert d'énergie vers une partie du corps	En l'absence de toute protection de l'équipement , effective dans les conditions normales de fonctionnement	Effective dans le cas d'un dysfonctionnement d'une protection principale de l'équipement	Effective uniquement de manière exceptionnelle, dans le cas où toutes les protections appropriées empêchent le fonctionnement prévu de l'équipement
	Exemple: protection mise en place sous forme d'instructions permettant de déconnecter le câble de télécommunication avant de soulever le couvercle	Exemple: après l'ouverture d'une porte, protection mise en place sous forme d'instructions contre les parties chaudes	Exemple: protection mise en place sous forme d'instructions des parties chaudes dans une photocopieuse de bureau, ou d'un massicot à rouleau continu sur une imprimante du commerce

0.6 Douleurs ou blessures dues à l'électricité (choc électrique)

0.6.1 Généralités

Le présent paragraphe décrit des modèles pour les douleurs ou blessures dues à l'électricité et des modèles pour réduire la probabilité de transfert d'énergie électrique pouvant provoquer une douleur ou blessure sur une partie du corps.

0.6.2 Modèles pour des douleurs ou blessures dues à l'électricité

Une douleur ou une blessure due à l'électricité peut survenir quand un courant électrique susceptible de provoquer une douleur ou une blessure est transféré vers une partie du corps (voir la Figure 3).

Un transfert d'énergie électrique se produit lorsqu'il existe au moins deux contacts électriques avec le corps:

- le premier contact électrique se situe entre une partie du corps et une partie conductrice de l'équipement;
- le deuxième contact électrique se situe entre une autre partie du corps, et
 - la terre, ou
 - une autre partie conductrice de l'équipement.

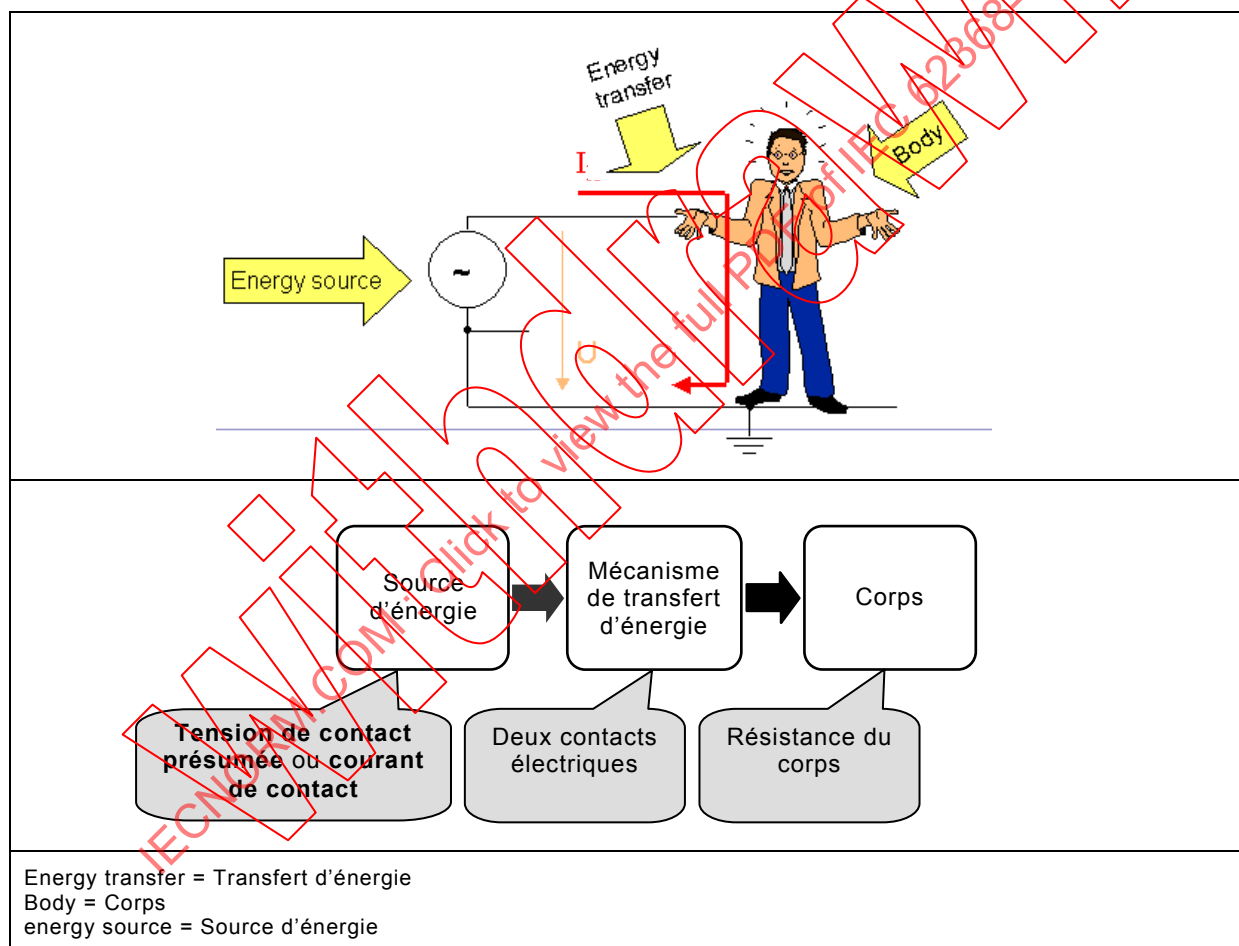


Figure 3 – Schéma et modèle pour les douleurs ou les blessures dues à l'électricité

En fonction de l'amplitude, de la durée, de la forme d'onde et de la fréquence du courant, l'effet sur le corps humain peut être indétectable, détectable ou douloureux et peut aller jusqu'à provoquer une blessure.

0.6.3 Modèles pour se protéger contre les douleurs ou blessures dues à l'électricité

Pour se protéger contre les douleurs ou blessures dues à l'électricité, il est nécessaire qu'une ou plusieurs **protections** soient interposées entre la source d'alimentation électrique pouvant provoquer une douleur ou une blessure et une partie du corps (voir la Figure 4).

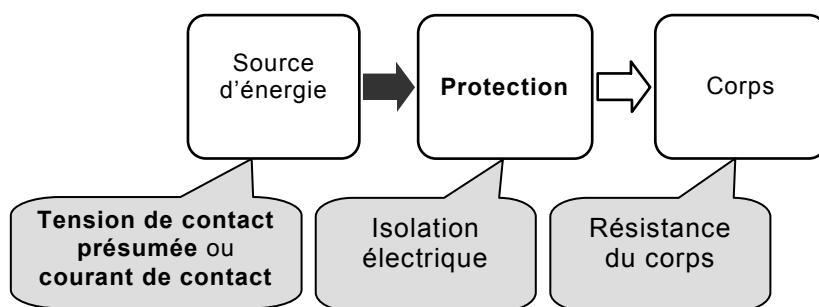


Figure 4 – Modèle pour se protéger contre les douleurs ou blessures dues à l'électricité

Une protection contre les douleurs dues à l'électricité est prévue dans les **conditions normales de fonctionnement** et les **conditions anormales de fonctionnement**. Une protection de ce type exige que, dans les **conditions normales de fonctionnement** et dans les **conditions anormales de fonctionnement**, une **protection principale** soit interposée entre une source d'énergie électrique pouvant provoquer une douleur et une **personne ordinaire**.

La **protection principale** la plus courante contre une source d'énergie électrique pouvant provoquer une douleur est l'isolation électrique (également appelée **isolation principale**) interposée entre la source d'énergie et une partie du corps.

Il est prévu de se protéger contre les blessures dues à l'électricité dans les **conditions normales de fonctionnement**, dans les **conditions anormales de fonctionnement**, et dans les **conditions de premier défaut**. Une protection de ce type exige que, dans les **conditions normales de fonctionnement** et dans les **conditions anormales de fonctionnement**, à la fois une **protection principale** et une **protection supplémentaire** soient interposées entre la source d'alimentation électrique pouvant provoquer une blessure et une **personne ordinaire** (voir 4.3.2.4), ou une **personne avertie** (voir 4.3.3.3). En cas de dysfonctionnement de l'une des **protections**, l'autre **protection** devient effective.

La **protection supplémentaire** contre une source d'alimentation électrique pouvant provoquer une blessure est interposée entre la **protection principale** et une partie du corps. Une **protection supplémentaire** peut être une isolation électrique supplémentaire (**isolation supplémentaire**) ou une barrière conductrice mise à la terre, voire une autre construction qui réalise la même fonction.

La **protection** la plus courante contre une source d'alimentation électrique pouvant provoquer une blessure est l'isolation électrique (également appelée **double isolation** ou **isolation renforcée**) interposée entre la source d'énergie et une partie du corps.

De même, une **protection renforcée** peut être interposée entre une source d'alimentation électrique pouvant provoquer une blessure et une partie du corps.

0.7 Incendie d'origine électrique

0.7.1 Généralités

Le présent paragraphe décrit des modèles pour réduire la probabilité d'inflammation (à l'intérieur de l'équipement) ou pour réduire la probabilité qu'un incendie (survenu à l'intérieur de l'équipement) ne se propage au-delà de l'équipement.

0.7.2 Modèles pour les incendies d'origine électrique

Un incendie d'origine électrique est causé par la conversion d'énergie électrique en énergie thermique (voir la Figure 5), lorsque l'énergie thermique chauffe un matériau combustible, entraînant son inflammation et sa combustion.

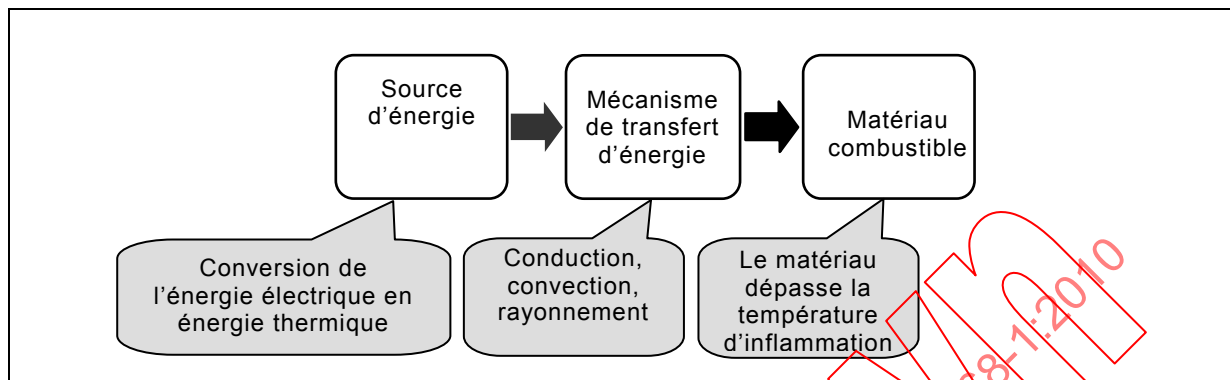


Figure 5 – Modèle pour les incendies d'origine électrique

Une énergie électrique est convertie en énergie thermique soit dans une résistance soit dans un arc, et est transférée vers un matériau combustible par conduction, convection ou rayonnement. À mesure que le matériau combustible chauffe, il se décompose chimiquement en gaz, en liquides et en solides. Une source d'inflammation peut enflammer le gaz, lorsque celui-ci a atteint sa température d'inflammation. Lorsque le gaz a atteint sa température d'inflammation spontanée, l'inflammation de ce dernier est automatique. Les deux cas entraînent un incendie.

0.7.3 Modèles pour se protéger contre les incendies d'origine électrique

La **protection principale** contre les incendies d'origine électrique (voir la Figure 6) consiste à maintenir le matériau à une température, dans les **conditions normales de fonctionnement** et dans les **conditions anormales de fonctionnement**, qui n'entraîne pas d'inflammation du matériau.

La **protection supplémentaire** contre les incendies d'origine électrique réduit la probabilité d'inflammation ou, en cas d'inflammation, réduit la probabilité de propagation de l'incendie.

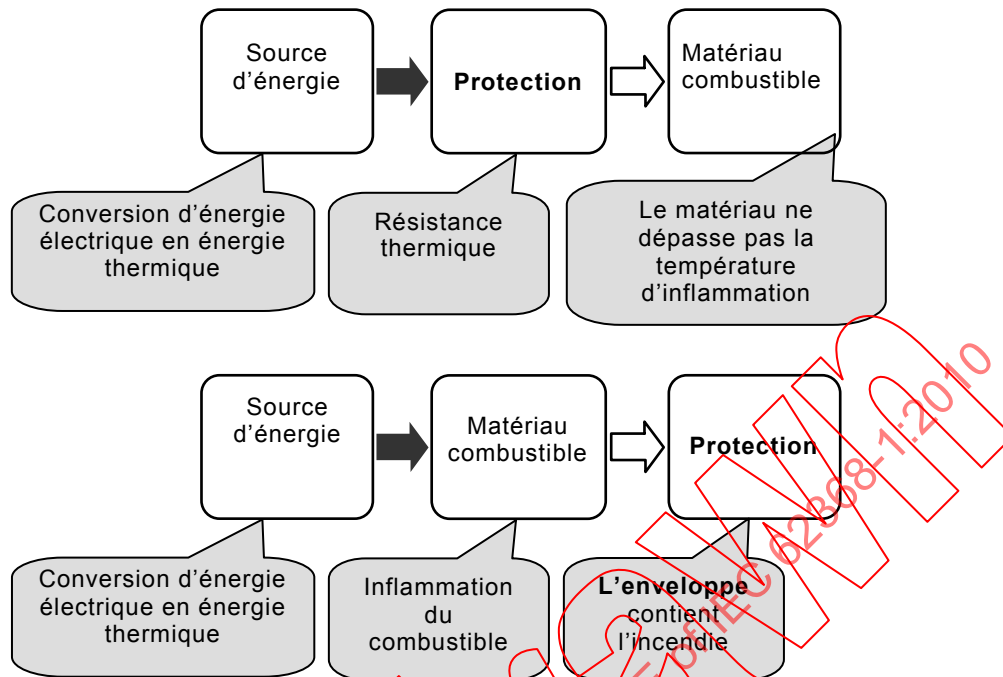


Figure 6 – Modèles pour se protéger contre les incendies

0.8 Blessures dues à des substances chimiques

Le présent paragraphe décrit des modèles à suivre pour réduire la probabilité de blessure due à une exposition à des substances chimiques.

Les blessures dues à des substances chimiques sont provoquées par une réaction chimique avec une partie du corps. L'étendue des blessures causées par un agent donné dépend à la fois de l'amplitude et de la durée de l'exposition et de la sensibilité de la partie du corps concernée à cet agent.

La **protection principale** contre les blessures dues à des substances chimiques est le confinement du matériau.

Les **protections supplémentaires** contre les blessures dues à des substances chimiques peuvent comprendre:

- un second récipient ou un récipient résistant au débordement;
- des enceintes de confinement;
- des vis inviolables pour empêcher l'accès non autorisé;
- des **protections mises en place sous forme d'instructions**.

Les réglementations nationales et régionales régissent l'utilisation de et l'exposition à des substances chimiques utilisées dans l'équipement. Ces réglementations ne permettent pas une classification pratique des substances chimiques semblable à la classification des autres sources d'alimentation dans la présente norme. Par conséquent, la classification des sources d'alimentation ne s'applique pas dans l'Article 7.

0.9 Blessures dues à un choc mécanique

Le présent paragraphe décrit des modèles pour réduire la probabilité des blessures telles que les coupures, les ecchymoses, les fractures osseuses, etc. dues au transfert d'énergie cinétique vers une partie du corps.

Les blessures dues à un choc mécanique sont dues au transfert d'énergie cinétique vers une partie du corps lorsqu'une collision se produit entre ladite partie et une partie de l'équipement. L'énergie cinétique est fonction du mouvement relatif entre une partie du corps et les parties **accessibles** de l'équipement, y compris les parties éjectées de l'équipement qui entrent en collision avec une partie du corps.

Exemples de sources d'énergie cinétique:

- mouvement du corps par rapport aux angles et aux arêtes vives;
- mouvement d'une partie dû à la rotation ou à d'autres parties mobiles, y compris les bouts rétreints;
- mouvement d'une partie dû au desserrage, à l'explosion ou à l'implosion de parties;
- mouvement de l'équipement dû à l'instabilité;
- mouvement de l'équipement dû à un défaut du mur, du plafond, ou du montage;
- mouvement de l'équipement dû à un défaut d'une poignée;
- mouvement d'une partie dû à une explosion de la batterie;
- mouvement de l'équipement dû à une instabilité ou à un défaut du chariot ou du support.

La **protection principale** contre les blessures dues à un choc mécanique est fonction de la source d'énergie spécifique. Les **protections principales** peuvent être:

- des arêtes et des angles arrondis;
- une **enveloppe** pour empêcher une partie mobile d'être **accessible**;
- une **enveloppe** pour empêcher la projection d'une partie mobile;
- un **verrouillage de sécurité** pour contrôler l'accès à une autre partie mobile;
- un moyen d'arrêter le mouvement d'une partie mobile;
- un moyen de stabiliser l'équipement;
- des poignées;
- des moyens de montage;
- des moyens de retenir les parties projetées lors d'une **explosion** ou d'une implosion.

La **protection supplémentaire** contre les blessures dues à un choc mécanique dépend de la source d'énergie spécifique. Les **protections supplémentaires** peuvent être:

- des **protections mises en place sous forme d'instructions**;
- des instructions et une formation;
- des **enveloppes** ou des barrières supplémentaires;
- des **verrouillages de sécurité**.

La **protection renforcée** contre les blessures dues à un choc mécanique dépend de la source d'énergie spécifique. Les **protections renforcées** peuvent être:

- du verre extra-épais à l'avant d'un tube cathodique;
- des rails de glissière et des moyens de support;
- un **verrouillage de sécurité**.

0.10 Blessures dues à la chaleur (brûlure de la peau)

0.10.1 Généralités

Le présent paragraphe décrit des modèles pour les blessures dues à la chaleur et des modèles pour réduire la probabilité qu'une énergie thermique puisse provoquer une douleur ou blessure lors de son transfert vers une partie du corps.

0.10.2 Modèles pour les blessures dues à la chaleur

Une blessure due à la chaleur peut survenir lorsque de l'énergie thermique susceptible de provoquer une blessure est transférée vers une partie du corps (voir la Figure 7).

Un transfert d'énergie thermique se produit lorsqu'un corps entre en contact avec une partie chaude de l'équipement. L'étendue de la blessure dépend de la différence de température, de la masse thermique de l'objet, du débit de transfert d'énergie thermique vers la peau et de la durée du contact.

Les exigences de la présente norme concernent uniquement les **protections** contre un transfert d'énergie thermique par conduction. Cette norme ne traite pas des **protections** contre le transfert d'énergie thermique par convection ou rayonnement.

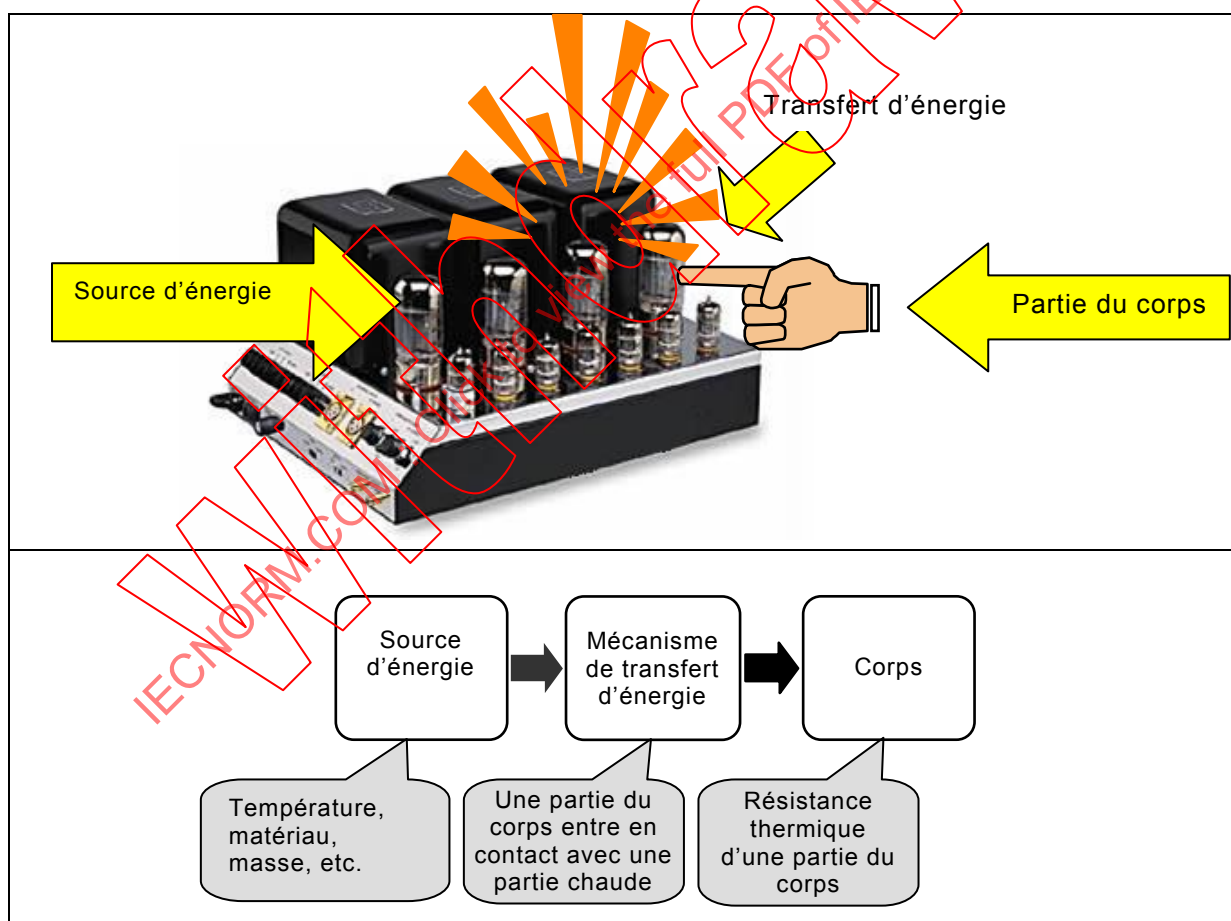


Figure 7 – Schéma et modèle pour les blessures dues à la chaleur

En fonction de la température, de la durée du contact, des propriétés du matériau et de la masse du matériau, la perception du corps humain peut aller d'une chaleur douce à une forte chaleur pouvant entraîner une douleur ou une blessure (brûlure).

0.10.3 Modèles pour se protéger contre les douleurs ou blessures dues à la chaleur

Pour se protéger contre les douleurs ou blessures dues à la chaleur, il est nécessaire qu'une ou plusieurs **protections** soient interposées entre une source d'énergie thermique pouvant provoquer une douleur ou une blessure et une **personne ordinaire** (voir la Figure 8).

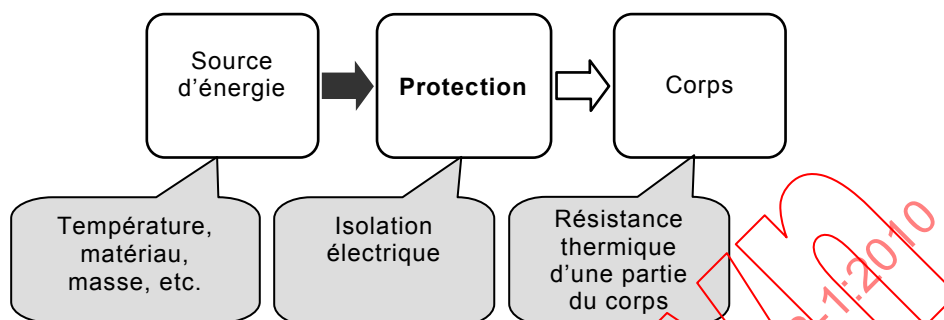


Figure 8 – Modèle pour se protéger contre les blessures dues à la chaleur

Une protection contre les douleurs dues à la chaleur est nécessaire dans les **conditions normales de fonctionnement** et dans les **conditions anormales de fonctionnement**. Une protection de ce type exige qu'une **protection principale** soit interposée entre une source d'énergie thermique pouvant provoquer une douleur et une **personne ordinaire**.

Une protection contre les blessures dues à la chaleur est nécessaire dans les **conditions normales de fonctionnement**, dans les **conditions anormales de fonctionnement** et dans les **conditions de premier défaut**. Une protection de ce type exige qu'une **protection principale** et une **protection supplémentaire** soient interposées entre une source d'énergie thermique pouvant provoquer une blessure et une **personne ordinaire**.

La **protection principale** contre une source d'énergie thermique pouvant provoquer une douleur ou une blessure est l'isolation thermique interposée entre la source d'énergie et une partie du corps. Dans certains cas, une **protection principale** contre une source d'énergie thermique pouvant provoquer une douleur ou une blessure peut être une **protection mise en place sous forme d'instructions** identifiant les parties chaudes et le moyen de réduire la probabilité d'une blessure. Dans certains cas, une **protection principale** réduit la probabilité qu'une source d'énergie thermique ne pouvant pas provoquer de blessure se transforme en source d'énergie thermique pouvant provoquer une douleur ou une blessure.

Des exemples de **protections principales** de ce type sont:

- le contrôle de la conversion d'énergie électrique en énergie thermique (par exemple, un **thermostat**);
- la dissipation de chaleur, etc.

La **protection supplémentaire** contre une source d'énergie thermique pouvant provoquer une blessure est l'isolation thermique interposée entre la source d'énergie et une partie du corps. Dans certains cas, une **protection supplémentaire** contre une source d'énergie thermique pouvant provoquer une douleur ou une blessure peut être une **protection mise en place sous forme d'instructions** identifiant les parties chaudes et le moyen de réduire la probabilité d'une blessure.

0.11 Blessures dues à des rayonnements

Le présent paragraphe décrit des modèles pour réduire la probabilité de blessure due à une exposition à une source d'énergie diffusée sous forme de rayonnements.

Les blessures dues au rayonnement relevant du domaine d'application de la présente norme sont généralement attribuées à l'un des mécanismes de transfert d'énergie suivants:

- montée en température d'un organe du corps provoquée par une exposition à un rayonnement non ionisant, comme l'énergie fortement localisée d'un laser dirigé sur la rétine, ou l'échauffement d'un volume plus grand comme l'énergie provenant d'un transmetteur sans fil à haute fréquence, de champs électromagnétiques, ou d'un émetteur HF, ou
- blessure auditive provoquée par une sur-stimulation de l'oreille par des pics excessifs ou des sons graves répétés, entraînant un endommagement physique ou nerveux.

L'énergie rayonnée est transférée par l'impact d'une onde émise sur une partie du corps.

La **protection principale** contre les blessures dues à un rayonnement est le confinement de l'énergie dans une **enveloppe** opaque à l'énergie rayonnée.

La **protection principale** contre les blessures auditives consiste à prévoir des messages d'avertissement et d'information pour expliquer à l'utilisateur comment manipuler l'équipement correctement.

Des exemples de **protections principales** contre les douleurs ou les blessures auditives consistent à prévoir des messages d'avertissement et d'information pour expliquer à l'utilisateur comment manipuler l'équipement correctement. Des exemples de **protections supplémentaires** contre les blessures auditives consistent à prévoir un **verrouillage de sécurité** ou une **enveloppe** hermétique aux sons.

Il existe plusieurs **protections supplémentaires** contre les blessures dues au rayonnement. Les **protections supplémentaires** peuvent comprendre des **verrouillages de sécurité** pour déconnecter l'alimentation du générateur, des vis inviolables pour empêcher l'accès non autorisé, etc.

ÉQUIPEMENTS DES TECHNOLOGIES DE L'AUDIO/VIDÉO, DE L'INFORMATION ET DE LA COMMUNICATION –

Partie 1: Exigences de sécurité

1 Domaine d'application

La présente partie de la CEI 62368 s'applique à la sécurité de l'équipement électrique et électronique dans le domaine des technologies audio, vidéo, d'information et de communication, et des machines commerciales ou de bureau dont la **tension assignée** est inférieure ou égale à 600 V. La présente norme ne contient ni les exigences de performances ni les caractéristiques fonctionnelles de l'équipement.

NOTE 1 Des exemples d'équipement relevant du domaine d'application de la présente norme sont donnés dans l'Annexe A.

La présente partie de la CEI 62368 s'applique également aux composants et aux sous-ensembles destinés à être intégrés dans cet équipement. Il n'est pas nécessaire que ces composants et ces sous-ensembles soient conformes à toutes les exigences présentées dans la norme, à condition que l'équipement complet, qui intègre ces composants et sous-ensembles, le soit.

Cette norme spécifie des **protections** pour les **personnes ordinaires**, les **personnes averties**, et les **personnes qualifiées**.

NOTE 2 En Australie, les opérations effectuées par une **personne avertie** ou par une **personne qualifiée** peuvent nécessiter une licence formelle de la part des autorités de réglementation.

La présente norme pose l'hypothèse d'une altitude de 2 000 m sauf spécification contraire du fabricant.

La présente norme ne s'applique pas aux équipements destinés à être utilisés dans des régions humides. Des exigences supplémentaires peuvent s'appliquer.

Cette norme ne s'applique pas aux équipements prévus pour une installation à l'extérieur.

NOTE 3 Les équipements de technologie de l'information et de la communication prévus pour une utilisation à l'extérieur sont traités dans la CEI 60950-22.

La présente norme ne contient pas d'exigences relatives à la sécurité fonctionnelle.

NOTE 4 Pour les exigences spécifiques relatives à la sécurité fonctionnelle et à la sûreté logicielle des systèmes électroniques liés à la sécurité (par exemple, les circuits électroniques de protection), voir la CEI 61508-1.

La présente norme ne traite pas:

- des processus de fabrication, à l'exception des essais de sécurité;
- des effets pouvant provoquer des blessures des gaz libérés par la décomposition ou la combustion thermique;
- des processus de destruction;
- des effets du transport (autres que ceux spécifiés dans la présente norme);
- des effets du stockage des matériaux, des composants ou de l'équipement lui-même;
- de la probabilité de blessures provoquées par un rayonnement particulaire, par exemple de particules alpha et bêta;

- de la probabilité de blessures thermiques dues à une énergie thermique de rayonnement ou de convection;
- de la probabilité de blessures provoquées par des liquides inflammables;
- de l'utilisation de l'équipement dans des atmosphères enrichies en oxygène ou **explosives**;
- de l'exposition à des substances chimiques autres que celles spécifiées dans l'Article 7;
- des décharges électrostatiques.

2 Références normatives

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).

CEI 60027-1, *Symboles littéraux à utiliser en électrotechnique – Partie 1: Généralités*

CEI 60065, *Appareils audio, vidéo et appareils électroniques analogues – Exigences de sécurité*

CEI 60068-2-6, *Essais d'environnement – Partie 2-6: Essais – Essai Fc: Vibrations (sinusoïdales)*

CEI 60068-2-78, *Essais d'environnement – Partie 2-78: Essais – Essai Cab: Chaleur humide, essai continu*

CEI 60079-10-1, *Atmosphères explosives – Partie 10-1: Classement des emplacements – Atmosphères explosives gazeuses*

CEI/TR 60083, *Prises de courant pour usages domestiques et analogues normalisées par les pays membres de la CEI*

CEI 60085, *Isolation électrique – Evaluation et désignation thermiques*

CEI 60086-4, *Piles électriques – Partie 4: Sécurité des piles au lithium*

CEI 60107-1:1997, *Méthodes de mesures applicables aux récepteurs de télévision – Partie 1: Considérations générales – Mesures aux domaines radiofréquences et vidéofréquences*

CEI 60112, *Méthode de détermination des indices de résistance et de tenue au cheminement des matériaux isolants solides*

CEI 60127 (toutes les parties), *Coupe-circuit miniatures*

CEI 60127-1:2006, *Miniature fuses – Part 1: Definitions for miniature fuses and general requirements for miniature fuse-links* (disponible en anglais uniquement)

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 60227-7:2003, *Conducteurs et câbles isolés au polychlorure de vinyle, de tension nominale au plus égale à 450/750 V – Partie 7: Câbles souples avec et sans écran, à deux âmes ou plus*

CEI 60245-1:2003, *Conducteurs et câbles isolés au caoutchouc – Tension assignée au plus égale à 450/750 V – Partie 1: Exigences générales*

CEI 60309-1, *Prises de courant pour usages industriels – Partie 1: Règles générales*

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 60320-1, *Connecteurs pour usages domestiques et usages généraux analogues – Partie 1: Prescriptions générales*

CEI 60320-2-2, *Connecteurs pour usages domestiques et usages généraux analogues – Partie 2-2: Connecteurs d'interconnexion pour matériels électriques domestiques et analogues*

CEI 60332-1-2, *Essais des câbles électriques et à fibres optiques soumis au feu – Partie 1-2: Essai de propagation verticale de la flamme sur conducteur ou câble isolé – Procédure pour flamme à prémélange de 1 kW*

CEI 60332-1-3, *Essais des câbles électriques et à fibres optiques soumis au feu – Partie 1-3: Essai de propagation verticale de la flamme sur conducteur ou câble isolé – Procédure pour la détermination des particules/gouttelettes enflammées*

CEI 60332-2-1, *Essais des câbles électriques et à fibres optiques soumis au feu – Partie 2-1: Essai de propagation verticale de la flamme sur conducteur ou câble isolé de petite section – Appareillage d'essai*

CEI 60332-2-2, *Essais des câbles électriques et à fibres optiques soumis au feu – Partie 2-2: Essai de propagation verticale de la flamme sur conducteur ou câble isolé de petite section – Procédure pour une flamme de type à diffusion*

CEI 60384-14:2005, *Fixed capacitors for use in electronic equipment – Part 14: Sectional specification: Fixed capacitors for electromagnetic interference suppression and connection to the supply mains* (disponible en anglais uniquement)

CEI 60417, *Symboles graphiques utilisables sur le matériel*

CEI 60505, *Évaluation et qualification des systèmes d'isolation électrique*

CEI 60529, *Degrés de protection procurés par les enveloppes (Code IP)*

CEI 60664-1:2007, *Coordination de l'isolement des matériels dans les systèmes (réseaux) à basse tension – Partie 1: Principes, exigences et essais*

CEI 60664-3:2003, *Coordination de l'isolement des matériels dans les systèmes (réseaux) à basse tension – Partie 3: Utilisation de revêtement, d'empotage ou de moulage pour la protection contre la pollution*

CEI 60664-4:2005, *Coordination de l'isolement des matériels dans les systèmes (réseaux) à basse tension – Partie 4: Considérations sur les contraintes de tension à haute fréquence*

CEI 60691:2002, *Protecteurs thermiques – Prescriptions et guide d'application*

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 60695-11-5:2004, *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 60695-11-20:1999, *Essais relatifs aux risques du feu – Partie 11-20: Flammes d'essai – Méthodes d'essai à la flamme de 500 W*

CEI/TS 60695-11-21, *Essais relatifs aux risques du feu – Partie 11-21: Flammes d'essai – Méthodes d'essai à la flamme de 500 W pour matériaux tubulaires polymères*

CEI 60728-11:2005, *Cable networks for television signals, sound signals and interactive services – Part 11: Safety* (disponible en anglais uniquement)

CEI 60730 (toutes les parties), *Dispositifs de commande électrique automatiques à usage domestique et analogue*

CEI 60730-1:1999, *Dispositifs de commande électrique automatiques à usage domestique et analogue – Partie 1: Règles générales*

IEC 60738-1, *Thermistors – Directly heated positive temperature coefficient – Part 1: Generic specification* (disponible en anglais uniquement)

CEI 60747-5-5: 2007, *Dispositifs à semi-conducteurs – Dispositifs discrets – Partie 5-5: Dispositifs optoélectroniques – Photocoupleurs*

CEI 60825 (toutes les parties), *Sécurité des appareils à laser*

CEI 60825-1:2007, *Sécurité des appareils à laser – Partie 1: Classification des matériels et exigences*

CEI 60825-2:2004, *Sécurité des appareils à laser – Partie 2: Sécurité des systèmes de télécommunication par fibres optiques (STFO)*

CEI 60825-12:2004, *Sécurité des appareils à laser – Partie 12: Sécurité des systèmes de communications optiques en espace libre utilisés pour la transmission d'informations*

CEI 60851-3:2009, *Fils de bobinage – Méthodes d'essai – Partie 3: Propriétés mécaniques*

CEI 60851-5:2008, *Fils de bobinage – Méthodes d'essai – Partie 5: Propriétés électriques*

CEI 60851-6:1996, *Fils de bobinage – Méthodes d'essai – Partie 6: Propriétés thermiques*

CEI 60896-11, *Batteries stationnaires au plomb – Partie 11: Batteries au plomb du type ouvert – Prescriptions générales et méthodes d'essai*

CEI 60896-21:2004, *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 60906-1, *Système CEI de prises de courant pour usages domestiques et analogues – Partie 1: Prises de courant 16 A à 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, *Appareillage à basse tension – Partie 1: Règles générales*

CEI 60950-1:2005, *Matériels de traitement de l'information – Sécurité – Partie 1: Exigences générales*

CEI 60950-23, *Matériels de traitement de l'information – Sécurité – Partie 23: Matériels de grande taille pour le stockage des données*

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 mm² à 35 mm² (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 mm² et jusqu'à 300 mm² (inclus)*

CEI 61051-2:1991, *Varistances utilisées dans les équipements électroniques – Deuxième partie: Spécification intermédiaire pour varistances pour limitations de surtensions transitoires*

CEI 61056-1, *Batteries d'accumulateurs au plomb-acide pour usage général (types à soupapes) – Partie 1: Prescriptions générales et caractéristiques fonctionnelles – Méthode d'essai*

CEI 61056-2, *Batteries d'accumulateurs au plomb-acide pour usage général (types à soupapes) – Partie 2: Dimensions, bornes et marquage*

CEI 61058-1:2000, *Interrupteurs pour appareils – Partie 1: Règles générales*

CEI 61140:2001, *Protection contre les chocs électriques – Aspects communs aux installations et aux matériels*

CEI/TS 61201:2007, *Utilisation des tensions limites conventionnelles de contact – Guide d'application*

CEI 61204-7, *Alimentations basse tension, sortie continue – Partie 7: Exigences de sécurité*

CEI 61293, *Marquage des matériels électriques avec des caractéristiques assignées relatives à l'alimentation électrique – Prescriptions de sécurité*

CEI 61427, *Accumulateurs pour les systèmes photovoltaïques (SPV) – Exigences générales et méthodes d'essais*

CEI/TS 61430, *Accumulateurs – Méthodes d'essai pour la vérification de la performance des dispositifs conçus pour réduire les risques d'explosion – Batteries de démarrage au plomb*

CEI 61434, *Accumulateurs alcalins et autres accumulateurs à électrolyte non acide – Guide pour l'expression des courants dans les normes d'accumulateurs alcalins*

CEI 61558-1:2005, *Sécurité des transformateurs, alimentations, bobines d'inductance et produits analogues – Partie 1: Exigences générales et essais*

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CEI 61810-1:2008, *Electromechanical elementary relays – Part 1: General requirements* (disponible en anglais uniquement)

CEI 61959, *Accumulateurs alcalins et autres accumulateurs à électrolyte non acide – Essais mécaniques pour accumulateurs portables étanches*

CEI 61960, *Accumulateurs alcalins et autres accumulateurs à électrolyte non acide – Éléments et batteries d'accumulateurs au lithium pour applications portables*

CEI 61965:2003, *Mechanical safety of cathode ray tubes* (disponible en anglais uniquement)

CEI 61984, *Connecteurs – Exigences de sécurité et essais*

CEI 62133, *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 62282-2, *Technologies des piles à combustible – Partie 2: Modules de piles à combustible*

CEI/TS 62393, *Portable and hand-held multimedia equipment – Mobile computers – Battery run-time measurement* (disponible en anglais uniquement)

CEI 62471:2006, *Sécurité photobiologique des lampes et des appareils utilisant des lampes*

CEI 62485-2, *Exigences de sécurité pour les batteries d'accumulateurs et les installations de batteries – Partie 2: Batteries stationnaires*¹

ISO 178, *Plastiques – Détermination des propriétés en flexion*

ISO 179-1, *Plastiques – Détermination de la résistance au choc Charpy – Partie 1: Essai de choc non instrumenté*

ISO 180, *Plastiques – Détermination de la résistance au choc Izod*

ISO 306, *Plastiques – Matières thermoplastiques – Détermination de la température de ramollissement Vicat (VST)*

ISO 527 (toutes les parties) – *Plastiques – Détermination des propriétés en traction*

¹ A publier.

ISO 871, *Plastiques – Détermination de la température d'allumage au moyen d'un four à air chaud*

ISO 3864 (toutes les parties), *Symboles graphiques – Couleurs de sécurité et signaux de sécurité*

ISO 3864-2, *Symboles graphiques – Couleurs de sécurité et signaux de sécurité – Partie 2: Principes de conception pour l'étiquetage de sécurité des produits*

ISO 4046-4:2002, *Papier, carton, pâtes et termes connexes – Vocabulaire – Partie 4: Catégories et produits transformés de papier et de carton*

ISO 4892-1, *Plastiques – Méthodes d'exposition à des sources lumineuses de laboratoire – Partie 1: Guide général*

ISO 4892-2:2006, *Plastiques – Méthodes d'exposition à des sources lumineuses de laboratoire – Partie 2: Lampes à arc au xénon*

ISO 4892-4, *Plastiques – Méthodes d'exposition à des sources lumineuses de laboratoire – Partie 4: Lampes à arc au carbone*

ISO 7000:2004, *Symboles graphiques utilisables sur le matériel – Index et tableau synoptique*

ISO 7010, *Symboles graphiques – Couleurs de sécurité et signaux de sécurité – Signaux de sécurité utilisés sur les lieux de travail et dans les lieux publics*

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*

3 Termes, définitions et abréviations

3.1 Généralités

Le présent article a été sous-divisé en « termes et abréviations » et « définitions ». Sauf spécification contraire, lorsque les mots « tension » et « courant » sont utilisés, il s'agit de valeurs efficaces.

3.2 Termes et abréviations

3.2.1 Termes dans l'ordre alphabétique

Terme	Description	
ES	Source d'énergie électrique	voir 5.2
ES1	Source d'énergie électrique de classe 1	
ES2	Source d'énergie électrique de classe 2	
ES3	Source d'énergie électrique de classe 3	
MS	Source d'énergie mécanique	voir 8.2
MS1	Source d'énergie mécanique de classe 1	
MS2	Source d'énergie mécanique de classe 2	

Terme	Description	
MS3	Source d'énergie mécanique de classe 3	
PS	Source d'énergie de puissance	voir 6.2
PS1	Source d'énergie de puissance classe 1	
PS2	Source d'énergie de puissance classe 2	
PS3	Source d'énergie de puissance classe 3	
RS	Source d'énergie par rayonnement	Voir 10.2
RS1	Source d'énergie par rayonnement de classe 1	
RS2	Source d'énergie par rayonnement de classe 2	
RS3	Source d'énergie par rayonnement de classe 3	
TS	Source d'énergie thermique	Voir 9.2
TS1	Source d'énergie thermique de classe 1	
TS2	Source d'énergie thermique de classe 2	
TS3	Source d'énergie thermique de classe 3	

3.2.2 Abréviations dans l'ordre alphabétique

CD	Disque compact
CD ROM	Disque optique compact
CRT	Tube cathodique (<i>cathode ray tube</i>)
IRC	Indice de résistance au cheminement
DVD	Disque numérique polyvalent
EIS	Système d'isolation électrique (<i>electrical insulation system</i>)
EUT	Équipement soumis à essai
IC	Circuits intégrés (<i>integrated circuits</i>)
LEL	Limite inférieure d'explosivité (<i>lower explosion limit</i>)
LFC	Composant à remplissage liquide (<i>Liquid Filled Component</i>)
LPS	Source d'alimentation limitée (<i>Limited Power Source</i>)
MOV	Varistances à oxyde métallique (<i>Metal Oxide Varistor</i>)
NiCd	Cadmium-nickel
EPI	Équipement de protection individuelle
CTP	Coefficient de température positif
Sb	Antimoine
SPD	Dispositifs de protection contre les surtensions (<i>Surge Protection Devices</i>)
UPS	Alimentation sans interruption (<i>Uninterruptible Power Supply</i>)
VDR	Varistance
VRLA	Plomb acide étanche à soupapes

3.3 Termes et définitions

Pour les besoins du présent document, les termes et définitions suivants s'appliquent. Pour le confort de l'utilisateur, les termes définis sont énumérés ci-dessous dans l'ordre alphabétique, avec indication du numéro afférent au terme défini.

accessible	3.3.6.1
zone à accès limité	3.3.6.6
étamine	3.3.6.2
substance chimique dangereuse	3.3.16.4
circuit externe	3.3.1.1
classification d'inflammabilité du matériau	3.3.4.2
distance d'isolement dans l'air	3.3.12.1
conditions anormales de fonctionnement	3.3.7.1
conditions normales de fonctionnement	3.3.7.4
condition de surcharge	3.3.7.5
condition de premier défaut	3.3.7.10
conducteur de protection	3.3.11.9
conducteur de liaison de protection	3.3.11.8
conducteur de mise à la terre de protection	3.3.11.10
construction de classe II	3.3.15.2
câble d'alimentation fixé à demeure	3.3.6.4
courant de conducteur de protection	3.3.14.6
courant de charge maximale	3.3.14.3
courant assigné	3.3.10.1
courant de contact	3.3.6.10
disjoncteur thermique	3.3.13.4
degré de pollution	3.3.6.5
dispositif de déconnexion	3.3.6.3
ligne de fuite	3.3.12.2
enveloppe	3.3.2.2
enveloppe électrique	3.3.2.1
enveloppe ignifuge	3.3.2.3
enveloppe mécanique	3.3.2.4
équipement de classe I	3.3.15.1
équipement de classe II	3.3.15.3
équipement de classe III	3.3.15.4
équipement à enficher directement	3.3.3.1
équipement portatif	3.3.3.2
équipement mobile	3.3.3.3
équipement relié en permanence	3.3.3.4
équipement de protection individuelle (EPI)	3.3.16.5
équipement enfichable, de type A	3.3.3.5
équipement enfichable, de type B	3.3.3.6
équipement stationnaire	3.3.3.7
équipement transportable	3.3.3.8
explosion	3.3.16.2
explosif	3.3.16.3
fréquence de réponse crête	3.3.7.6
fréquence assignée	3.3.10.2
impédance assignée de charge	3.3.7.7
isolation principale	3.3.5.1
double isolation	3.3.5.2
isolation fonctionnelle	3.3.5.3
isolation renforcée	3.3.5.4
isolation réalisée avec un isolant solide	3.3.5.5
isolation supplémentaire	3.3.5.6
verrouillage de sécurité	3.3.11.13
limiteur de température	3.3.13.3
réseau d'alimentation	3.3.1.2
matériau de classe 5VA	3.3.4.2.1

matériau de classe 5VB	3.3.4.2.2
matériau combustible	3.3.4.1
matériau consommable	3.3.16.1
matériau de classe HB40	3.3.4.2.3
matériau de classe HB75	3.3.4.2.4
matériau plastique cellulaire de classe HBF	3.3.4.2.5
matériau plastique cellulaire de classe HF-1	3.3.4.2.6
matériau plastique cellulaire de classe HF-2	3.3.4.2.7
matériau de classe V-0	3.3.4.2.8
matériau de classe V-1	3.3.4.2.9
matériau de classe V-2	3.3.4.2.10
matériau de classe VTM-0	3.3.4.2.11
matériau de classe VTM-1	3.3.4.2.12
matériau de classe VTM-2	3.3.4.2.13
mauvais usage raisonnablement prévisible	3.3.7.8
fonctionnement intermittent	3.3.7.2
fonctionnement de courte durée	3.3.7.9
personne avertie	3.3.8.1
personne ordinaire	3.3.8.2
personne qualifiée	3.3.8.3
source potentielle d'incendie causé par la formation d'un arc électrique	3.3.9.2
source potentielle d'incendie causé par un phénomène de résistivité	3.3.9.3
puissance de sortie non écrêtée	3.3.7.3
puissance assignée	3.3.10.3
plage de tensions assignées	3.3.10.5
caractéristiques assignées du courant de protection	3.3.10.6
protection	3.3.11.12
protection principale	3.3.11.1
double protection	3.3.11.2
protection de l'équipement	3.3.11.3
protection de l'installation	3.3.11.4
protection mise en place sous forme d'instructions	3.3.11.5
protection individuelle	3.3.11.6
protection de précaution	3.3.11.7
protection renforcée	3.3.11.11
protection mise en place grâce à l'expérience acquise	3.3.11.14
protection supplémentaire	3.3.11.15
source potentielle d'incendie (PIS – <i>potential ignition source</i>)	3.3.9.1
température de charge la plus élevée	3.3.13.1
température de charge la moins élevée	3.3.13.2
essai individuel de série	3.3.6.7
essai sur prélèvement	3.3.6.8
essai de type	3.3.6.11
thermostat	3.3.13.5
papier mousseline	3.3.6.12
outil	3.3.6.9
tension continue	3.3.14.1
tension transitoire du réseau d'alimentation	3.3.14.2
valeur de crête de la tension de service	3.3.14.4
tension de contact présumée	3.3.14.5
tension de service efficace	3.3.14.8
tension assignée	3.3.10.4
tension de tenue prescrite	3.3.14.7
tension supérieure de tension de charge	3.3.14.9
tension de service	3.3.14.10

3.3.1 Termes relatifs aux circuits

3.3.1.1

circuit externe

circuit électrique qui est externe à l'équipement et n'est pas un **réseau d'alimentation**

NOTE Un **circuit externe** est classifié comme ES1, ES2 ou ES3, et PS1, PS2 ou PS3.

3.3.1.2

réseau d'alimentation

système de distribution d'alimentation en courant alternatif ou continu (externe à l'équipement) qui fournit l'énergie de fonctionnement à l'équipement et est PS3

NOTE Un **réseau d'alimentation** comprend des services publics ou privés et, sauf spécification contraire dans la présente norme, des sources équivalentes à des générateurs motorisés et des alimentations sans **interruption**.

3.3.2 Termes relatifs à l'enveloppe

3.3.2.1

enveloppe électrique

enveloppe assurant la **protection** contre les blessures dues à l'électricité

[VEI 195-06-13, modifiée]

3.3.2.2

enveloppe

enceinte assurant le type et le degré de protection approprié pour l'application prévue

[VEI 195-02-35]

NOTE La même **enveloppe** peut présenter plusieurs types et degrés de protection pour plusieurs applications prévues comme une **enveloppe électrique**, une **enveloppe ignifuge** ou une **enveloppe mécanique**. De même, une partie d'une **enveloppe** peut offrir un type et un degré de protection pour une application prévue, et une autre partie de la même **enveloppe** d'autre type et degré de protection pour une autre application prévue.

3.3.2.3

enveloppe ignifuge

enveloppe assurant la **protection** contre la propagation du feu depuis l'intérieur de l'**enveloppe** vers l'extérieur de l'**enveloppe**

3.3.2.4

enveloppe mécanique

enveloppe assurant la **protection** contre les blessures dues à un choc mécanique

3.3.3 Termes relatifs à l'équipement

3.3.3.1

équipement à enficher directement

équipement dans lequel la fiche de raccordement au **réseau d'alimentation** fait partie intégrante de l'**enveloppe** de l'équipement

3.3.3.2

équipement portatif

équipement mobile, ou partie d'un équipement de type indifférent, destiné à être tenu à la main en utilisation normale

3.3.3.3

équipement mobile

équipement soit:

- d'une masse maximale de 18 kg et non fixé en place, soit
- fourni avec des roues, des roulettes ou un autre moyen permettant de faciliter les mouvements qu'une **personne ordinaire** doit exécuter selon son utilisation prévue

3.3.3.4

équipement relié en permanence

équipement pouvant uniquement être connecté électriquement au **réseau d'alimentation** à l'aide d'un **outil**

3.3.3.5

équipement enfichable de type A

équipement destiné à être raccordé au **réseau d'alimentation** par une fiche et un socle de prise de courant non industriels (CEI/TR 60083 ou norme nationale équivalente) ou par un connecteur non industriel (CEI 60320-1), ou les deux

3.3.3.6

équipement enfichable de type B

équipement destiné à être raccordé au **réseau d'alimentation** par une fiche et un socle de prise de courant industriels (CEI 60309-1 ou norme nationale équivalente) ou par un connecteur industriel (CEI 60320-1), ou les deux

3.3.3.7

équipement stationnaire

- équipement fixé, ou
- **équipement relié en permanence**, ou
- équipement qui, en raison de ses caractéristiques physiques, n'est normalement pas déplacé

NOTE Un **équipement stationnaire** n'est ni un **équipement mobile** ni un **équipement transportable**.

3.3.3.8

équipement transportable

équipement prévu pour être régulièrement transporté

NOTE Il peut s'agir par exemple d'ordinateurs portables, de lecteurs CD et d'accessoires portables, y compris leurs alimentations externes.

3.3.4 Termes relatifs à l'inflammabilité

3.3.4.1

matériau combustible

matériau organique, susceptible de combustion

NOTE 1 Pour les besoins de la présente norme, le métal autre que le magnésium, ou la céramique sont des exemples de matériaux qui ne sont pas susceptibles de subir de combustion.

NOTE 2 Tous les matériaux thermoplastiques sont considérés comme susceptibles de subir une combustion, indépendamment de la **classification d'inflammabilité du matériau**.

3.3.4.2

classe d'inflammabilité du matériau

reconnaissance du comportement au feu des matériaux et de leur capacité de s'éteindre s'ils sont allumés

Les matériaux sont classifiés comme ci-dessous lorsqu'ils sont soumis à essai conformément à la CEI 60695-11-10, à la CEI 60695-11-20, à l'ISO 9772 ou à l'ISO 9773.

3.3.4.2.1**matériau de classe 5VA**

matériau soumis à essai dans l'épaisseur significative la plus fine utilisée et classifié 5VA conformément à la CEI 60695-11-20

3.3.4.2.2**matériau de classe 5VB**

matériau soumis à essai dans l'épaisseur significative la plus fine utilisée et classifié 5VB conformément à la CEI 60695-11-20

3.3.4.2.3**matériau de classe HB40**

matériau soumis à essai dans l'épaisseur significative la plus fine utilisée et classifié HB40 conformément à la CEI 60695-11-10

3.3.4.2.4**matériau de classe HB75**

matériau soumis à essai dans l'épaisseur significative la plus fine utilisée et classifié HB75 conformément à la CEI 60695-11-10

3.3.4.2.5**matériau plastique cellulaire de classe HBF**

matériau plastique cellulaire soumis à essai dans l'épaisseur significative la plus fine utilisée et classifié HBF conformément à l'ISO 9772

3.3.4.2.6**matériau plastique cellulaire de classe HF-1**

matériau plastique cellulaire soumis à essai dans l'épaisseur significative la plus fine utilisée et classifié HF-1 conformément à l'ISO 9772

3.3.4.2.7**matériau plastique cellulaire de classe HF-2**

matériau plastique cellulaire soumis à essai dans l'épaisseur significative la plus fine utilisée et classifié HF-2 conformément à l'ISO 9772

3.3.4.2.8**matériau de classe V-0**

matériau soumis à essai dans l'épaisseur significative la plus fine utilisée et classifié V-0 conformément à la CEI 60695-11-10

3.3.4.2.9**matériau de classe V-1**

matériau soumis à essai dans l'épaisseur significative la plus fine utilisée et classifié V-1 conformément à la CEI 60695-11-10

3.3.4.2.10**matériau de classe V-2**

matériau soumis à essai dans l'épaisseur significative la plus fine utilisée et classifié V-2 conformément à la CEI 60695-11-10

3.3.4.2.11**matériau de classe VTM-0**

matériau soumis à essai dans l'épaisseur significative la plus fine utilisée et classifié VTM-0 conformément à l'ISO 9773

3.3.4.2.12

matériau de classe VTM-1

matériau soumis à essai dans l'épaisseur significative la plus fine utilisée et classifié VTM-1 conformément à l'ISO 9773

3.3.4.2.13

matériau de classe VTM-2

matériau soumis à essai dans l'épaisseur significative la plus fine utilisée et classifié VTM-2 conformément à l'ISO 9773

3.3.5 Isolation

3.3.5.1

isolation principale

isolation assurant une **protection principale** contre les chocs électriques

[VEI 195-06-06, modifiée]

NOTE Ce concept ne s'applique pas à l'isolation utilisée exclusivement dans un but fonctionnel.

3.3.5.2

double isolation

isolation comprenant à la fois une **isolation principale** et une **isolation supplémentaire**

[VEI 195-06-08]

3.3.5.3

isolation fonctionnelle

isolation entre parties conductrices qui est uniquement nécessaire au bon fonctionnement du matériel

3.3.5.4

isolation renforcée

système d'isolation unique qui assure un degré de protection contre les chocs électriques équivalant à une **double isolation**

3.3.5.5

isolation réalisée avec un isolant solide

matériau isolant solide interposé entre deux parties conductrices ou entre une partie conductrice et une partie du corps

[CEI 60664-1:2007, 3.4, modifiée]

3.3.5.6

isolation supplémentaire

isolation indépendante appliquée en plus de l'**isolation principale** pour fournir une **isolation supplémentaire** pour la protection contre le choc électrique

[VEI 195-06-07, modifiée]

3.3.6 Divers

3.3.6.1

accessible

qui peut être touché par une partie du corps

NOTE Une partie du corps est représentée par une ou plusieurs des sondes spécifiées dans l'Annexe V.

3.3.6.2**étamine**

pièce de coton blanchi d'environ 40 g/m²

NOTE L'**étamine** est une gaze en coton grossier, tissée de façon non serrée, utilisée à l'origine pour emballer le fromage.

3.3.6.3**dispositif de déconnexion**

moyen de déconnecter électriquement l'équipement du **réseau d'alimentation** qui, en position ouverte, est conforme aux exigences spécifiées pour la fonction **d'isolation**

3.3.6.4**câble d'alimentation fixé à demeure**

câble souple d'alimentation fixé ou monté sur l'équipement et ne pouvant pas être retiré sans l'utilisation d'**outils**

3.3.6.5**degré de pollution**

nombre caractérisant la pollution prévue du micro-environnement

3.3.6.6**zone à accès limité**

zone **accessible** uniquement aux **personnes qualifiées** et aux **personnes averties** munies de l'autorisation adéquate

[VEI 195-04-04, modifiée]

3.3.6.7**essai individuel de série**

essai auquel est soumis chaque dispositif en cours ou en fin de fabrication pour vérifier qu'il satisfait à des critères définis

[CEI 60664-1:2007, 3.19.2]

3.3.6.8**essai sur prélèvement**

essai effectué sur un certain nombre de dispositifs prélevés au hasard dans un lot

[CEI 60664-1:2007, 3.19.3]

3.3.6.9**outil**

objet pouvant être utilisé sur une vis, un verrou ou un moyen de fixation similaire

NOTE Les **outils** peuvent être par exemple des pièces de monnaie, de la vaisselle, un tournevis, une pince, etc.

3.3.6.10**courant de contact**

courant électrique traversant le corps humain lorsqu'une partie du corps entre en contact avec au moins deux parties **accessibles** ou une partie **accessible** et la terre

3.3.6.11**essai de type**

essai réalisé sur un échantillon représentatif afin de déterminer si sa conception et sa fabrication répondent aux exigences de la présente norme

3.3.6.12

papier mousseline

papier mousseline entre 12 g/m² et 30 g/m²

NOTE Le **papier mousseline** est un papier doux, fin, généralement transparent utilisé pour emballer les articles délicats.

[ISO 4046-4:2002, définition 4.215 modifiée]

3.3.7 Conditions de fonctionnement et de défaut

3.3.7.1

conditions anormales de fonctionnement

conditions de fonctionnement temporaires qui ne sont ni les **conditions normales de fonctionnement** ni les **conditions de premier défaut** de l'équipement proprement dit

NOTE 1 Les **conditions anormales de fonctionnement** sont spécifiées à l'Article B.3.

NOTE 2 Des **conditions anormales de fonctionnement** peuvent être induites par l'équipement ou par une personne.

NOTE 3 Des **conditions anormales de fonctionnement** peuvent entraîner le dysfonctionnement d'un composant, d'un dispositif ou d'une **protection**.

3.3.7.2

fonctionnement intermittent

fonctionnement en une série de cycles, chacun étant composé d'une période de fonctionnement suivie d'une période pendant laquelle l'équipement est éteint ou en veille

3.3.7.3

puissance de sortie non écrêtée

puissance dissipée aux bornes de l'**impédance assignée de charge** en régime sinusoïdal, la mesure étant effectuée à 1 000 Hz à l'apparition de l'écrtage de l'une ou l'autre des alternances

3.3.7.4

conditions normales de fonctionnement

mode de fonctionnement qui reflète le mieux les conditions d'utilisation normale les plus rigoureuses qu'il est raisonnable d'attendre

NOTE Sauf spécification contraire, les conditions d'utilisation normale les plus rigoureuses sont les valeurs par défaut les plus défavorables telles que spécifiées à l'Article B.2.

3.3.7.5

condition de surcharge

conditions anormales de fonctionnement ou **conditions de premier défaut** où la charge exercée sur l'équipement ou le circuit va au-delà des **conditions normales de fonctionnement**, mais n'entraîne pas immédiatement un état de non fonctionnement

3.3.7.6

fréquence de réponse crête

fréquence d'essai qui produit la puissance de sortie maximale mesurée à l'**impédance assignée de charge**

NOTE Il convient que la fréquence appliquée se situe dans la plage de fonctionnement prévue de l'amplificateur/du transducteur.

3.3.7.7

impédance assignée de charge

impédance ou résistance, spécifiée par le fabricant dans les instructions utilisateur ou marquée sur l'équipement, par laquelle il convient de terminer un circuit de sortie

3.3.7.8

mauvais usage raisonnablement prévisible

utilisation d'un produit, procédé ou service dans des conditions ou à des fins non prévues par le fournisseur mais qui peut provenir d'un comportement humain envisageable

[Guide ISO/CEI 51, définition 3.14]

3.3.7.9

fonctionnement de courte durée

fonctionnement dans les **conditions normales de fonctionnement** pendant une période spécifiée, qui commence alors que l'équipement est froid, les intervalles après chaque période de fonctionnement étant suffisants pour permettre à l'équipement de refroidir à la température ambiante

3.3.7.10

condition de premier défaut

défaut dans les **conditions normales de fonctionnement** d'une **protection** unique (mais non d'une **protection renforcée**) ou d'un composant unique ou d'un dispositif

3.3.8 Personnes

3.3.8.1

personne avertie

personne avertie ou encadrée par une **personne qualifiée** en sources d'énergie et qui peut utiliser l'équipement et les **protections de précaution** de manière responsable par rapport à ces sources d'alimentation

[VEI 826-18-02, modifiée]

NOTE Encadré, tel qu'utilisé dans la définition, signifie qu'il dirige et surveille les performances des autres.

3.3.8.2

personne ordinaire

personne qui n'est ni une **personne qualifiée** ni une **personne avertie**

[VEI 826-18-03]

3.3.8.3

personne qualifiée

personne ayant la formation ou l'expérience appropriée pour lui permettre d'éviter les dangers et de réduire la probabilité des risques pouvant être créés par l'équipement

[VEI 826-18-01, modifiée]

3.3.9 Sources potentielles d'incendie

3.3.9.1

source potentielle d'incendie

PIS (*potential ignition source*)

lieu où une énergie électrique peut provoquer une inflammation

3.3.9.2

source potentielle d'incendie causé par la formation d'un arc électrique

lieu où un arc peut se produire en raison de l'ouverture d'un conducteur ou d'un contact

NOTE 1 Un circuit de protection électronique ou des mesures de construction supplémentaires peuvent être utilisés pour empêcher qu'un emplacement ne devienne une **source potentielle d'incendie causé par la formation d'un arc électrique**.

NOTE 2 Un faux contact ou une rupture dans une connexion électrique susceptible de se produire sur des pistes conductrices sur des cartes imprimées est considéré comme relevant du domaine d'application de cette définition.

3.3.9.3

source potentielle d'incendie causé par un phénomène de résistivité

lieu où un composant peut s'enflammer en raison d'une puissance dissipée excessive

3.3.10 Caractéristiques assignées

3.3.10.1

courant assigné

courant d'entrée de l'équipement tel que déclaré par le fabricant dans les **conditions normales de fonctionnement**

3.3.10.2

fréquence assignée

fréquence d'alimentation ou plage de fréquences telle que déclarée par le fabricant

3.3.10.3

puissance assignée

puissance d'entrée de l'équipement telle que déclarée par le fabricant dans les **conditions normales de fonctionnement**

3.3.10.4

tension assignée

valeur de la tension, fixée par le fabricant à un composant, à un dispositif ou à un matériel et à laquelle on se réfère pour le fonctionnement et pour les caractéristiques fonctionnelles

[CEI 60664-1, définition 3.9]

NOTE 1 L'équipement peut présenter plus d'une valeur de **tension assignée** ou bien une **plage de tensions assignées**.

NOTE 2 Pour une alimentation triphasée, la tension entre phases s'applique.

3.3.10.5

plage de tensions assignées

plage de tensions d'alimentation telle que déclarée par le fabricant, exprimée par ses **tensions assignées** supérieure et inférieure

3.3.10.6

caractéristiques assignées du courant de protection

caractéristiques assignées d'un dispositif de protection contre les surintensités qui est en place ou réputé être en place pour protéger un circuit

3.3.11 Protections

3.3.11.1

protection principale

protection assurée dans les **conditions normales** et **anormales de fonctionnement** lorsque qu'une source d'énergie susceptible de provoquer une douleur ou une blessure est présente dans l'équipement

3.3.11.2

double protection

protection comprenant une **protection principale** et une **protection supplémentaire**

3.3.11.3

protection de l'équipement

protection constituant une partie physique de l'équipement

3.3.11.4**protection de l'installation**

protection qui constitue une partie physique d'une installation réalisée par l'homme

3.3.11.5**protection mise en place sous forme d'instructions**

instruction impliquant un comportement spécifié afin d'éviter le contact ou l'exposition à une source d'énergie de classe 2 ou 3 (voir 4.2)

3.3.11.6**protection individuelle**

équipement de protection individuelle qui est porté sur le corps

3.3.11.7**protection de précaution**

comportement d'une **personne avertie** visant à éviter tout contact ou exposition à une source d'énergie de classe 2, sous la supervision ou d'après les instructions d'une **personne qualifiée**

3.3.11.8**conducteur de liaison de protection**

conducteur de protection dans l'équipement, ou combinaison de parties conductrices dans l'équipement, raccordant une borne principale de mise à la terre de protection à une partie de l'équipement qui doit être mise à la terre pour des raisons de sécurité

3.3.11.9**conducteur de protection**

conducteur prévu à des fins de sécurité (par exemple, protection contre les chocs électriques)

[VEI 195-02-09]

NOTE Un **conducteur de protection** est soit un **conducteur de mise à la terre de protection**, soit un **conducteur de liaison de protection**.

3.3.11.10**conducteur de mise à la terre de protection**

conducteur de protection raccordant une borne principale de mise à la terre de protection dans l'équipement à un point de terre dans l'installation du bâtiment pour une mise à la terre de protection

[VEI 195-02-11, modifiée]

3.3.11.11**protection renforcée**

protection unique qui est opérationnelle dans:

- les **conditions normales de fonctionnement**,
- les **conditions anormales de fonctionnement**, et
- des **conditions de premier défaut**

3.3.11.12**protection**

partie physique, système ou instruction spécifiquement prévu pour réduire la probabilité de douleur ou de blessure ou, en cas d'incendie, pour réduire la probabilité d'inflammation ou de propagation du feu

NOTE Voir 0.5 pour une explication plus détaillée d'une **protection**.

3.3.11.13

verrouillage de sécurité

moyen de transformer automatiquement une source d'alimentation en une source d'alimentation de classe inférieure préalablement à la possibilité de transfert de l'énergie supérieure vers une partie du corps

3.3.11.14

protection mise en place grâce à l'expérience acquise

comportement d'une **personne qualifiée** visant à éviter le contact ou l'exposition à une source d'énergie de classe 2 ou 3 basé sur une formation et l'expérience

3.3.11.15

protection supplémentaire

protection appliquée en plus de la **protection principale** qui est ou devient opérationnelle en cas de dysfonctionnement de la **protection principale**

3.3.12 Distances

3.3.12.1

distance d'isolement dans l'air

distance la plus courte dans l'air entre deux parties conductrices

[CEI 60664-1:2007, définition 3.2]

3.3.12.2

ligne de fuite

distance la plus courte, le long de la surface d'un matériau isolant, entre deux parties conductrices

[ISO 60664-1:2007, définition 3.3 modifiée]

3.3.13 Températures et commandes

3.3.13.1

température de charge la plus élevée

température maximale admissible mesurée à la surface d'une batterie lors de son chargement

3.3.13.2

température de charge la moins élevée

température minimale admissible mesurée à la surface d'une batterie lors de son chargement

3.3.13.3

limiteur de température

dispositif permettant de limiter la température d'un système, soit au-dessous soit au-dessus d'une valeur particulière, en contrôlant, soit directement soit indirectement, le flux d'une énergie thermique à l'intérieur ou à l'extérieur du système

NOTE Un **limiteur de température** peut être à réenclenchement automatique ou réenclenchement manuel.

3.3.13.4

disjoncteur thermique

dispositif permettant de limiter la température d'un système, dans les **conditions de premier défaut**, en contrôlant, soit directement soit indirectement, le flux d'une énergie thermique à l'intérieur ou à l'extérieur du système

NOTE Un **disjoncteur thermique** peut fonctionner une fois ou être à réenclenchement manuel.

3.3.13.5**thermostat**

dispositif permettant de maintenir la température d'un système à l'intérieur d'une plage en contrôlant, soit directement soit indirectement, le flux d'une énergie thermique à l'intérieur ou à l'extérieur du système

3.3.14 Tensions et courants**3.3.14.1****tension en courant continu**

valeur moyenne d'une tension présentant une ondulation crête-à-crête ne dépassant pas 10 % de la valeur moyenne

NOTE Lorsqu'une ondulation crête-à-crête dépasse 10 % de la valeur moyenne, les exigences liées à la tension crête sont applicables.

3.3.14.2**tension transitoire du réseau d'alimentation**

tension crête la plus élevée attendue au niveau de l'entrée d'énergie dans l'équipement, provenant de transitoires externes vers le **réseau d'alimentation**

3.3.14.3**courant de charge maximale**

limite supérieure du courant de charge par élément de batterie en charge

NOTE Le courant de charge maximale peut être défini pour chaque plage de températures de charge normalisée, plage de températures de charge faible et plage de températures de charge élevée.

3.3.14.4**valeur de crête de la tension de service**

valeur crête de la **tension de service**, y compris tout composant en courant continu et les impulsions de crête répétitives générées dans l'équipement

3.3.14.5**tension de contact présumée**

tension entre les parties conductrices **accessibles** simultanément lorsque ces parties conductrices ne sont pas touchées

3.3.14.6**courant de conducteur de protection**

courant s'écoulant à travers le **conducteur de mise à la terre de protection** dans les **conditions normales de fonctionnement**

NOTE Le **courant du conducteur de protection** était auparavant compris dans le terme « courant de fuite ».

3.3.14.7**tension de tenue prescrite**

tension crête que l'isolation considérée doit supporter

3.3.14.8**tension de service efficace**

valeur efficace vraie de la **tension de service**

NOTE 1 Une mesure efficace vraie comprend un composant en courant continu de la forme d'onde.

NOTE 2 La valeur efficace obtenue d'une forme d'onde présentant une tension efficace en courant alternatif « *A* » et un décalage de tension en courant continu « *B* » est donnée par la formule suivante:

$$\text{valeur efficace} = (A^2 + B^2)^{1/2}$$

3.3.14.9

limite supérieure de tension de charge

tension maximale admise par élément de batterie en charge, telle que spécifiée par le fabricant de l'accumulateur

NOTE Une valeur différente de la limite supérieure de tension de charge peut être définie pour chaque plage de températures de charge normalisée, plage de températures de charge faible et plage de températures de charge élevée.

3.3.14.10

tension de service

tension la plus élevée appliquée à une isolation particulière qui peut apparaître lorsque l'équipement est alimenté en **tension assignée** ou toute tension comprise dans la **plage de tensions assignées** dans les **conditions normales de fonctionnement**

[CEI 60664-1, définition 3.5, modifiée]

NOTE Les transitoires externes ne sont pas pris en considération.

3.3.15 Classes d'équipement par rapport à la protection contre les chocs électriques

3.3.15.1

équipement de classe I

équipement dans lequel la protection contre les chocs électriques ne repose pas uniquement sur l'**isolation principale**, mais qui comporte une **protection supplémentaire** sous la forme de moyens de raccordement des parties conductrices **accessibles** au **conducteur de mise à la terre de protection** faisant partie du câblage fixe de l'installation, d'une manière telle que des parties conductrices **accessibles** ne puissent devenir actives en cas de dysfonctionnement de l'**isolation principale**

NOTE Pour l'équipement destiné à être utilisé avec un câble ou un cordon souple, cette disposition comprend un **conducteur de protection** en tant que partie du câble ou du cordon souple.

3.3.15.2

construction de classe II

partie d'un équipement dont la protection contre les chocs électriques repose sur une **double isolation** ou sur une **isolation renforcée**

[CEI 60335-1, 3.3.11, modifiée]

3.3.15.3

équipement de classe II

équipement dont la protection contre les chocs électriques ne repose pas sur une **isolation principale** uniquement, mais dans lequel une **protection supplémentaire** est prévue, ces mesures ne comportant pas de moyen de mise à la terre de protection et ne dépendant pas des conditions d'installation

3.3.15.4

équipement de classe III

équipement dont la protection contre les chocs électriques dépend de l'alimentation de ES1 et dans lequel ES3 n'est pas généré

[CEI 60950-1, 1.2.4.3, modifiée]

3.3.16 Termes relatifs aux éléments chimiques

3.3.16.1

matériau consommable

matériau utilisé par l'équipement pour remplir sa fonction prévue, et destiné à être remplacé ou reconstitué périodiquement ou occasionnellement, y compris un matériau ayant une durée de vie inférieure à celle de l'équipement

3.3.16.2

explosion

réaction chimique d'un composé chimique ou d'un mélange mécanique qui, quand elle commence, subit une combustion ou une décomposition très rapide, libérant de grands volumes de gaz fortement chauffés qui exercent une pression sur le milieu environnant

NOTE Une **explosion** peut également être une réaction mécanique dans laquelle un dysfonctionnement du conteneur provoque un échappement soudain de pression, et le contenu, depuis l'intérieur d'un appareil sous pression. En fonction du débit de l'échappement d'énergie, une **explosion** peut être catégorisée comme une déflagration, une détonation, ou une rupture de pression.

3.3.16.3

explosif

substance ou mélange de substances qui peut subir une modification chimique rapide avec ou sans une source extérieure d'oxygène, générant de grandes quantités d'énergie généralement accompagnées par des gaz chauds

3.3.16.4

substance chimique dangereuse

substance chimique présentant une phase de risque ou équivalente sur les fiches techniques relatives aux aspects liés à la santé humaine et pouvant se présenter sous la forme d'un solide, d'une poudre, d'un liquide ou d'un gaz

NOTE La poussière et d'autres matériaux particuliers peuvent également être des **substances chimiques dangereuses** en fonction de leur composition et de la possibilité d'interaction avec le corps humain.

3.3.16.5

équipement de protection individuelle EPI

protection individuelle, généralement portée sur le corps, qui réduit l'exposition connue d'une personne à une source d'alimentation de classe 3

NOTE Les exemples d'EPI comprennent des blindages, des lunettes, des gants, des tabliers, des masques faciaux ou des appareils respiratoires.

4 Exigences générales

4.1 Généralités

4.1.1 Application des exigences d'acceptation des matériaux, composants et sous-ensembles

Les exigences sont spécifiées dans les articles correspondants et, lorsqu'une référence figure dans ces articles, dans les annexes correspondantes.

Lorsque la conformité des matériaux, des composants ou des sous-ensembles est démontrée par une inspection, cette conformité peut provenir de la révision de données publiées ou de résultats d'essais antérieurs.

Les composants et les sous-ensembles conformes à la CEI 60950-1 ou à la CEI 60065 sont acceptables en tant que partie de l'équipement traité dans la présente norme sans autre évaluation que la considération de l'utilisation appropriée du composant ou du sous-ensemble dans le produit fini.

NOTE 2 Le présent alinéa sera supprimé dans une future version de la norme. Il est ajouté ici pour faciliter la transition de la CEI 60950-1 et de la CEI 60065 à la présente norme.

4.1.2 Utilisation de composants

Sauf spécification contraire, lorsque le composant ou une caractéristique d'un composant constitue une **protection**, les composants doivent être conformes soit aux exigences de la présente norme, soit aux aspects relatifs à la sécurité des normes CEI appropriées sur les composants.

NOTE 1 Une norme CEI sur les composants est considérée comme appropriée uniquement si le composant en question relève clairement de son domaine d'application.

L'évaluation et les essais des composants doivent être réalisés comme suit:

- l'application et l'utilisation correctes d'un composant doivent être vérifiées conformément à ses caractéristiques assignées;
- un composant dont la conformité à une norme harmonisée avec la norme CEI sur les composants appropriée a été démontrée doit être soumis aux essais applicables de la présente norme en tant que partie de l'équipement, à l'exception des essais faisant partie de la norme CEI sur les composants appropriée;
- un composant dont la conformité à une norme appropriée comme ci-dessus n'a pas été démontrée doit être soumis aux essais applicables de la présente norme, en tant que partie de l'équipement, et aux essais applicables de la norme sur les composants, dans les conditions présentes dans l'équipement;

NOTE 2 L'essai applicable pour la conformité à une norme sur les composants est, en général, réalisé séparément.

- lorsqu'il n'existe pas de norme CEI sur les composants appropriée, ou lorsque les composants sont utilisés dans des circuits non conformes à leurs caractéristiques assignées spécifiées, les composants doivent être soumis à essai dans les conditions présentes dans l'équipement. Le nombre d'échantillons requis pour l'essai est, en général, identique à celui requis par une norme équivalente.

4.1.3 Conception et construction de l'équipement

L'équipement doit être conçu et monté de telle sorte que, dans les **conditions normales de fonctionnement** (voir Article B.2), les **conditions anormales de fonctionnement** (voir Article B.3), et les **conditions de premier défaut** (voir Article B.4), des **protections** soient prévues pour réduire la probabilité de blessure ou, en cas d'incendie, de dommage matériel.

NOTE Dans les **conditions normales de fonctionnement**, les protections spécifiées dans la présente norme peuvent ou non éviter les douleurs, en fonction de la personne et des conditions de fonctionnement de l'équipement.

Les parties de l'équipement pouvant provoquer des blessures ne doivent pas être **accessibles**, et les parties **accessibles** ne doivent pas provoquer de blessure.

Pour une **personne ordinaire** ou une **personne avertie**, le réglage d'une commande ne doit pas annuler une **protection de l'équipement**.

La conformité est vérifiée par examen et par les essais appropriés.

4.1.4 Installation de l'équipement

L'évaluation de l'équipement conformément à la présente norme doit tenir compte des instructions des fabricants concernant l'installation, le déplacement, l'entretien et le fonctionnement, le cas échéant.

4.1.5 Aspects relatifs à la construction non traités spécifiquement

Lorsque l'équipement implique des technologies, des matériaux ou méthodes de construction non traités spécifiquement dans la présente norme, l'équipement doit présenter des

protections correspondant au moins à celles généralement prévues par la présente norme et aux principes de sécurité énoncés ci-après.

NOTE Il convient que la nécessité d'exigences détaillées supplémentaires pour répondre à une situation nouvelle soit portée rapidement à l'attention du comité concerné.

4.1.6 Orientation lors du transport et de l'utilisation

Lorsqu'il est clair que l'orientation d'utilisation de l'équipement est susceptible d'avoir un effet significatif sur l'application des exigences ou sur les résultats des essais, toutes les orientations d'utilisation spécifiées dans les instructions d'installation ou utilisateur doivent être prises en compte. En outre, pour les **équipements transportables**, toutes les orientations de transport doivent être prises en compte.

4.1.7 Critères de choix

Lorsque la norme indique un choix entre différents critères de conformité, ou entre différentes méthodes ou conditions d'essai, ce choix est spécifié par le fabricant.

4.1.8 Liquides conducteurs

Pour les exigences électriques de la présente norme, les liquides conducteurs doivent être traités comme des parties conductrices.

4.1.9 Instruments de mesure électriques

Les instruments de mesure électriques doivent disposer d'une bande passante adaptée pour effectuer des lectures précises, prenant en compte l'ensemble des composants (courant continu, fréquence du **réseau d'alimentation**, haute fréquence et contenu harmonique) du paramètre mesuré.

Pour la mesure de la valeur efficace, on doit veiller à ce que l'appareil de mesure donne la valeur efficace vraie des formes d'onde non sinusoïdales comme celle des formes d'onde sinusoïdales.

Les mesures sont effectuées à l'aide d'un appareil de mesure dont l'impédance d'entrée influence peu les mesures.

4.1.10 Mesures de température

Sauf spécification contraire, lorsque le résultat d'un essai est susceptible de dépendre de la température ambiante, la plage de températures ambiantes de l'équipement spécifiée par le fabricant (T_{ma}) doit être prise en compte. Lors d'un essai réalisé à une température ambiante spécifique (T_{amb}), une extrapolation (supérieure et inférieure) des résultats de l'essai peut être utilisée pour considérer l'impact de T_{ma} sur le résultat. Les composants et les sous-ensembles peuvent être considérés en dehors de l'équipement si l'extrapolation et les résultats d'essai sont représentatifs de l'ensemble de l'équipement tel que soumis à essai. Les données d'essai et les spécifications du fabricant appropriées peuvent être examinées pour déterminer l'effet des variations de température sur un composant ou un sous-ensemble (voir B.1.7).

4.1.11 Conditions stables

Des conditions stables sont les conditions dans lesquelles l'équilibre thermique est considéré comme atteint (voir B.1.7).

4.1.12 Hiérarchie des protections

Les **protections** nécessaires pour les **personnes ordinaires** sont acceptables, mais pas systématiquement nécessaires, pour les **personnes averties** et les **personnes qualifiées**.

De même, les **protections** nécessaires pour les **personnes averties** sont acceptables, mais pas systématiquement nécessaires, pour les **personnes qualifiées**.

Une **protection renforcée** peut être utilisée à la place d'une **protection principale** ou d'une **protection supplémentaire** ou d'une **double protection**. Une **double protection** peut être utilisée à la place d'une **protection renforcée**.

Des **protections** autres que les **protections de l'équipement** peuvent être spécifiées dans des articles spécifiques (par exemple, voir 8.4.1, 8.5.1 et le Tableau 42).

4.1.13 Exemples mentionnés dans la norme

Lorsque des exemples sont donnés dans la présente norme, d'autres exemples, situations et solutions ne sont pas exclus.

4.1.14 Essais sur des parties ou des échantillons autres que sur le produit fini

Si un essai est réalisé sur une partie ou un échantillon en dehors du produit fini, l'essai doit être effectué comme si la partie ou l'échantillon se situait dans le produit fini.

4.1.15 Marquages et instructions

L'équipement qui, selon la présente norme, doit

- porter des marquages, ou
- présenter des instructions, ou
- disposer de **protections mises en place sous forme d'instructions**

doit répondre aux exigences appropriées de l'Annexe F.

NOTE En Finlande, en Norvège et en Suède, l'équipement enfichable de type A de classe I destiné à être connecté à un autre équipement ou à un réseau doit, si la sécurité repose sur une connexion de mise à la terre fiable ou si les parasurtenseurs sont connectés entre les bornes du réseau et les parties **accessibles**, présenter un marquage spécifiant que l'équipement doit être connecté à un socle de raccordement au **réseau d'alimentation** mis à la terre.

4.2 Classification des sources d'alimentation

4.2.1 Source d'énergie de classe 1

Sauf spécification contraire, une source de classe 1 est une source d'énergie dont les niveaux ne dépassent pas les limites de classe 1 dans

- les **conditions normales de fonctionnement** et
- les **conditions anormales de fonctionnement** qui ne conduisent pas à une **condition de premier défaut**,

et ne dépassent pas les limites de classe 2 dans les **conditions de premier défaut**.

Dans les **conditions normales de fonctionnement** et dans les **conditions anormales de fonctionnement**, l'énergie d'une source de classe 1, en contact avec une partie du corps, peut se révéler détectable, mais n'est ni douloureuse ni susceptible de provoquer une blessure. En ce qui concerne les incendies, l'énergie d'une source de classe 1 n'est pas susceptible d'entraîner une inflammation.

Dans les **conditions de premier défaut**, une source d'énergie de classe 1, en contact avec une partie du corps, peut être douloureuse mais n'est pas susceptible de provoquer une blessure.

4.2.2 Source d'énergie de classe 2

Sauf spécification contraire, une source de classe 2 est une source d'énergie dont les niveaux dépassent les limites de classe 1 et ne dépassent pas celles de classe 2 dans les **conditions normales de fonctionnement**, dans les **conditions anormales de fonctionnement**, ou dans les **conditions de premier défaut**. L'énergie d'une source de classe 2, en contact avec une partie du corps, peut être douloureuse, mais n'est pas susceptible de provoquer une blessure. En ce qui concerne les incendies, l'énergie d'une source de classe 2 peut entraîner une inflammation dans certaines conditions.

4.2.3 Source d'énergie de classe 3

Une source de classe 3 est une source d'énergie dont les niveaux dépassent les limites de classe 2 dans les **conditions normales de fonctionnement**, dans les **conditions anormales de fonctionnement**, ou dans les **conditions de premier défaut**, ou toute source d'alimentation déclarée comme étant une source de classe 3. L'énergie d'une source de classe 3, en contact avec une partie du corps, peut provoquer une blessure. En ce qui concerne les incendies, l'énergie d'une source de classe 3 peut entraîner une inflammation et la propagation de flammes, en présence d'un combustible.

4.2.4 Classification des sources d'alimentation selon un mode déclaratif

Le fabricant peut déclarer une source d'énergie de classe 1 comme étant une source d'énergie de classe 2 ou une source d'énergie de classe 3.

Le fabricant peut déclarer une source d'énergie de classe 2 comme étant une source d'énergie de classe 3.

Les **protections** doivent s'appliquer conformément à la classe déclarée.

Un conducteur neutre est déclaré comme une source d'énergie électrique de classe 3.

Un **conducteur de protection** est une source d'énergie électrique de classe 1 et ne peut pas être déclaré d'une source d'énergie de classe supérieure.

4.3 Protection contre les sources d'énergie

4.3.1 Généralités

Le présent paragraphe spécifie des exigences de protection pour les **personnes ordinaires**, les **personnes averties** et les **personnes qualifiées**.

Les termes « personnes », « corps », et « parties du corps » sont représentés par les sondes d'accessibilité de l'Annexe V.

4.3.2 Protections destinées à protéger une personne ordinaire

4.3.2.1 Protections entre une source d'énergie de classe 1 et une personne ordinaire

Il n'est nécessaire d'interposer aucune **protection** entre une source d'énergie de classe 1 et une **personne ordinaire** (voir la Figure 9). Ainsi, une source d'énergie de classe 1 peut être **accessible** à une **personne ordinaire**.

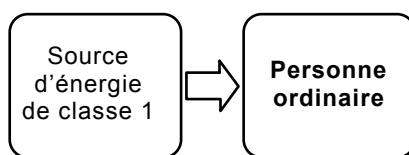


Figure 9 – Modèle pour protéger une personne ordinaire contre une source d'énergie de classe 1

4.3.2.2 Protections entre une source d'énergie de classe 2 et une personne ordinaire

Dans les **conditions normales de fonctionnement**, au moins une **protection principale** doit être interposée entre une source d'énergie de classe 2 et une **personne ordinaire** (voir la Figure 10).



Figure 10 – Modèle pour protéger une personne ordinaire contre une source d'énergie de classe 2

4.3.2.3 Protections entre une source d'énergie de classe 2 et une personne ordinaire dans les conditions d'entretien par une personne ordinaire

Si les conditions d'entretien par une **personne ordinaire** exigent qu'une **protection principale** soit ôtée ou détruite, une **protection mise en place sous forme d'instructions** telle que décrite à l'Article F.5 doit être prévue et placée de telle sorte qu'une **personne ordinaire** prenne connaissance des instructions avant d'ôter ou de détruire la **protection principale** de l'équipement (voir la Figure 11).

La **protection mise en place sous forme d'instructions** (voir Article F.5) doit inclure toutes les actions suivantes:

- identifier les parties et les emplacements de la source d'énergie de classe 2;
- spécifier des actions pour protéger les personnes de cette source d'énergie, et
- spécifier des actions pour rétablir ou restaurer la **protection principale**.

Si les conditions d'entretien par une **personne ordinaire** exigent qu'une **protection principale** soit ôtée ou détruite, et lorsque l'équipement est destiné à un usage domestique, une **protection mise en place sous forme d'instructions** (voir Article F.5), à l'attention des adultes, doit constituer un avertissement contre le retrait ou la destruction de la **protection principale** par les enfants.

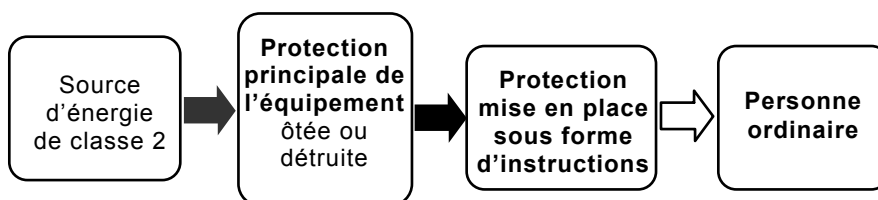


Figure 11 – Modèle pour protéger une personne ordinaire contre une source d'énergie de classe 2 dans les conditions d'entretien par une personne ordinaire

4.3.2.4 Protections entre une source d'énergie de classe 3 et une personne ordinaire

Une **protection principale de l'équipement** et une **protection supplémentaire de l'équipement** (double protection) ou une **protection renforcée de l'équipement** doivent être interposées entre une source d'énergie de classe 3 et une **personne ordinaire** (voir la Figure 12).

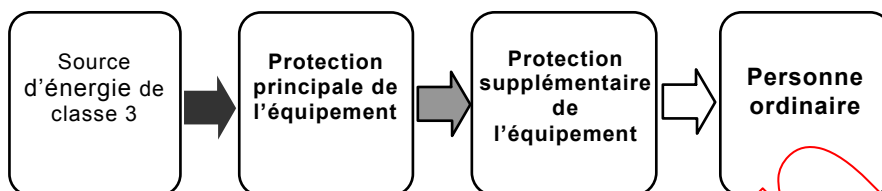


Figure 12 – Modèle pour protéger une personne ordinaire contre une source d'énergie de classe 3

4.3.3 Protection d'une personne avertie

4.3.3.1 Protections entre une source d'énergie de classe 1 et une personne avertie

Il n'est nécessaire d'interposer aucune **protection** entre une source d'énergie de classe 1 et une **personne avertie**. Ainsi, une source d'énergie de classe 1 peut être **accessible** par une **personne avertie** (voir la Figure 13).



Figure 13 – Modèle pour protéger une personne avertie contre une source d'énergie de classe 1

4.3.3.2 Protections entre une source d'énergie de classe 2 et une personne avertie

Pendant l'entretien par une **personne avertie**, les **protections de l'équipement** contre une source d'énergie de classe 2 peuvent être ôtées ou détruites. Dans ce cas, une **personne avertie** est supposée utiliser une précaution telle qu'une **protection** contre une source d'énergie de classe 2 (voir la Figure 14).



Figure 14 – Modèle pour protéger une personne avertie contre une source d'énergie de classe 2

4.3.3.3 Protections entre une source d'énergie de classe 3 et une personne avertie

Une **protection principale de l'équipement** et une **protection supplémentaire de l'équipement** (double protection) ou une **protection renforcée** doivent être interposées entre une source d'énergie de classe 3 et une **personne avertie** (voir la Figure 15).

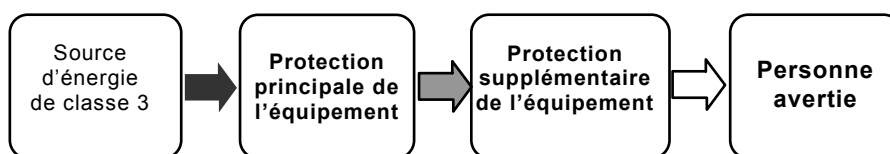


Figure 15 – Modèle pour protéger une personne avertie contre une source d'énergie de classe 3

4.3.4 Protection d'une personne qualifiée

4.3.4.1 Protections entre une source d'énergie de classe 1 et une personne qualifiée

Il n'est nécessaire d'interposer aucune **protection** entre une source d'énergie de classe 1 et une **personne qualifiée** (voir la Figure 16).

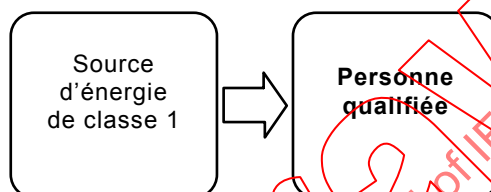


Figure 16 – Modèle pour protéger une personne qualifiée contre une source d'énergie de classe 1

4.3.4.2 Protections entre une source d'énergie de classe 2 et une personne qualifiée

Pendant l'entretien par une **personne qualifiée**, les **protections de l'équipement** contre une source d'énergie de classe 2 peuvent être ôtées ou détruites. Dans ce cas, une **personne qualifiée** est supposée utiliser une expérience telle qu'une **protection** contre une source d'énergie de classe 2 (voir la Figure 17).



Figure 17 – Modèle pour protéger une personne qualifiée contre une source d'énergie de classe 2

4.3.4.3 Protections entre une source d'énergie de classe 3 et une personne qualifiée

Pendant l'entretien par une **personne qualifiée**, les **protections de l'équipement** contre une source d'énergie de classe 3 peuvent être ôtées ou détruites. Dans ce cas, une **personne qualifiée** est supposée utiliser une expérience telle qu'une **protection** contre une source d'énergie de classe 3 (voir la Figure 18).



Figure 18 – Modèle pour protéger une personne qualifiée contre une source d'énergie de classe 3

4.3.4.4 Protections entre des sources d'énergie de classe 3 et une personne qualifiée dans les conditions d'entretien de l'équipement

Dans les conditions d'entretien de l'équipement sur une source d'énergie de classe 3, une **protection de l'équipement** prévue pour réduire la probabilité de blessure due à une réaction involontaire doit être interposée entre:

- une autre source d'énergie de classe 3, n'étant pas en cours d'entretien et à proximité de la source d'énergie de classe 3 en cours d'entretien; et
- une **personne qualifiée** (voir 0.5.7 et la Figure 19).



Figure 19 – Modèle pour protéger une personne qualifiée contre des sources d'énergie de classe 3 dans les conditions d'entretien de l'équipement

4.3.5 Protections dans une zone à accès limité

Certains équipements sont destinés à être installés exclusivement dans des **zones à accès limité**. Ce type d'équipement doit présenter des **protections** telles que requises en 4.3.3 pour les **personnes averties** et en 4.3.4 pour les **personnes qualifiées**.

4.4 Protections

4.4.1 Généralités

Le présent paragraphe spécifie les exigences relatives à la composition, à l'accessibilité et à la solidité pour les **protections**.

4.4.2 Matériaux ou composants équivalents

Lorsque la norme spécifie un paramètre particulier de **protection**, comme une classe thermique d'isolation ou une **classification d'inflammabilité du matériau**, une **protection** présentant un paramètre supérieur peut être utilisée.

NOTE Pour une hiérarchisation des **classifications d'inflammabilité du matériau**, voir les Tableaux S.1, S.2 et S.3.

4.4.3 Composition d'une protection

Une **protection** peut être composée d'un seul élément, ou bien de deux éléments ou plus.

4.4.4 Parties accessibles d'une protection

4.4.4.1 Généralités

Lorsqu'une **protection** robuste est **accessible** à une **personne ordinaire** ou à une **personne avertie**, seul le côté de la **protection** opposé à la source d'énergie peut être **accessible**.

Les exigences relatives aux **protections principales** et aux **protections supplémentaires**, si elles constituent des éléments de **doubles protections**, peuvent être permutées.

4.4.4.2 Parties accessibles d'une protection principale

En ce qui concerne une source d'énergie de classe 2, le côté de la **protection principale** opposé à la source d'énergie peut être **accessible** à une **personne ordinaire** (voir la Figure 20).

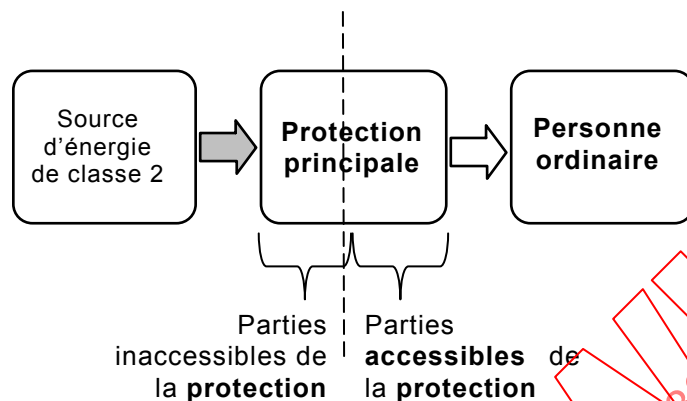


Figure 20 – Illustration des parties accessibles et inaccessibles d'une protection principale

4.4.4.3 Parties accessibles des protections supplémentaires et renforcées

En ce qui concerne une source d'énergie de classe 3, le côté de la **protection supplémentaire** opposé à la source d'énergie peut être **accessible** à une **personne ordinaire** ou à une **personne avertie**; toutefois, la **protection principale** ne doit pas être **accessible** à une **personne ordinaire** ni à une **personne avertie** (voir la Figure 21).

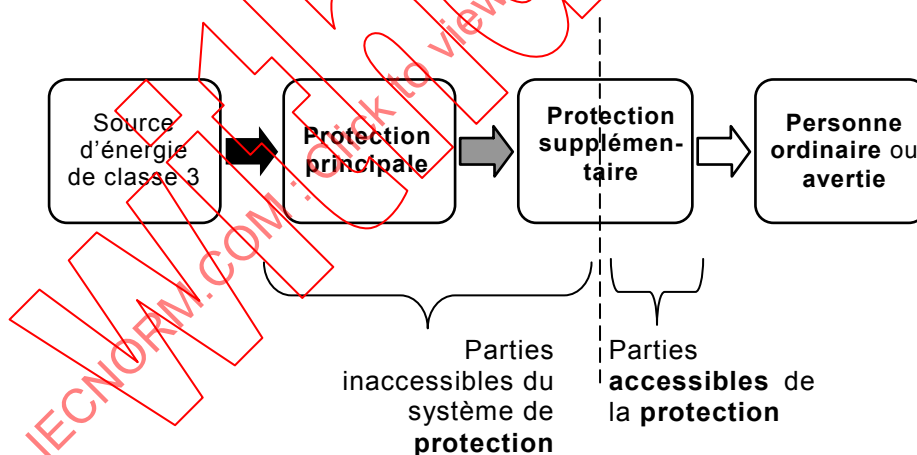


Figure 21 – Illustration des parties accessibles et inaccessibles d'une protection supplémentaire

En ce qui concerne une source d'énergie de classe 3, le côté de la **protection renforcée** opposé à la source d'énergie peut être **accessible** à une **personne ordinaire** ou à une **personne avertie** (voir la Figure 22).

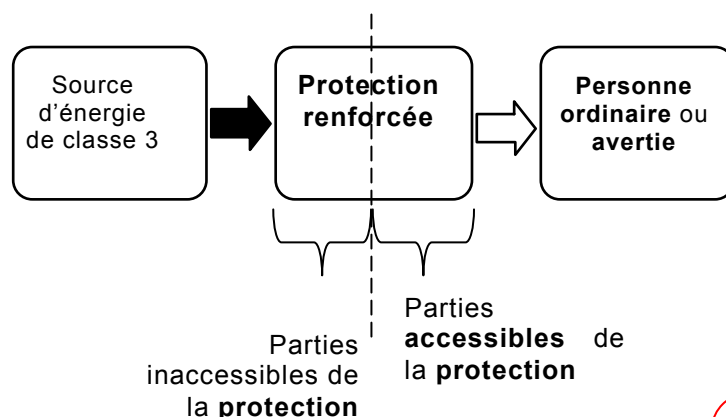


Figure 22 – Illustration des parties accessibles et inaccessibles d'une protection renforcée

4.4.5 Robustesse de la protection

Lorsqu'une **protection** robuste (par exemple, une **isolation réalisée avec un isolant solide**, du métal mis à la terre, etc.) est **accessible** à une **personne ordinaire** ou à une **personne avertie**, la **protection** doit être conforme à l'essai de résistance mécanique spécifié dans l'Annexe T pour cette **protection**, selon le cas.

Il n'est pas nécessaire qu'une **protection** robuste qui ne présente pas de parties **accessibles** soit conforme à l'essai de résistance mécanique à la condition qu'une barrière ou une **enveloppe accessible** empêchant une **personne ordinaire** ou une **personne avertie** d'accéder à la **protection** soit conforme à l'essai de résistance mécanique spécifié dans l'Annexe T pour cette **protection**.

Si une **protection** est composée d'un matériau thermoplastique, cette **protection** doit être construite de façon à ce que toute contraction ou déformation du matériau due à la relaxation des contraintes internes ne puisse pas altérer sa fonction de **protection**. Voir l'Article T.8 pour les conditions de relaxation des contraintes et l'Annexe V pour la détermination de l'accessibilité.

D'autres essais de résistance mécanique sont spécifiés dans les différents articles.

4.4.6 Protection contenant de l'air

Lorsqu'une **protection** est composée d'air (par exemple, une **distance d'isolement dans l'air**), une barrière ou une **enveloppe** doit empêcher tout déplacement de l'air par une partie du corps ou une partie conductrice. La barrière doit être conforme à l'essai de résistance mécanique spécifié dans l'Annexe T, selon le cas.

4.5 Explosion

4.5.1 Généralités

Une **explosion** peut être provoquée par

- réaction chimique,
- déformation mécanique d'un conteneur étanche,
- combustion ou décomposition rapide, produisant un grand volume de gaz chaud,
- haute pression,
- une température élevée.

NOTE 1 En fonction du débit d'énergie, une **explosion** peut être catégorisée comme une déflagration, une détonation ou une rupture de pression.

NOTE 2 Un supercondensateur (par exemple, un condensateur double couche) est une source d'**énergie** élevée et peut exploser à la suite d'une surcharge et d'une température élevée.

Pour les exigences concernant l'**explosion** des batteries, voir l'Annexe M.

4.5.2 Exigences

Dans les **conditions normales de fonctionnement** et dans les **conditions anormales de fonctionnement**, il ne doit pas se produire d'**explosion**.

Dans les **conditions de premier défaut**, l'équipement doit être conforme aux parties appropriées des Articles 6 et 8.

4.5.3 Conformité

La conformité est vérifiée par examen et par les essais spécifiés aux Articles B.2, B.3 et B.4.

5 Blessure due à un choc électrique

5.1 Généralités

Afin de réduire la probabilité d'effets douloureux et de blessures dus au courant électrique passant à travers le corps humain, l'équipement doit être muni des **protections** spécifiées dans le présent article.

5.2 Classification et limites des sources d'énergie électrique

5.2.1 Classifications des sources d'énergie électrique

5.2.1.1 ES1

ES1 est une source d'énergie électrique de classe 1 dont les niveaux ne dépassent pas les limites de ES1 dans

- les **conditions normales de fonctionnement**, et
- les **conditions anormales de fonctionnement** qui ne conduisent pas à une **condition de premier défaut**,

et ne dépassent pas les limites de ES2 dans les **conditions de premier défaut**.

NOTE ES1 peut être **accessible** à une **personne ordinaire**.

5.2.1.2 ES2

ES2 est une source d'énergie électrique de classe 2 dont les niveaux ne dépassent pas les limites de ES2 dans

- les **conditions normales de fonctionnement**,
- les **conditions anormales de fonctionnement**, et
- les **conditions de premier défaut**,

mais n'est pas ES1.

NOTE ES2 peut être **accessible** à une **personne avertie**.

5.2.1.3 ES3

ES3 est une source d'énergie électrique de classe 3 dont les niveaux dépassent les limites de ES2 dans les **conditions normales de fonctionnement**, les **conditions anormales de fonctionnement** ou les **conditions de premier défaut**.

NOTE 1 L'énergie d'ES3 peut entraîner des effets physiologiques nocifs en cas de contact avec une partie du corps.

NOTE 2 Les parties et les circuits classés ES3 peuvent être **accessibles** à une **personne qualifiée**.

Tous les conducteurs porteurs de courant d'un circuit de **réseau d'alimentation** en courant alternatif, y compris le neutre, sont déclarés ES3.

Les parties conductrices peuvent être classées ES3 sans mesure ni évaluation.

5.2.2 Limites de ES1, ES2 et ES3

5.2.2.1 Généralités

Le présent paragraphe spécifie les paramètres et leurs amplitudes pour les sources d'énergie électriques ES1, ES2 et ES3.

Les limites spécifiées dans le présent paragraphe sont relatives à la terre ou bien à une partie **accessible**.

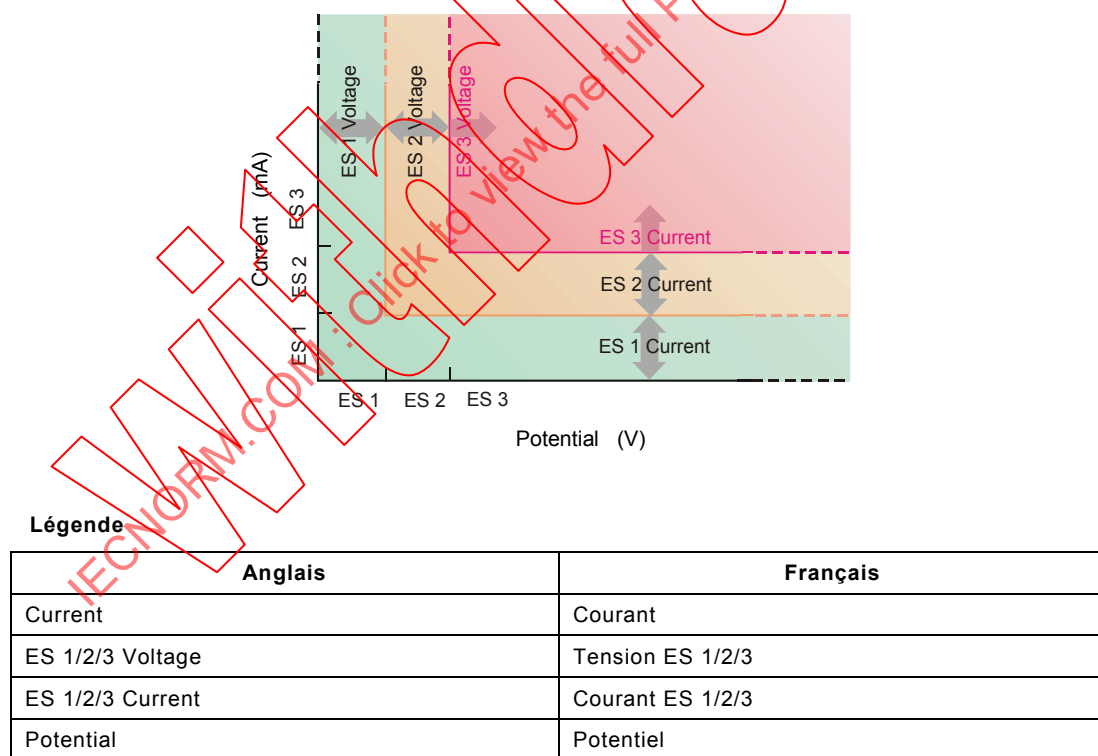


Figure 23 – Illustration montrant que les limites ES dépendent à la fois de la tension et du courant

Comme illustré dans la Figure 23, pour ES1 et ES2, pour toute tension jusqu'à la limite de tension, il n'existe pas de limite pour le courant. De même, pour les courants jusqu'à la limite de courant, il n'existe pas de limite pour la tension. Cependant, pour ES1 et ES2, en aucun cas la limite de courant et la limite de tension ne peuvent être dépassées toutes les deux. ES2 est une source d'énergie dont à la fois la tension et le courant dépassent les limites de ES1, mais ne dépassent pas les limites de ES2. ES3 représente toutes les sources dont la

limite de tension et la limite de courant dépassent celles de ES2. Les limites de tension dans cette figure ne s'appliquent pas aux condensateurs chargés (voir 5.2.2.3).

5.2.2.2 Limites de tension et de courant stables

Une classe de source d'énergie électrique est déterminée d'après la tension et le courant disponibles (voir les Tableaux 4, 5 et 6).

Il s'agit des valeurs maximales pouvant être fournies par la source pendant 2 s ou plus. Les courants sont mesurés conformément à 5.7.

NOTE Les limites de courant proviennent de la CEI/TS 60479-1:2005:

- limites en courant continu d'après la Figure 22;
- limites en courant alternatif d'après la Figure 20.

Tableau 4 – Limites de sources d'énergie électrique pour les courants continus et les courants alternatifs basse fréquence

Source d'énergie	Limite de ES1	Limite de ES2	ES3
CC	2 mA	25 mA	Supérieure à la limite de ES2
CA jusqu'à 1 kHz	0,5 mA eff. 0,707 mA de crête	5 mA en valeur efficace 7,07 mA en valeur crête	
CA et CC combinés	$\frac{I_{dc} \text{ mA}}{2} + \frac{I_{ac} \text{ mA r.m.s.}}{0,5} \leq 1$ $\frac{I_{dc} \text{ mA}}{2} + \frac{I_{ac} \text{ mA peak}}{0,707} \leq 1$ dc = cc ac = ca r.m.s = efficace peak = crête	Voir la Figure 24	
Les valeurs crête doivent être utilisées pour le courant non sinusoïdal. Les limites de courant proviennent de la CEI 60479-1 pour les conditions sèches.			

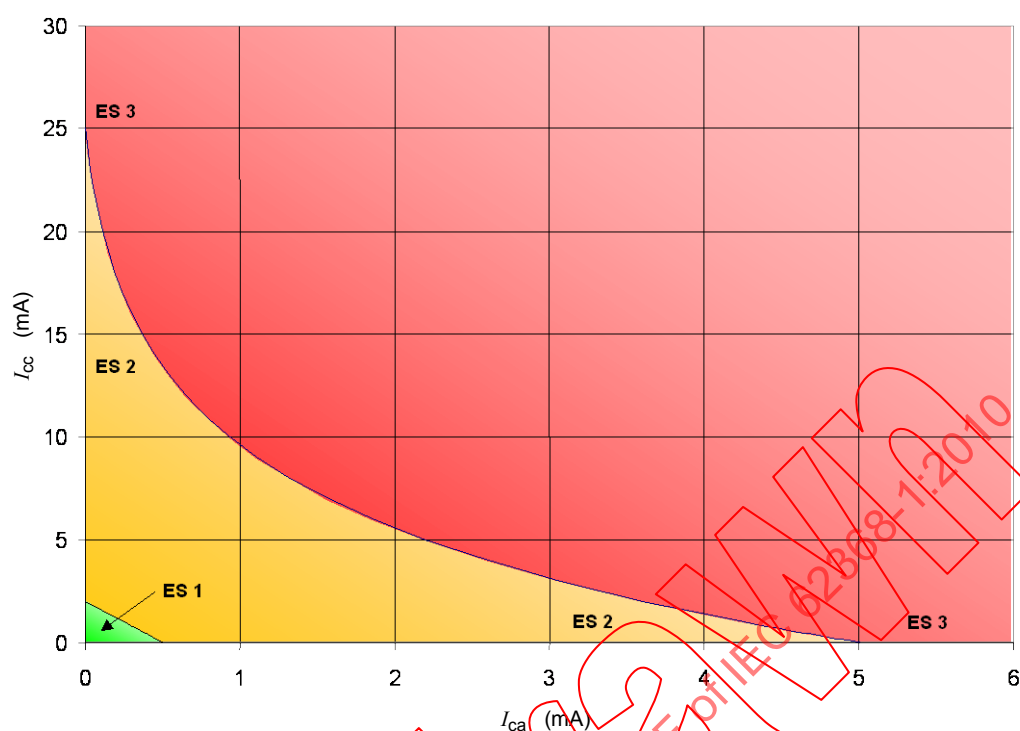


Figure 24 – Valeurs maximales pour les courants alternatif et continu combinés

La courbe de limite de ES2 est fondée sur la formule suivante:

$$5,104 \times e^{(-0,16 \times I_{cc})} - 0,097 \geq I_{ca}$$

où

I_{ca} est le courant alternatif mesuré dans la plage de 0 mA à 5 mA;

I_{cc} est le courant continu mesuré dans la plage de 0 mA à 25 mA.

Tableau 5 – Limites de sources d'énergie électrique pour les tensions continue et alternative basse fréquence

Source d'énergie	Limite de ES1	Limite de ES2	ES3
CC	60 V	120 V	Supérieure à la limite de ES2
CA jusqu'à 1 kHz	30 V en valeur efficace 42,4 V en valeur crête	50 V en valeur efficace 70,7 V en valeur crête	
Tensions alternative et continue combinées	$\frac{U_{dc} \text{ V}}{60} + \frac{U_{ac} \text{ V r.m.s.}}{30} \leq 1$ dc = cc ac = ca r.m.s = efficace	Voir la Figure 25	

Les valeurs crête doivent être utilisées pour la tension non sinusoïdale.

Les limites de tension proviennent de la CEI/TS 61201:2000 dans des conditions sèches.

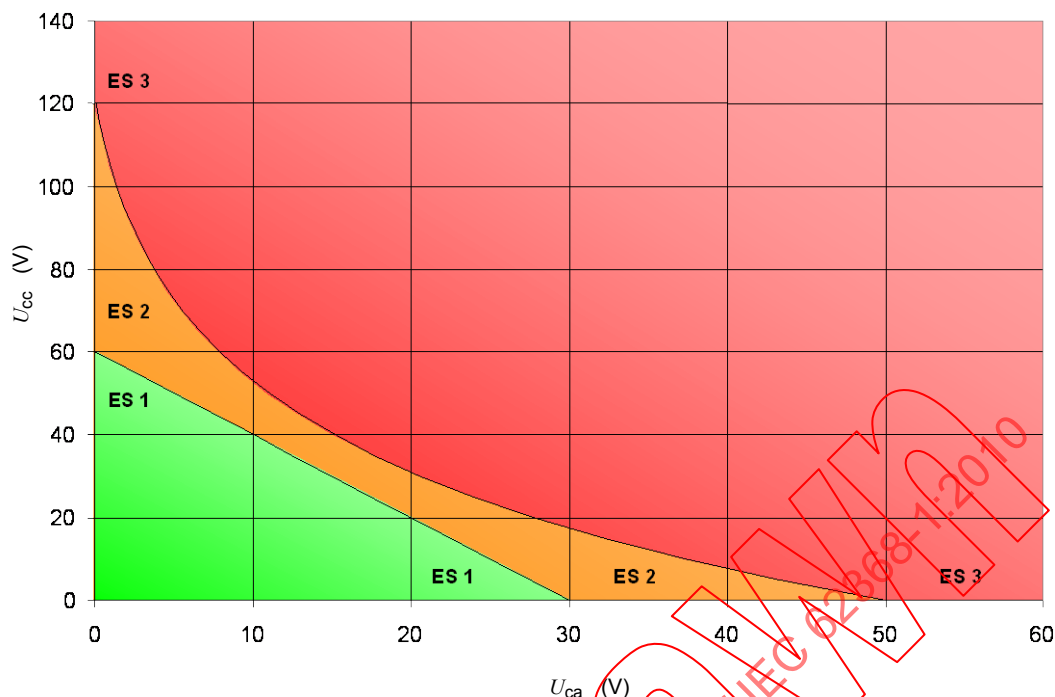


Figure 25 – Valeurs maximales pour les tensions alternatives et continue combinées

La courbe de limite de ES2 est fondée sur la formule suivante:

$$51,746 \times e^{(-0,028 \times U_{cc})} - 1,746 \geq U_{ca}$$

où

U_{ca} est la tension alternative mesurée dans la plage de 0 V à 50 V efficace.

U_{cc} est la **tension continue** mesurée dans la plage de 0 V à 120 V.

Tableau 6 – Limites de sources d'énergie électrique pour les tension et courant moyenne et haute fréquence

Source d'énergie		Limite de ES1	Limite de ES2	ES3
1 kHz jusqu'à 100 kHz	Tension	30 V en valeur efficace $+0,4 \times f$	50 V en valeur efficace $+0,9 \times f$	Supérieure à la limite de ES2
	Courant	0,5 mA en valeur efficace $\times f$	5 mA en valeur efficace $+0,95 \times f$	
Supérieure à 100 kHz	Tension	70 V en valeur efficace	140 V en valeur efficace	
	Courant	50 mA en valeur efficace	100 mA en valeur efficace	

Pour les formes d'onde non sinusoïdales et pour les signaux à fréquences multiples, utiliser la Figure 4 ou de la CEI 60990:1999 le cas échéant, pour mesurer la valeur du courant.

f est en kHz.

5.2.2.3 Limites de capacité

Lorsque la source d'énergie électrique est un condensateur, la source d'énergie est classifiée à partir de la tension de charge et de la capacité.

La capacité est la valeur assignée du condensateur plus la tolérance spécifiée.

Les limites de ES1 et de ES2 pour les différentes valeurs de capacité sont indiquées dans le Tableau 7.

NOTE 1 Les valeurs de capacité pour ES2 proviennent du Tableau 2 de la CEI/TS 61201:2007.

NOTE 2 Les valeurs pour ES1 sont calculées en divisant les valeurs du Tableau 2 de la CEI/TS 61201:2007 par deux (2).

Tableau 7 – Limites de sources d'énergie électrique pour un condensateur chargé

C nF	ES1 $U_{\text{crête}}$ V	ES2 $U_{\text{crête}}$ V
300 ou supérieur	60	120
170	75	150
91	100	200
61	125	250
41	150	300
28	200	400
18	250	500
12	350	700
8,0	500	1 000
4,0	1 000	2 000
1,6	2 500	5 000
0,8	5 000	10 000
0,4	10 000	20 000
0,2	20 000	40 000
0,133 ou inférieur	25 000	50 000
Une interpolation linéaire peut être utilisée entre les deux points les plus proches.		

5.2.2.4 Limites d'impulsion unique

Lorsque la source d'énergie électrique est une impulsion unique, la source d'énergie est classifiée à partir de la tension et de la durée ou bien à partir du courant et de la durée. Les valeurs sont données dans les Tableaux 8 et 9. Si la tension dépasse la limite, alors le courant ne doit pas dépasser la limite. Si le courant dépasse la limite, la tension ne doit pas dépasser la limite. Les courants sont mesurés conformément à 5.7. Pour les impulsions répétitives, voir 5.2.2.5.

Pour les durées d'impulsion jusqu'à 10 ms, la limite de tension ou de courant valable pour 10 ms s'applique.

NOTE 1 Les limites d'impulsion sont calculées sur la base de la CEI/TS 60479-1:2005, de la Figure 22 et du Tableau 10.

NOTE 2 Ces impulsions uniques ne comprennent pas de transitoires.

NOTE 3 La durée d'impulsion est considérée comme le temps s'écoulant jusqu'au moment où la tension ou le courant dépasse les limites de ES1.

Tableau 8 – Limites de tension pour les impulsions uniques

Durée d'impulsion jusqu'à et y compris ms	Niveau de la source d'énergie électrique	
	ES1 $U_{\text{crête}}$ V	ES2 $U_{\text{crête}}$ V
10	60	196
20		178
50		150
80		135
100		129
200		117
300		110
400		102
500		98
600		97
700		96
800		94
900		93
1 000		89
2 000		80
Si la durée se situe entre les valeurs de deux des lignes, la valeur ES2 de $U_{\text{crête}}$ de la ligne en dessous doit être utilisée ou bien une interpolation logarithmique entre deux lignes adjacentes peut être utilisée, en arrondissant la valeur calculée à la milliseconde la plus proche.		

Tableau 9 – Limites de courant pour les impulsions uniques

Durée d'impulsion jusqu'à et y compris ms	Niveau de la source d'énergie électrique	
	ES1 $I_{\text{crête}}$ mA	ES2 $I_{\text{crête}}$ mA
10	2	200
20	2	153
50	2	107
100	2	81
200	2	62
500	2	43
1 000	2	33
2 000	2	25
Si la durée se situe entre les valeurs de deux des lignes, la valeur ES2 de $I_{\text{crête}}$ de la ligne en dessous doit être utilisée ou bien une interpolation logarithmique entre deux lignes adjacentes peut être utilisée, en arrondissant la valeur calculée à la milliseconde la plus proche.		

5.2.2.5 Limites pour les impulsions répétitives

À l'exception des impulsions traitées dans l'Annexe H, une classe de source d'énergie électrique à impulsion répétitive est déterminée à partir, soit de la tension disponible, soit du

courant disponible (voir le Tableau 10). Si la tension dépasse la limite, alors le courant ne doit pas dépasser la limite. Si le courant dépasse la limite, la tension ne doit pas dépasser la limite. Les courants sont mesurés conformément à 5.7.

La tension est la valeur maximale qui peut être fournie par la source dans une charge résistive ne dépassant pas 1 MΩ.

Le courant est la valeur maximale qui peut être fournie par la source pour toute impulsion dans une charge résistive.

Tableau 10 – Limites de sources d'énergie électrique pour les impulsions répétitives

Durée d'interruption des impulsions		ES1	ES2	ES3
Inférieure à 3	Courant	0,707 mA de crête	7,07 mA de crête	Supérieure à la limite de ES2
	Tension	42,4 V en valeur crête	70,7 V en valeur crête	
3 s ou plus	Courant	2 mA de crête	Voir Tableau 9	
	Tension	60 V en valeur crête	Voir Tableau 8	

5.2.2.6 Signaux de sonnerie

Lorsque la source d'énergie électrique est un signal de sonnerie de réseau téléphonique analogique tel que défini dans l'Annexe H, la classe de source d'énergie est considérée comme étant ES2.

5.2.2.7 Signaux audio

Pour les sources d'énergie électrique contenant des signaux audio, voir l'Article E.1 f).

5.3 Protection contre les sources d'énergie électrique

5.3.1 Généralités

Le présent paragraphe spécifie des exigences de protection pour les parties **accessibles** aux **personnes ordinaires**, aux **personnes averties**, et aux **personnes qualifiées**. Voir 5.3.6 pour l'accessibilité et le Tableau 11 pour une présentation.

Tableau 11 – Présentation des exigences de protection (personnes)

Personne	Nombre de protections de l'équipement nécessaires interposées entre une source d'énergie électrique et des personnes		
	ES1	ES2	ES3
Personne ordinaire	0	1	2
Personne avertie	0	0	2
Personne qualifiée	0	0	0 ou 1 ^a

^a Voir 4.3.4.4.

5.3.2 Protection d'une personne ordinaire

5.3.2.1 Protections entre ES1 et une personne ordinaire

Aucune **protection** n'est nécessaire entre ES1 et une **personne ordinaire**.

5.3.2.2 Protections entre ES2 et une personne ordinaire

Au moins une **protection** doit être interposée entre ES2 et une **personne ordinaire** (voir la Figure 10 et la Figure 11).

5.3.2.3 Protections entre ES3 et une personne ordinaire

Sauf spécification contraire, au moins une **protection principale de l'équipement** et une **protection supplémentaire de l'équipement (double protection)** ou une **protection renforcée** doit être interposée entre ES3 et une **personne ordinaire** (voir la Figure 12).

5.3.3 Protection d'une personne avertie

5.3.3.1 Protections entre ES1 ou ES2 et une personne avertie

Aucune **protection** n'est nécessaire entre ES1 ou ES2 et une **personne avertie** (voir la Figure 14).

5.3.3.2 Protections entre ES3 et une personne avertie

Sauf spécification contraire, au moins une **protection principale de l'équipement** et une **protection supplémentaire de l'équipement (double protection)** ou une **protection renforcée** doit être interposée entre ES3 et une **personne avertie** (voir la Figure 15).

5.3.4 Protection d'une personne qualifiée

5.3.4.1 Protections entre ES1 ou ES2 et une personne qualifiée

Aucune **protection** n'est nécessaire entre ES1 ou ES2 et une **personne qualifiée** (voir la Figure 16 et la Figure 17).

5.3.4.2 Protections entre ES3 et une personne qualifiée

Les conducteurs nus en ES3 doivent être placés ou protégés de telle sorte qu'un contact involontaire avec ces conducteurs lors des opérations d'entretien soit improbable (voir les Figures 18 et 19).

5.3.5 Protections entre les sources d'énergie

5.3.5.1 Généralités

Le présent paragraphe spécifie les **protections** entre ES1, ES2 et ES3.

Le Tableau 12 donne une présentation du nombre requis de **protections de l'équipement** entre les sources d'énergie électrique.

Tableau 12 – Présentation du nombre requis de protections de l'équipement

Source d'énergie électrique	Nombre requis de protections de l'équipement interposées		
	ES1	ES2	ES3
ES1	0	1	2 ^a
ES2	1	0	2 ^b
ES3	2 ^a	2 ^b	0
^a Voir 5.3.5.2.			
^b Voir 5.3.5.3.			

5.3.5.2 Protections entre ES1, ES2 et ES3

Au moins une **protection principale** doit être interposée entre ES2 et ES1 (voir les Figures 26, 27 et 28).



Figure 26 – Modèle pour protéger ES1 contre ES2

Au moins une **protection principale** et une **protection supplémentaire** doivent être interposées entre ES3 et ES1 (voir les Figures 27 et 28).

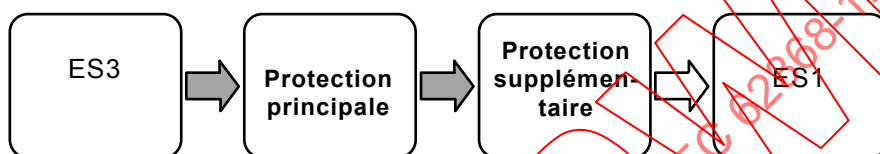


Figure 27 – Modèle pour protéger ES1 contre ES3

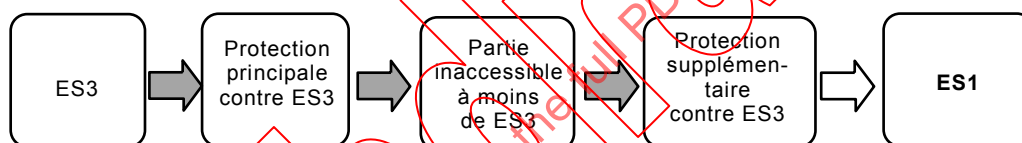


Figure 28 – Modèle pour protéger ES1 contre ES3

5.3.5.3 Protection de ES2 contre ES3

Au moins une **protection principale** et une **protection supplémentaire** doivent être interposées entre ES3 et ES2 (voir les Figures 29 et 30).

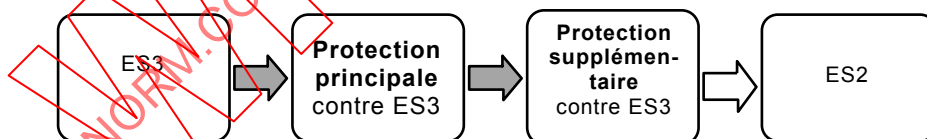


Figure 29 – Modèle à suivre pour protéger ES2 contre ES3



Figure 30 – Modèle pour protéger ES2 contre ES3

5.3.6 Accessibilité des sources d'énergie électrique et des protections

5.3.6.1 Exigences

Les éléments suivants ne doivent pas être **accessibles** aux **personnes ordinaires**:

- les parties nues de ES2, à l'exception des broches des connecteurs. Cependant, ce type de broches ne doit pas être **accessible** dans les **conditions normales de fonctionnement** à la sonde mousse de la Figure V.3; et
- les parties nues de ES3, et
- une **protection principale** ES3.

Les éléments suivants ne doivent pas être **accessibles** aux **personnes averties**:

- les parties nues de ES3, et
- une **protection principale** ES3.

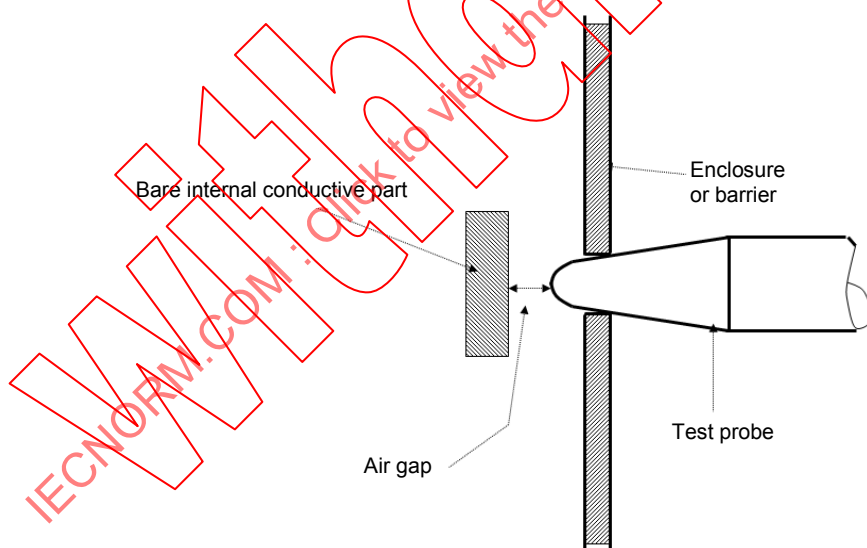
5.3.6.2 Exigences en matière de contact

Pour les tensions ES3 jusqu'à 420 V crête, la sonde d'essai adaptée indiquée dans l'Annexe V ne doit pas entrer en contact avec une partie conductrice interne nue.

Pour les tensions ES3 supérieures à 420 V crête, la sonde d'essai adaptée indiquée dans l'Annexe V ne doit pas entrer en contact avec une partie conductrice interne nue et doit garder un entrefer avec cette partie (voir la Figure 31).

Cet entrefer doit:

- satisfaire à un essai de rigidité diélectrique conformément à 5.4.11.1 à une tension d'essai (continue ou alternative de crête) égale à la tension d'essai pour l'**isolation principale** du Tableau 32 correspondant à la **valeur de crête de la tension de service**; ou
- présenter une distance minimale conformément au Tableau 13.



Légende

Anglais	Français
Bare internal conductive part	Partie conductrice interne nue
Enclosure or barrier	Enveloppe ou séparation
Air gap	Entrefer
Test probe	Sonde d'essai

Figure 31 – Exigences en matière de contact avec des parties conductrices internes nues

Tableau 13 – Distance d'entrefer minimale

Valeur de crête de la tension de service	Distance d'entrefer mm	
V de crête ou c.c. Jusqu'à et y compris	Degré de pollution	
	2	3
>420 et ≤ 1 000	0,2	0,8
1 200	0,25	
1 500	0,5	
2 000	1,0	
2 500	1,5	
3 000	2,0	
4 000	3,0	
5 000	4,0	
6 000	5,5	
8 000	8,0	
10 000	11	
12 000	14	
15 000	18	
20 000	25	
25 000	33	
30 000	40	
40 000	60	
50 000	75	
60 000	90	
80 000	130	
100 000	170	
Une interpolation linéaire peut être utilisée entre les deux points les plus proches, la distance d'entrefer minimale calculée arrondie au 0,1 mm supérieur ou la valeur de la ligne suivante, la valeur la plus faible étant retenue.		

5.3.6.3 Conformité

La conformité est vérifiée en réalisant l'essai approprié de l'Annexe T, suivi des essais de l'Annexe V.

En outre, pour les parties ES3 nues à une tension supérieure à 420 V crête, la conformité est vérifiée par une mesure de la distance ou par un essai de rigidité diélectrique.

Les composants et les sous-ensembles conformes aux normes CEI leur correspondant ne sont pas soumis au doigt d'essai de V.1.2 lorsqu'ils sont utilisés dans le produit fini.

5.3.6.4 Bornes utilisées pour connecter un fil dénudé

L'utilisation d'un fil dénudé pour réaliser une connexion avec une borne, destinée à être utilisée par une **personne ordinaire** (par exemple, une borne de haut-parleur sur un amplificateur audio) ne doit pas entraîner de contact avec ES2 ou ES3 (pour les tensions de signal audio, voir le Tableau E.1 pour les valeurs de ES2 et de ES3).

La conformité est vérifiée par l'essai de V.1.6.

5.4 Matériaux d'isolation et exigences

5.4.1 Généralités

5.4.1.1 Isolation

Le présent paragraphe spécifie des matériaux isolants, des **distances d'isolement dans l'air**, des **lignes de fuite** et une **isolation réalisée avec un isolant solide**, ainsi que l'utilisation de ces matériaux dans les composants.

Une isolation offrant une fonction de **protection** est désignée comme une **isolation principale**, une **isolation supplémentaire**, une **double isolation** ou une **isolation renforcée**.

5.4.1.2 Propriétés des matériaux isolants

Le choix et l'application de matériaux isolants doivent prendre en compte les besoins en termes de rigidité diélectrique, de résistance mécanique, de dimensions, de fréquences de **tension de service** et d'autres propriétés pour l'environnement de fonctionnement (température, pression, humidité et pollution) tels que spécifiés à l'Article 5 et l'Annexe T.

Le matériau isolant ne doit pas être hygroscopique comme déterminé en 5.4.1.3.

NOTE Pour protéger l'**isolation réalisée avec un isolant solide** contre un endommagement dû aux tensions transitoires, il convient que la rigidité diélectrique de l'**isolation réalisée avec un isolant solide** soit supérieure à la rigidité diélectrique de la **distance d'isolement dans l'air** (parallèle) associée.

5.4.1.3 Conformité

La conformité est vérifiée par examen et, si nécessaire, par évaluation des données du matériau.

Si nécessaire, si les données ne confirment pas que le matériau est non hygroscopique, la nature hygroscopique du matériau est déterminée en soumettant le composant ou le sous-ensemble utilisant l'isolation en question au traitement d'humidité décrit en 5.4.10. L'isolation est ensuite soumise à l'essai de rigidité diélectrique approprié décrit en 5.4.11.1 alors qu'elle se trouve toujours dans l'enceinte humide ou dans le local dans lequel les échantillons ont été amenés à la température prescrite.

5.4.1.4 Fréquence

Pour les fréquences fondamentales supérieures à 30 kHz, les **distances d'isolement dans l'air**, les **lignes de fuite** et l'**isolation réalisée avec un isolant solide** doivent satisfaire à 5.4.2, 5.4.3 et 5.4.4.9 respectivement.

NOTE 1 Pour les fréquences fondamentales supérieures à 30 kHz, les exigences sont fondées sur la CEI 60664-1 et la CEI 60664-4.

Si le circuit a une fréquence de **réseau d'alimentation** et une fréquence fondamentale supérieures à 30 kHz, alors les exigences du cas le plus défavorable relatives aux **distances d'isolement dans l'air**, aux **lignes de fuite** et à l'**isolation réalisée avec un isolant solide** doivent être appliquées.

Comme alternative, pour une **isolation réalisée avec un isolant solide** et des fréquences supérieures à 30 kHz, l'essai de fréquence élevée de 5.4.4.9 peut être remplacé par l'essai de rigidité diélectrique décrit en 5.4.11.1 dans les conditions suivantes:

- la résistance du champ est à peu près uniforme; et
- aucun vide ni aucun entrefer n'est présent dans l'**isolation réalisée avec un isolant solide**.

NOTE 2 Dans ce contexte, le champ électrique est considéré comme à peu près uniforme si les écarts sont inférieurs de $\pm 20\%$ à la valeur moyenne de la résistance du champ.

5.4.1.5 Températures de fonctionnement maximales pour les matériaux isolants

5.4.1.5.1 Exigences

Dans les **conditions normales de fonctionnement**, les températures du matériau isolant ne doivent pas dépasser la limite de température du matériau isolant, y compris les matériaux isolants des composants, ni la limite de température maximale du système d'isolation telle que donnée dans le Tableau 14.

Pour les températures maximales inférieures ou égales à 100 °C, aucun système d'isolation classifié n'est nécessaire.

5.4.1.5.2 Méthode d'essai

Les températures du matériau isolant sont mesurées conformément à B.1.7.

*L'équipement ou des parties de l'équipement fonctionnent dans les **conditions normales de fonctionnement** (voir Article B.2) comme suit:*

- *pour le fonctionnement continu, jusqu'à ce que des conditions stables soient établies; et*
- *pour le **fonctionnement intermittent**, jusqu'à ce que des conditions stables soient établies, à l'aide des périodes assignées « ON » et « OFF »; et*
- *pour le **fonctionnement de courte durée**, pour le temps de fonctionnement spécifié par le fabricant.*

Des composants et d'autres parties peuvent être soumis à essai indépendamment du produit fini à condition que les conditions d'essai applicables au produit fini soient appliquées au composant ou à une partie du composant.

L'équipement destiné à la construction ou au montage, ou à être intégré dans un équipement de plus grande taille, est soumis à essai dans les conditions réelles ou simulées les plus défavorables spécifiées dans les instructions d'installation.

5.4.1.5.3 Conformité

La température du matériau d'isolation électrique ou du système d'isolation électrique (EIS - electrical insulation system) ne doit pas dépasser les limites du Tableau 14.

Pour un matériau isolant unique, l'indice de température relatif (RTI – relative temperature index) déclaré du fabricant du matériau peut être utilisé s'il est adapté à la classe d'isolation applicable.

NOTE Par exemple, un matériau assigné jusqu'à 124 °C est considéré comme adapté aux classes dont la température est inférieure (classe avec les codes alphabétiques E et A), et non aux classes dont la température est supérieure (classe avec les codes alphabétiques B, F, H, N, R et C).

Aucun essai n'est nécessaire si la classification thermique appartient à la classe 105 conformément à la CEI 60085.

Pour les classifications thermiques au-dessus de la classe 105, l'EIS doit satisfaire à la CEI 60085.

Tableau 14 – Limites de températures des matériaux, composants et systèmes

Partie	Température maximale $T_{\max}$ °C
Isolation, y compris l'isolation d'enroulement:	
du matériau ou de l'EIS de classe 105 (A)	100 ^a
du matériau ou de l'EIS de classe 120 (E)	115 ^a
du matériau ou de l'EIS de classe 130 (B)	120 ^a
du matériau ou de l'EIS de classe 155 (F)	140 ^a
du matériau ou de l'EIS de classe 180 (H)	165 ^a
du matériau ou de l'EIS de classe 200 (N)	180 ^a
du matériau ou de l'EIS de classe 220 (R)	200 ^a
du matériau ou de l'EIS de classe 250	225 ^a
Isolation du câblage interne et externe, y compris les cordons d'alimentation:	
– sans marquage de la température	70
– avec marquage de la température	Température marquée sur le câble ou la bobine, ou valeur assignée fixée par le fabricant
Autre isolation thermoplastique	Voir 5.4.1.11
Composants	Voir également l'Annexe G
^a Si la température d'un enroulement est déterminée par des thermocouples, ces valeurs sont réduites de 10 K, excepté dans le cas d'un – moteur, ou – d'un enroulement avec thermocouples intégrés. Les classes sont liées aux classes de températures des matériaux isolants électriques et des systèmes d'isolation électriques conformément à la CEI 60085. Les désignations alphabétiques assignées sont données entre parenthèses. Pour chaque matériau, les données de ce matériau doivent être prises en compte pour déterminer la température maximale appropriée.	

5.4.1.6 Degrés de pollution

Le présent paragraphe décrit différents degrés de pollution de l'environnement de fonctionnement pour les produits traités par la présente norme.

Degré de pollution 1

Absence de pollution ou uniquement pollution sèche, non conductrice. La pollution n'exerce aucune influence.

NOTE 1 À l'intérieur de l'équipement, des composants ou des sous-ensembles étanches de manière à exclure la poussière et l'humidité constituent des exemples du **degré de pollution 1**.

Degré de pollution 2

Uniquement pollution non conductrice, si ce n'est qu'une conductivité temporaire provoquée par la condensation est attendue ponctuellement.

NOTE 2 Le **degré de pollution 2** est généralement adapté aux équipements couverts par le domaine d'application de la présente norme.

Degré de pollution 3

Pollution conductrice ou pollution sèche non conductrice devenant conductrice en raison de la condensation, ce qui est attendu.

5.4.1.7 Isolation dans les transformateurs à dimensions variables

Le présent paragraphe spécifie la méthode de détermination des **distances d'isolement dans l'air**, des **lignes de fuite** et des distances traversant l'isolation sur toute la longueur de l'enroulement d'un transformateur.

Si l'isolation d'un transformateur présente différentes **tensions de service** sur la longueur de l'enroulement, les **distances d'isolement dans l'air**, les **lignes de fuite** et les distances dans l'isolation peuvent varier de façon correspondante.

NOTE Un exemple d'une telle construction est un enroulement 30 kV, constitué de multiples bobines connectées en série, et mises à la terre ou connectées en un point commun à une extrémité.

5.4.1.8 Isolation dans les circuits générant des impulsions de démarrage

Le présent paragraphe spécifie la méthode de détermination des **distances d'isolement dans l'air**, des **lignes de fuite** et des distances dans l'isolation des circuits générant des impulsions de démarrage.

Pour les circuits générant des impulsions de démarrage (par exemple, pour allumer une lampe à décharge), les exigences relatives à l'**isolation principale**, à l'**isolation supplémentaire** et à l'**isolation renforcée** s'appliquent aux **lignes de fuite** et aux distances dans l'isolation. Pour les **distances d'isolement dans l'air**, voir G.12.2.

NOTE Pour les **tensions de service** dans les cas ci-dessus, voir 5.4.1.9.1, i).

5.4.1.9 Détermination de la tension de service

5.4.1.9.1 Généralités

Le présent paragraphe spécifie les différents paramètres et hypothèses qui doivent être pris en compte lors de la détermination de la **tension de service**.

Pour la détermination des **tensions de service**, toutes les exigences suivantes s'appliquent:

- les parties conductrices **accessibles** non mises à la terre sont supposées mises à la terre;
- si un enroulement du transformateur ou une autre partie n'est pas connecté(e) à un circuit qui établit son potentiel par rapport à la terre, l'enroulement ou l'autre partie sont supposés être reliés à la terre au point où la **tension de service** la plus élevée est obtenue;
- à l'exception des spécifications de 5.4.1.7, pour une isolation entre deux enroulements du transformateur, la tension la plus élevée entre deux points dans les deux enroulements est la **tension de service**, en tenant compte des tensions auxquelles les enroulements d'entrée seront connectés;
- à l'exception des spécifications de 5.4.1.7, pour l'isolation entre un enroulement du transformateur et une autre partie, la tension la plus élevée entre un point sur l'enroulement et l'autre partie est la **tension de service**;
- dans le cas d'une **double isolation**, la **tension de service** appliquée à l'**isolation principale** est déterminée en imaginant l'**isolation supplémentaire** en court-circuit, et inversement. Pour une **double isolation** entre les enroulements d'un transformateur, le court-circuit est supposé au point où la **tension de service** la plus élevée est produite dans l'autre isolation;

- f) lorsque la **tension de service** est déterminée par mesure, l'énergie d'entrée apportée à l'équipement doit être la **tension assignée** ou la tension comprise dans la **plage de tensions assignées** qui produit la valeur mesurée la plus élevée;
- g) la **tension de service** entre
- tous les points dans le circuit alimentés par le **réseau d'alimentation** et toutes les parties connectées à la terre; et
 - tous les points dans le circuit alimentés par le **réseau d'alimentation** et tous les points dans un circuit isolé de ce même réseau doivent être supposés supérieurs aux valeurs suivantes:
 - la **tension assignée** ou la tension supérieure de la **plage de tensions assignées**; et
 - la tension mesurée;
- h) lors de la détermination de la **tension de service** pour un **circuit externe** ES1 ou ES2, les tensions normales de fonctionnement doivent être prises en compte. Si les tensions de fonctionnement ne sont pas connues, la **tension de service** doit être établie comme les limites supérieures de ES1 ou ES2 selon le cas.
- Des signaux de courte durée (comme une sonnerie de téléphone) ne doivent pas être pris en compte pour la détermination de la **tension de service**;
- i) pour les circuits générant des impulsions de démarrage (par exemple, les lampes à décharge, voir Article G.12), la **valeur de crête de la tension de service** est la valeur de crête des impulsions alors que la lampe est connectée mais avant qu'elle ne s'allume. La **tension de service** pour déterminer les **lignes de fuite** minimales est la tension mesurée après l'allumage de la lampe;
- j) les surtensions temporaires et les tensions de crête récurrentes doivent être prises en considération.

5.4.1.9.2 Tension de service efficace

Les conditions à court terme (par exemple, des signaux de sonnerie de téléphone cadencés dans les **circuits externes**) et les transitoires non répétitifs (par exemple, en raison des perturbations atmosphériques) ne sont pas pris en compte pour déterminer la **tension de service efficace**.

NOTE Les **lignes de fuite** sont déterminées à partir des **tensions de service efficaces**.

5.4.1.9.3 Valeur de crête de la tension de service

Pour la **valeur de crête de la tension de service** utilisée pour déterminer la **tension de tenue prescrite** pour des **distances d'isolement dans l'air** minimales et des tensions d'essai pour la rigidité diélectrique:

- lors de la détermination de la **valeur de crête de la tension de service** entre des circuits connectés au **réseau d'alimentation** et des circuits isolés de ce même réseau, la tension d'un circuit ES2, d'un circuit ES1 ou de **circuits externes** (y compris de signaux de sonnerie de téléphone) doit être considérée comme nulle;
- lors de la détermination de la **valeur de crête de la tension de service** pour un **circuit externe** qui ne présente pas de transitoires, la **valeur de crête de la tension de service** de signaux répétitifs, tels que des signaux de sonnerie de téléphone, doit être prise en compte;
- les transitoires non répétitifs (par exemple, dus aux perturbations atmosphériques) ne doivent pas être pris en compte.

5.4.1.10 Surfaces isolantes

Une surface isolante **accessible** est considérée couverte d'une feuille métallique fine pour la détermination des **distances d'isolement dans l'air**, des **lignes de fuite** et des distances dans l'isolation (voir la Figure O.13).

5.4.1.11 Parties thermoplastiques sur lesquelles les parties métalliques conductrices sont montées directement

5.4.1.11.1 Exigences

Les parties thermoplastiques sur lesquelles les parties métalliques conductrices sont montées directement doivent être suffisamment résistantes pour chauffer si le ramollissement du plastique entraînait le dysfonctionnement d'une **protection**.

5.4.1.11.2 Conformité

La conformité est vérifiée par examen des données de l'essai Vicat du fabricant du matériau. Si les données ne sont pas disponibles, la conformité est vérifiée soit par l'essai Vicat décrit dans le présent paragraphe, soit par l'essai à la bille décrit en 5.4.1.11.3.

*La température mesurée dans les **conditions normales de fonctionnement**, telles que spécifiées à l'Article B.2, doit être au moins inférieure de 15 K à la température de ramollissement Vicat telle que spécifiée dans l'essai Vicat B50 de l'ISO 306.*

*La température mesurée dans les **conditions anormales de fonctionnement** de l'Article B.3 doit être inférieure à la température de ramollissement Vicat.*

*La température de ramollissement Vicat d'une partie non métallique soutenant des parties dans un circuit alimenté par le **réseau d'alimentation** ne doit pas être inférieure à 125 °C.*

5.4.1.11.3 Essai à la bille

*La conformité est vérifiée par examen des données de l'essai à la bille du fabricant ou en soumettant la partie à l'essai à la bille conformément à la CEI 60695-10-2. L'essai est réalisé dans une enceinte chauffée à une température de $(T - T_{amb} + T_{ma} + 15 \text{ °C}) \pm 2 \text{ °C}$. Cependant, une partie thermoplastique soutenant des parties dans un circuit alimenté par le **réseau d'alimentation** est soumise à essai à une température minimale de 125 °C.*

Les significations de T , T_{ma} et T_{amb} sont telles qu'indiquées en B.2.6.1.

Après l'essai, la dimension d (diamètre de l'indentation) ne doit pas dépasser 2 mm.

L'essai n'est pas effectué s'il apparaît clairement à l'examen des caractéristiques physiques du matériau que ce dernier répond aux exigences de cet essai.

5.4.2 Distances d'isolement dans l'air

5.4.2.1 Généralités

Le présent paragraphe spécifie les **distances d'isolement dans l'air** requises pour une **tension de service** donnée et les différents autres paramètres qui ont un effet sur les **distances d'isolement dans l'air**.

Les **distances d'isolement dans l'air** doivent être dimensionnées de telle façon que les surtensions et transitoires qui peuvent entrer dans l'équipement, et les valeurs crête de la tension qui peuvent être générées à l'intérieur de l'équipement, ne détruisent pas la **distance d'isolement dans l'air**.

Le paramètre, **tension de tenue prescrite**, prend en compte les surtensions et transitoires qui peuvent entrer dans l'équipement ou qui peuvent être générés dans l'équipement. Les dimensions pour une **distance d'isolement dans l'air** qui subit l'effet des transitoires du **réseau d'alimentation** ou un **circuit externe** sont déterminées à partir de la **tension de tenue prescrite** pour cette **distance d'isolement dans l'air**.

La détermination de la **distance d'isolement dans l'air** tient compte de la **valeur de crête de la tension de service** (y compris les tensions stables et les tensions de crête récurrentes) et des surtensions temporaires.

Il est tenu compte des tensions haute fréquence pour déterminer la **distance d'isolement dans l'air**.

Les dimensions pour les **distances d'isolement dans l'air** jouant le rôle d'**isolation principale**, d'**isolation supplémentaire** et d'**isolation renforcée** ne doivent pas être inférieures aux dimensions minimales déterminées en 5.4.2.7, ou doivent être déterminées conformément à 5.4.2.8.

Les **distances d'isolement dans l'air** minimales telles que déterminées en 5.4.2.7 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 **verrouillages de sécurité**, voir l'Annexe K. Pour les distances entre les contacts de **dispositifs de déconnexion**, voir l'Annexe L.

La **distance d'isolement dans l'air** entre la surface isolante extérieure (voir 5.4.2.2) d'un connecteur (y compris une ouverture dans l'**enveloppe**) et les parties conductrices connectées à ES2 à l'intérieur du connecteur (ou dans l'**enveloppe**) doivent être conformes aux exigences relatives à l'**isolation principale**.

La **distance d'isolement dans l'air** entre la surface isolante extérieure (voir 5.4.2.2) d'un connecteur (y compris une ouverture dans l'**enveloppe**) et les parties conductrices connectées à ES3 à l'intérieur du connecteur (ou dans l'**enveloppe**) doivent être conformes aux exigences relatives à l'**isolation renforcée**. A titre d'exception, la **distance d'isolement dans l'air** peut être conforme aux exigences pour l'**isolation principale** si le connecteur est:

- fixé à l'équipement; et
- situé à l'intérieur de l'**enveloppe électrique** extérieure de l'équipement; et
- **accessible** uniquement après le retrait d'un sous-ensemble qui
 - doit être à sa place dans les **conditions normales de fonctionnement**, et
 - est fourni avec une **protection mise en place sous forme d'instructions** pour remplacer le sous-ensemble retiré.

NOTE 2 Les essais de 5.4 s'appliquent à ce type de connecteurs après le retrait du sous-ensemble.

Pour toutes les autres **distances d'isolement dans l'air** dans les connecteurs, y compris les connecteurs qui ne sont pas fixés à l'équipement, les valeurs minimales déterminées conformément à 5.4.2.7 s'appliquent.

Les **distances d'isolement dans l'air** minimales ci-dessus pour les connecteurs ne s'appliquent pas aux connecteurs énumérés à l'Article G.20.

5.4.2.2 Conformité

La conformité est vérifiée par mesure en prenant en compte les articles appropriés des Annexes O et T.

Les conditions suivantes s'appliquent:

- les **parties mobiles** sont placées dans leur position la plus défavorable;
- les **distances d'isolement dans l'air** d'une **enveloppe** de matériau isolant à travers un intervalle ou une ouverture sont mesurées conformément à la Figure O.13, point X;

- les dimensions des **distances d'isolement dans l'air** jouant le rôle d'**isolation principale**, d'**isolation supplémentaire** et d'**isolation renforcée** sont mesurées après les essais décrits dans l'Annexe T;
- après les essais décrits dans l'Annexe T, l'essai de rigidité diélectrique doit s'appliquer;
- au cours des essais de force, les **enveloppes** en métal ne doivent pas entrer en contact avec les parties conductrices nues
 - des circuits ES2, à moins que le produit ne soit dans une **zone à accès limité**, ou
 - des circuits ES3;
- pour l'essai de bris de glace, voir l'Article T.9. Les endommagements de la finition, les petits éclats ne réduisant pas les **distances d'isolement dans l'air** en dessous des valeurs spécifiées, les fissures superficielles et les éléments similaires sont ignorés. Si une fissure apparaît, les **distances d'isolement dans l'air** ne doivent pas être réduites. Pour les fissures non visibles à l'œil nu, un essai de rigidité diélectrique doit être réalisé.

5.4.2.3 Procédure d'essai pour déterminer les distances d'isolement dans l'air minimales

5.4.2.3.1 Généralités

Pour déterminer la valeur minimale de chaque **distance d'isolement dans l'air** requise, la valeur la plus élevée des trois méthodes suivantes doit être utilisée.

Méthode 1: Déterminer les **distances d'isolement dans l'air** conformément à 5.4.2.3.2 à l'aide des **tensions de tenue prescrites**.

Méthode 2: Déterminer la **valeur de crête de la tension de service** et la **distance d'isolement dans l'air** à partir du Tableau 18.

Méthode 3: Si la fréquence fondamentale est supérieure à 30 kHz, mesurer la **valeur de crête de la tension de service** à la fréquence fondamentale et déterminer la **distance d'isolement dans l'air** à partir du Tableau 19.

5.4.2.3.2 Détermination de la distance d'isolement dans l'air à l'aide de la tension de tenue prescrite

La **distance d'isolement dans l'air** doit être déterminée selon les étapes suivantes:

a) Déterminer la tension transitoire:

- 1) pour l'équipement destiné à être connecté au **réseau d'alimentation**, déterminer la **tension transitoire du réseau d'alimentation** en courant alternatif selon 5.4.2.4.1;
- 2) pour l'équipement destiné à être connecté à un **réseau d'alimentation en courant continu**, déterminer la tension transitoire selon 5.4.2.4.2, ainsi que la **tension continue** nominale;
- 3) pour l'équipement destiné à être connecté à un **circuit externe**, déterminer la tension transitoire du **circuit externe** selon 5.4.2.4.3;

b) Déterminer la **tension de tenue prescrite** selon 5.4.2.5;

c) Déterminer la **distance d'isolement dans l'air** minimale selon 5.4.2.7.

L'effet des transitoires d'un **circuit externe** composé d'un câble coaxial ou d'une antenne n'est pas pris en compte lors de la détermination des **distances d'isolement dans l'air**.

5.4.2.4 Détermination des tensions transitoires

5.4.2.4.1 Détermination des tensions transitoires du réseau d'alimentation en courant alternatif

Le présent paragraphe spécifie la méthode pour déterminer la **tension transitoire du réseau d'alimentation** en courant alternatif qu'il est nécessaire de prendre en compte lors de la détermination de la **tension de tenue prescrite**.

Pour les équipements destinés à être alimentés par le **réseau d'alimentation** en courant alternatif, la valeur de la **tension transitoire du réseau d'alimentation** dépend de la catégorie de surtension et de la tension du **réseau d'alimentation** en courant alternatif. En général, les **distances d'isolement dans l'air**, dans l'équipement destiné à être connecté au **réseau d'alimentation** en courant alternatif doivent être conçues pour la catégorie II de surtension.

NOTE Voir l'Annexe I pour plus d'indications sur la détermination des catégories de surtension.

L'équipement susceptible, une fois installé, d'être soumis à des tensions transitoires dépassant celles prévues pour la catégorie de surtension pour laquelle il est conçu exige une protection supplémentaire à l'extérieur de l'équipement. Dans ce cas, les instructions d'installation doivent indiquer la nécessité d'une protection externe.

La valeur applicable de la **tension transitoire du réseau d'alimentation** doit être déterminée à partir de la catégorie de surtension et de la tension du **réseau d'alimentation** en courant alternatif, à l'aide du Tableau 15.

Tableau 15 – Tensions transitoires du réseau d'alimentation

Tension du réseau d'alimentation en courant alternatif ^a jusqu'à et y compris		Tension transitoire du réseau d'alimentation ^b V en valeur crête			
V en valeur efficace	V en valeur crête ^c	Catégorie de surtension			
		I	II	III	IV
50	71	330	500	800	1 500
100 ^d	141	500	800	1 500	2 500
150 ^e	210	800	1 500	2 500	4 000
300 ^f	420	1 500	2 500	4 000	6 000
600 ^g	840	2 500	4 000	6 000	8 000

^a Pour l'équipement destiné à être connecté à une alimentation à 3 conducteurs triphasée, ne présentant pas de conducteur neutre, la tension d'alimentation du **réseau d'alimentation** en courant alternatif est la tension entre phases. Dans tous les autres cas, dans lesquels un conducteur neutre est présent, il s'agit d'une tension phase-neutre.

^b La **tension transitoire du réseau d'alimentation** constitue toujours l'une des valeurs du tableau. L'interpolation n'est pas autorisée.

^c Voir 5.4.2.5.1.

^d Au Japon, la valeur des **tensions transitoires du réseau d'alimentation** pour la tension d'alimentation du **réseau d'alimentation** en courant alternatif nominal de 100 V est déterminée à partir des colonnes applicables à la tension d'alimentation du **réseau d'alimentation** en courant alternatif nominal de 150 V.

^e Y compris 120/208 V et 120/240 V.

^f Y compris 230/400 V et 277/480 V.

^g Y compris 400/690 V.

5.4.2.4.2 Détermination des tensions transitoires du réseau d'alimentation en courant continu

Le présent paragraphe spécifie la méthode pour déterminer les tensions transitoires des systèmes de distribution d'alimentation en courant continu qu'il est nécessaire de prendre en compte lors de la détermination de la **tension de tenue prescrite**.

Si un système de distribution d'alimentation en courant continu mis à la terre est entièrement contenu dans un seul bâtiment, la tension transitoire est sélectionnée comme suit:

- si le système de distribution d'alimentation en courant continu est mis à la terre en un seul point, la valeur de crête de la tension transitoire est supposée être de 500 V; ou
- si le système de distribution d'alimentation en courant continu est mis à la terre à la source et au niveau de l'équipement, la valeur de crête de la tension transitoire est supposée être de 350 V; ou

NOTE La connexion à la terre de protection peut être à la source du système de distribution d'alimentation en courant continu ou au niveau de l'emplacement de l'équipement, ou les deux (voir la Recommandation K.27 de l'UIT-T).

- si le câblage associé au système de distribution d'alimentation en courant continu mesure moins de 4 m ou est entièrement installé dans un conduit métallique continu, la valeur de crête de la tension transitoire est supposée être de 150 V.

Si un système de distribution d'alimentation en courant continu n'est pas mis à la terre ou n'est pas contenu dans le même bâtiment, la tension transitoire doit être supposée égale à la **tension transitoire du réseau d'alimentation** dans le **réseau d'alimentation** à partir duquel l'alimentation en courant continu est dérivée. Si, cependant, le système de distribution d'alimentation en courant continu n'est pas contenu dans le même bâtiment, et est construit à l'aide de techniques d'installation et de protection identiques à celles des **circuits externes**, la tension transitoire doit être déterminée à l'aide de la classification appropriée décrite en 5.4.2.4.3.

Si l'équipement est alimenté par une batterie particulière sans moyen de recharge à partir d'une alimentation du **réseau d'alimentation** externe, la tension transitoire ne doit pas être prise en compte.

5.4.2.4.3 Détermination des tensions transitoires du circuit externe

Le présent paragraphe spécifie des tensions transitoires de **circuit externe** pour différentes configurations physiques de ce même circuit.

La valeur applicable de la tension transitoire sur un **circuit externe** doit être déterminée à l'aide du Tableau 16. Lorsque plus d'un emplacement ou d'une condition est applicable, le transitoire le plus élevé s'applique. Une sonnerie ou un autre signal interrompu ne doit pas être pris en compte si la tension de ce signal est inférieure à celle du transitoire.

Les tensions transitoires de **circuits externes** n'exigent pas de **protection**, mais les tensions transitoires doivent être prises en compte lors du dimensionnement d'une **protection** nécessaire entre les différentes catégories de circuits (par exemple, ES1, ES2 et ES3).

Si les tensions transitoires du **circuit externe** sont connues, il convient d'utiliser la valeur connue.

NOTE 1 L'Australie a publié ses limites de surtension dans l'AS/ACIF G624:2005.

NOTE 2 Des mesures adaptées sont supposées avoir été prises pour réduire la probabilité que les transitoires présentés à l'équipement dépassent les valeurs spécifiées dans le Tableau 16. Dans les installations où des transitoires présentés à l'équipement peuvent dépasser les valeurs spécifiées dans le Tableau 16, des mesures supplémentaires telles qu'une limitation des surtensions peuvent se révéler nécessaires.

Tableau 16 – Tensions transitoires du circuit externe

Installé complètement dans la structure du bâtiment ^c			
ID	Type de câble	Conditions supplémentaires	Tensions transitoires ^a
1	Conducteur à paires ^d – non blindé		1 000 V 1,2/50 μ s Différentiel uniquement si un conducteur est mis à la terre dans l'équipement
2	Conducteur à paires ^d – non blindé	Un câble est installé complètement dans un réseau de liaison avec l'équipement (réseau de liaison (BN) maillé, réseau IBN maillé ou réseau IBN en étoile) (sans connexion vers l'extérieur)	500 V 1,2/50 μ s Différentiel uniquement si un conducteur est mis à la terre dans l'équipement
3	Conducteur à paires ^d – non blindé	La longueur du câble est inférieure ou égale à 4 m. Le câble se connecte à l'équipement qui fait généralement partie du même réseau de liaison ou est alimenté par le même circuit de dérivation (sans connexion vers l'extérieur)	Non applicable
4	Conducteur à paires ^d – blindé ^b		Non applicable
5	Tous les autres conducteurs	Interfaces avec un équipement ne présentant pas de connexion ni de référence à la terre	Non applicable
6	Câble coaxial ^b	Le blindage de câble est mis à la terre aux deux extrémités	Non applicable
7	Câble coaxial	Le blindage du câble n'est pas mis à la terre au niveau de l'équipement	Conducteur central au blindage non pris en compte 1 000 V 1,2/50 μ s blindage à la terre
8	Antenne intégrée		Non applicable
9	Tous les conducteurs		Non applicable
10	Câble coaxial	Le câble est connecté à un socle de raccordement d'un système de distribution du câble	Non applicable

Tableau 16 (suite)

Une partie du câble ou du réseau connecté est à l'extérieur du bâtiment ou de la structure ^c			
ID	Type de câble	Conditions supplémentaires	Tensions transitoires ^a
11	Conducteur à paires ^d – non blindé	Le bâtiment ou la structure peut disposer ou non d'une liaison équipotentielle	1 500 V 10/700 μ s Différentiel uniquement si un conducteur est mis à la terre dans l'équipement
12	Conducteur à paires ^d – blindé		1 500 V 10/700 μ s Différentiel uniquement si un conducteur est mis à la terre dans l'équipement
13	Conducteur à paires ^d – blindé	Le bâtiment ou la structure dispose d'une liaison équipotentielle	1 500 V 10/700 μ s Différentiel uniquement si un conducteur est mis à la terre dans l'équipement
14	Tous les autres conducteurs	Le circuit externe n'est pas mis à la terre à chaque extrémité, mais il présente une référence à la terre (par exemple, entre la connexion et le réseau d'alimentation)	Tension transitoire du réseau d'alimentation ou tension transitoire du circuit externe du circuit à partir duquel le circuit en question est dérivé, en prenant la valeur la plus élevée
15	Câble coaxial	Équipement autre que des répéteurs coaxiaux alimentés. Le blindage du câble est mis à la terre au niveau de l'équipement	4 000 V 10/700 μ s Conducteur central au blindage
16	Câble coaxial	Répéteurs coaxiaux alimentés (câble coaxial jusqu'à 4,4 mm). Le blindage du câble est mis à la terre au niveau de l'équipement	5 000 V 10/700 μ s Conducteur central au blindage
17	Câble coaxial	Équipement autre que des répéteurs coaxiaux alimentés. Le blindage du câble n'est pas mis à la terre au niveau de l'équipement. Le blindage du câble est mis à la terre à l'entrée du bâtiment	4 000 V 10/700 μ s Conducteur central au blindage 1 500 V 1,2/50 μ s blindage à la terre
18	Câble coaxial	Le câble se connecte à une antenne extérieure	10 kV à partir de 1 nF
19	Conducteur à paires ^d	Le câble se connecte à une antenne extérieure	10 kV à partir de 1 nF
20	Câble coaxial	La connexion du câble venant de l'extérieur du bâtiment est réalisée via un point de transfert. Le blindage du câble coaxial depuis l'extérieur du bâtiment et le blindage du câble coaxial du câble situé dans le bâtiment sont connectés ensemble et connectés à la terre.	Non applicable

NOTE 1 En Norvège et en Suède, le blindage du câble sur les câbles coaxiaux n'est généralement pas mis à la terre à l'entrée du bâtiment. Pour les conditions d'installation, voir l'EN 60728-11.

NOTE 2 Les effets des tensions stables non souhaitées générées à l'extérieur de l'équipement (par exemple, différences de potentiel de terre et tensions induites sur les réseaux de télécommunication par les systèmes de train électrique) sont contrôlés par les pratiques d'installation. Ces pratiques dépendent de l'application et ne sont pas traitées par la présente norme.

^a Voir la recommandation K.68 de l'UIT-T. En cas d'induction de l'alimentation, des tensions transitoires de 650 V efficace pour $0,35 \text{ s} < t < 0,5 \text{ s}$ peuvent être présentes.

^b Pour qu'un câble blindé entraîne une réduction dans les transitoires, le blindage doit être continu, mis à la terre aux deux extrémités et présenter une impédance de transfert maximale de $20 \Omega/\text{km}$ (pour f inférieur à 1 MHz).

^c Un conducteur est considéré comme quittant le bâtiment s'il s'achève sur l'équipement mis à la terre vers un réseau de mise à la terre différent.

^d Un conducteur à paires comprend une paire torsadée.

5.4.2.5 Détermination de la tension de tenue prescrite

5.4.2.5.1 Tensions transitoires du réseau d'alimentation

À moins que 5.4.2.5.2 s'applique, la **tension de tenue prescrite** est déterminée conformément à a), b) ou c) dans le présent paragraphe.

Pour l'équipement alimenté par le **réseau d'alimentation** en courant alternatif, a) et b) s'appliquent. Pour l'équipement alimenté par le **réseau d'alimentation** en courant continu, c) s'applique.

Les abréviations suivantes sont utilisées.

$U_{\text{tenue prescrite}}$	la valeur de crête de la tension d'alimentation du réseau d'alimentation en courant alternatif dans la deuxième colonne du Tableau 15 correspondant à la tension assignée ou la limite supérieure de la plage de tensions assignées
$U_{\text{transitoire réseau}}$	la tension transitoire du réseau d'alimentation déterminée en 5.4.2.4
$U_{\text{transitoire mesuré}}$	la tension transitoire maximale du réseau d'alimentation en courant alternatif, déterminée conformément à 5.4.2.6

a) Pour les circuits alimentés à partir du **réseau d'alimentation** en courant alternatif, soit a)1) soit a)2) peut être utilisé.

1) $U_{\text{tenue prescrite}} = U_{\text{transitoire réseau}}$

2) $U_{\text{tenue prescrite}} = U_{\text{transitoire mesuré}}$

b) Pour les circuits isolés du **réseau d'alimentation** en courant alternatif, soit b)1), soit b)2), soit b)3) peut être utilisé.

1) $U_{\text{tenue prescrite}} = U_{\text{transitoire réseau}}$

2) $U_{\text{tenue prescrite}} = U_{\text{transitoire mesuré}}$

3) Déterminer la **tension transitoire du réseau d'alimentation** en courant alternatif à partir de 5.4.2.4.1. $U_{\text{tenue prescrite}}$ est une catégorie de surtension inférieure dans le Tableau 15 pour une tension du **réseau d'alimentation** en courant alternatif donnée.

b)3) s'applique normalement aux cas suivants:

- un circuit isolé dérivé du **réseau d'alimentation**, et connecté à la borne principale de mise à la terre de protection conformément à 5.6.4;
- un circuit isolé, dérivé du **réseau d'alimentation** et séparé du circuit connecté au **réseau d'alimentation** par un écran en métal lui-même connecté à la borne principale de mise à la terre de protection conformément à 5.6.4.

c) Pour les circuits alimentés par un **réseau d'alimentation** en courant continu, b)1), b)2) ou b)3) doit s'appliquer.

5.4.2.5.2 Tensions transitoires d'une source en courant continu

Dans un circuit isolé du **réseau d'alimentation** alimenté par une source en courant continu disposant d'un filtrage capacitif, et connecté à la terre de protection, la **tension de tenue prescrite** doit être supposée égale à la valeur de crête de la **tension continue** de la source, ou à la **valeur de crête de la tension de service** du circuit isolé du **réseau d'alimentation**, la valeur la plus élevée étant retenue.

Si l'équipement est alimenté par une batterie particulière sans moyen de recharge à partir d'un **réseau d'alimentation** externe, la tension transitoire n'est pas prise en compte.

5.4.2.5.3 Tensions transitoires du circuit externe

À l'exception des spécifications de 5.5.4, pour les tensions transitoires d'un **circuit externe**, la **tension de tenue prescrite** est

- la tension transitoire du **circuit externe** déterminée en 5.4.2.4.3, ou

- la valeur mesurée conformément à 5.4.2.6 c).

Si la tension transitoire est inférieure à la tension crête du signal de courte durée (comme une sonnerie de téléphone), ce signal de courte durée doit être pris en compte pour la détermination de la **tension de tenue prescrite**.

Pour les circuits connectés à la distribution du câble coaxial et aux antennes extérieures, la conformité est vérifiée par les essais de 5.5.4.

5.4.2.5.4 Combinaison de tensions transitoires

Si les tensions transitoires décrites en 5.4.2.5.1, 5.4.2.5.2 et 5.4.2.5.3 influencent la même **distance d'isolement dans l'air**, la plus grande de ces tensions est utilisée lors de la détermination de la **tension de tenue prescrite**. Les valeurs ne doivent pas être additionnées.

5.4.2.6 Mesure des niveaux de tension transitoire

Le présent paragraphe spécifie la méthode permettant de mesurer les niveaux transitoires réels de tous les circuits (lorsque le fabricant a prévu un réseau de limitation des transitoires).

Les essais suivants sont effectués uniquement s'il est prescrit de déterminer si la tension transitoire à travers la **distance d'isolement dans l'air** dans un circuit est inférieure ou non à la tension normale (en raison, par exemple, de l'effet d'un filtre dans l'équipement). La tension transitoire à travers la **distance d'isolement dans l'air** est mesurée à l'aide de la procédure d'essai suivante.

Au cours des essais, l'équipement n'est pas connecté au **réseau d'alimentation** ni à un système de distribution d'alimentation en courant continu externe, ni à un **circuit externe**. Tous les parasurtenseurs internes à l'équipement situés dans les circuits connectés au **réseau d'alimentation** ou au système de distribution d'alimentation en courant continu externe sont déconnectés. Si l'équipement est destiné à être utilisé avec une alimentation séparée, cette dernière est connectée à l'équipement pendant les essais.

Un dispositif de mesure de tension est connecté à travers la **distance d'isolement dans l'air** concernée.

a) Tensions transitoires venant d'un **réseau d'alimentation** en courant alternatif

Pour mesurer la tension transitoire à travers une **distance d'isolement dans l'air** due aux tensions transitoires sur un **réseau d'alimentation**, le générateur d'impulsions d'essai du circuit 2 du Tableau D.1 est utilisé pour générer 1,2/50 μ s impulsions. U_c est égal à la **tension transitoire du réseau d'alimentation** déterminée en 5.4.2.4.1.

Au moins trois impulsions de polarités alternées, avec des intervalles d'au moins 1 s entre les impulsions, sont appliquées entre tous les points suivants lorsque cela est approprié:

- entre phases;
- 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.

b) Tensions transitoires venant d'un **réseau d'alimentation** en courant continu

Pour mesurer la tension transitoire à travers une **distance d'isolement dans l'air** due aux tensions transitoires sur un système de distribution d'alimentation en courant continu, le générateur d'impulsions d'essai du circuit 2 du Tableau D.1 est utilisé pour générer 1,2/50 μ s impulsions. U_c est égal à la tension transitoire déterminée en 5.4.2.4.2.

Au moins trois impulsions de polarités alternées, avec des intervalles d'au moins 1 s entre les impulsions, sont appliquées entre tous les points suivants lorsque cela est approprié:

- les points de connexion d'alimentation positif et négatif;
- tous les points de connexion d'alimentation reliés ensemble et la terre de protection.

c) Tensions transitoires d'un **circuit externe**

Pour mesurer la tension transitoire à travers une **distance d'isolement dans l'air** due aux tensions transitoires sur un **circuit externe**, le générateur d'essai adapté de l'Annexe D est utilisé pour générer des impulsions applicables et décrites dans le Tableau 16. U_c est égal à la tension transitoire du **circuit externe** déterminée en 5.4.2.4.3.

Au moins trois 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 **circuit externe** d'un type d'interface unique:

- chaque paire de bornes dans une interface (par exemple, A et B ou tête et nuque);
- toutes les bornes d'un type d'interface unique reliées ensemble et la terre.

S'il existe plusieurs circuits identiques, un seul est soumis à essai.

5.4.2.7 Détermination de la distance d'isolement dans l'air minimale

Les **distances d'isolement dans l'air** minimales peuvent être déterminées par mesure comme spécifié dans le présent paragraphe ou par un essai de rigidité diélectrique conformément à 5.4.2.8.

Pour l'équipement à utiliser jusqu'à 2 000 m au-dessus du niveau de la mer, chaque **distance d'isolement dans l'air** doit être conforme à la valeur appropriée indiquée dans les Tableaux 17, 18 ou 19.

NOTE La distribution homogène du champ servant de base au Tableau 20 est, dans la pratique, irréalisable. Seule une distribution entre non homogène et homogène peut être obtenue.

Des valeurs inférieures à celles des Tableaux 17, 18 ou 19 peuvent être utilisées si un essai de rigidité diélectrique conforme à 5.4.2.8 est effectué en tant qu'**essai de type** à l'aide de la valeur de **tension de tenue prescrite** déterminée conformément à 5.4.2.5.

Tableau 17 – Distances d'isolement dans l'air minimales jusqu'à 2 000 m au-dessus du niveau de la mer, distribution non homogène du champ (en présence de transitoires venant du réseau d'alimentation ou de circuits externes)

Tension de tenue prescrite	Isolation principale ou supplémentaire mm			Isolation renforcée mm		
V de crête ou c.c. jusqu'à et y compris	Degré de pollution			Degré de pollution		
	1 ^a	2	3	1 ^a	2	3
330	0,01	0,2	0,8	0,04	0,6	1,5
400	0,02			0,07		
500	0,04			0,10		
600	0,06			0,14		
800	0,10			0,5		
1 000	0,15			0,6		
1 200	0,25			0,9		
1 500	0,5		1,5			
2 000	1,0			2,2		
2 500	1,5			3,0		
3 000	2,0			3,8		
4 000	3,0			5,5		
5 000	4,0			8,0		
6 000	5,5			8,0		
8 000	8,0			14		
10 000	14			19,4		
12 000	14			24		
15 000	18			31,4		
20 000	25			44		
25 000	33			60		
30 000	40			72		
40 000	60			98		
50 000	75			130		
60 000	90			162		
80 000	130			226		
100 000	170			290		

Une interpolation linéaire peut être utilisée entre les deux points les plus proches, les **distances d'isolement dans l'air** minimales calculées arrondies au 0,1 mm supérieur ou la valeur de la ligne suivante, la valeur la plus faible étant retenue.

^a Les valeurs pour le **degré de pollution** 1 peuvent être utilisées si un échantillon est conforme aux essais décrits en 5.4.8.

Valeur de crête de la tension de service	Isolation principale ou supplémentaire mm			Isolation renforcée mm					
V de crête ou c.c. jusqu'à et y compris	Degré de pollution			Degré de pollution					
	1 ^a	2	3	1 ^a	2	3			
330	0,01	0,2	0,8	0,04	0,6	1,5			
400	0,02			0,074					
500	0,04			0,13					
600	0,06			0,234	0,76				
800	0,13			0,76					
1 000	0,26	0,26	0,8	1,19	1,8	1,8			
1 200	0,42								
1 500	0,76			1,8					
2 000	1,27			2,8					
2 500	1,8			3,8					
3 000	2,4			6,2					
4 000	3,8			7,9					
5 000	6,7			11					
6 000	7,9			11					
8 000	11,0			19					
10 000	15,2			26,8					
12 000	19			32,56					
15 000	25			42					
20 000	34			59,4					
25 000	44			77					
30 000	55			95,4					
40 000	77			131					
50 000	100			175					
60 000	120			219					
80 000	175			307					
100 000	230			395					

Les valeurs indiquées dans le tableau ci-dessus sont dérivées de la CEI 60664-1:2007, Tableau F.7a.

Une interpolation linéaire peut être utilisée entre les deux points les plus proches, les **distances d'isolement dans l'air** minimales calculées arrondies au 0,1 mm supérieur ou la valeur de la ligne suivante, la valeur la plus faible étant retenue.

^a Les valeurs pour le **degré de pollution** 1 peuvent être utilisées si un échantillon est conforme aux essais décrits en 5.4.8.

Tableau 19 – Distances d'isolement dans l'air minimales jusqu'à 2 000 m au-dessus du niveau de la mer, distribution non homogène du champ (pour les tensions stables, les surtensions temporaires et les valeurs crête de la tension récurrentes pour les fréquences supérieures à 30 kHz)

Valeur de crête de la tension de service jusqu'à et y compris V en valeur crête	Isolation principale ou supplémentaire mm	Isolation renforcée mm
600	0,06	0,12
800	0,18	0,36
1 000	0,5	1,0
1 200	1,4	2,8
1 400	2,35	4,7
1 600	4,0	8,0
1 800	6,7	13,4
2 000	11	22,0

Une interpolation linéaire peut être utilisée entre les deux points les plus proches, les **distances d'isolement dans l'air** minimales calculées arrondies au 0,1 mm supérieur.

5.4.2.8 Distances d'isolement dans l'air minimales établies d'après l'essai de rigidité diélectrique

Les **distances d'isolement dans l'air** pour une **isolation principale**, une **isolation supplémentaire** et une **isolation renforcée** doivent supporter un essai de rigidité diélectrique en plus d'être conformes aux valeurs de **distance d'isolement dans l'air** minimales du Tableau 21. L'essai peut être réalisé à l'aide d'une tension d'impulsion ou d'une tension en courant alternatif ou d'une **tension en courant continu**. L'essai de tension de tenue aux chocs est effectué avec une tension présentant une forme d'onde adaptée (voir l'Annexe D) avec les valeurs spécifiées dans le Tableau 21. L'essai de tension en courant alternatif est réalisé à l'aide d'une tension sinusoïdale avec les valeurs efficaces spécifiées dans le Tableau 21.

L'essai de **tension en courant continu** est réalisé à l'aide d'une **tension en courant continu** avec une valeur de **tension en courant continu** moyenne telle que spécifiée dans le Tableau 21. La **tension de tenue prescrite** est déterminée comme indiqué en 5.4.2.5. L'essai est effectué comme suit.

- en appliquant cinq impulsions de chaque polarité avec un intervalle d'au moins 1 s entre les impulsions; ou
- en appliquant une tension efficace en courant alternatif pendant 5 s; ou
- en appliquant une **tension en courant continu** pendant 5 s dans une polarité et ensuite pendant 5 s dans la polarité inverse.

NOTE Lors de la vérification des **distances d'isolement dans l'air** à l'intérieur de l'équipement par un essai de rigidité diélectrique (par exemple, une tension d'impulsion), s'assurer que la tension d'essai électrique spécifiée est présente à la **distance d'isolement dans l'air** soumise à essai.

Tableau 20 – Distances d'isolement dans l'air minimales établies d'après l'essai de rigidité diélectrique

Tension de tenue prescrite	Isolation principale ou supplémentaire mm			Isolation renforcée mm		
V de crête ou c.c. jusqu'à et y compris	Degré de pollution			Degré de pollution		
	1 ^a	2	3	1 ^a	2	3
330	0,01	0,2	0,8	0,04	0,43	1,45
400	0,02			0,07		
500	0,04			0,10		
600	0,06			0,14		
800	0,10			0,3		
1 000	0,15			0,33		
1 200	0,2			0,43		
1 500	0,3			0,6		
2 000	0,45			0,88		
2 500	0,6			1,2		
3 000	0,8			1,45		
4 000	1,2			2,0		
5 000	1,5			3,0		
6 000	2,0			3,0		
8 000	3,0			4,5		
10 000	3,5			6,0		
12 000	4,5			7,5		
15 000	5,5			9,6		
20 000	8,0			13,4		
25 000	10			17		
30 000	12,5			21		
40 000	17			28,6		
50 000	22			35		
60 000	27			43		
80 000	35			59		
100 000	45			75		

Une interpolation linéaire peut être utilisée entre les deux points les plus proches, les **distances d'isolement dans l'air** minimales calculées arrondies au 0,1 mm supérieur ou la valeur de la ligne suivante, la valeur la plus faible étant retenue.

Ce tableau est basé sur les données relatives aux champs homogènes.

^a Les valeurs pour le **degré de pollution** 1 peuvent être utilisées si un échantillon est conforme aux essais décrits en 5.4.8.

Tableau 21 – Tensions d'essai pour la vérification des distances d'isolement dans l'air jusqu'à 2 000 m au-dessus du niveau de la mer

Tension de tenue prescrite jusqu'à et y compris kV de crête	Tension d'essai de rigidité diélectrique pour les distances d'isolement dans l'air applicables à l'isolation principale et à l'isolation supplémentaire		
	kV de crête impulsion de 1,2/50 µs	kV en valeur efficace	kV en courant continu
0,33	0,35	0,23	0,35
0,5	0,55	0,4	0,55
0,8	0,91	0,52	0,74
1,5	1,75	0,95	1,35
2,5	2,95	1,89	2,67
4,0	4,8	2,61	3,69
6,0	7,3	3,97	5,61
8,0	9,8	5,34	7,55
12,0	14,8	8,08	11,43
U^a	$1,23 \times U$	$0,68 \times U$	$0,95 \times U$
Une interpolation linéaire peut être utilisée entre les deux points les plus proches, la tension d'essai minimale calculée arrondie au 0,01 kV supérieur.			
Pour une isolation renforcée , la tension d'essai pour la rigidité diélectrique représente 160 % de la valeur de celle utilisée pour l' isolation principale .			
Pour des essais individuels de série , la tension d'essai est réduite de 20 % et la durée réduite à 1 s.			
Si l'EUT ne satisfait pas à l'essai efficace ou en courant continu, l'essai d'impulsion doit être utilisé.			
^a U est une tension de tenue prescrite supérieure à 12,0 kV.			

5.4.2.9 Facteurs de multiplication pour des altitudes supérieures à 2 000 m au-dessus du niveau de la mer

Pour les équipements destinés à être utilisés à une altitude de 2 000 m au-dessus du niveau de la mer, les **distances d'isolement dans l'air** minimales spécifiées dans les Tableaux 17, 18, 19 et 20, et les tensions d'essai de rigidité diélectrique indiquées dans le Tableau 21 sont multipliées par le facteur de multiplication applicable pour l'altitude souhaitée selon le Tableau 22 (essais effectués au niveau de la mer).

NOTE 1 Il est acceptable d'utiliser une chambre à vide pour simuler des altitudes plus élevées.

NOTE 2 En Chine, il existe des exigences particulières permettant de choisir des facteurs de multiplication à des altitudes supérieures à 2 000 m.

Tableau 22 – Facteurs de multiplication pour les distances d'isolement dans l'air et les tensions d'essai

Altitude m	Pression barométrique normale kPa	Facteur de multiplication pour les distances d'isolement dans l'air	Facteur de multiplication pour les tensions d'essai de rigidité diélectrique			
			≥0,01 mm à <0,0625 mm	≥0,0625 mm à <1 mm	≥1 mm à <10 mm	≥10 mm à <100 mm
2 000	80,0	1,00	1,00	1,00	1,00	1,00
3 000	70,0	1,14	1,05	1,05	1,07	1,10
4 000	62,0	1,29	1,10	1,10	1,15	1,20
5 000	54,0	1,48	1,17	1,16	1,24	1,33

Une interpolation linéaire peut être utilisée entre les deux points les plus proches, le facteur de multiplication minimal calculé arrondi au 0,01 supérieur.

5.4.3 Lignes de fuite

5.4.3.1 Généralités

Les **lignes de fuite** pour des fréquences jusqu'à 30 kHz doivent être dimensionnées de telle façon que, pour une **tension de service efficace** donnée, un **degré de pollution** et un groupe de matériau, il n'y ait ni contournement ni rupture de l'isolation (par exemple, due au cheminement).

Des **lignes de fuite** pour des fréquences supérieures à 30 kHz sont envisagées. Les exigences relatives aux **lignes de fuite** pour des fréquences pouvant atteindre 30 kHz peuvent s'appliquer pour des fréquences de plus de 30 kHz, jusqu'à ce que des données supplémentaires soient disponibles.

La **ligne de fuite** entre la surface isolante extérieure (voir 5.4.3.2) d'un connecteur (y compris une ouverture dans l'**enveloppe**) et les parties conductrices connectées à ES2 à l'intérieur du connecteur (ou dans l'**enveloppe**) doit être conforme aux exigences relatives à l'**isolation principale**.

La **ligne de fuite** entre la surface isolante extérieure (voir 5.4.3.2) d'un connecteur (y compris une ouverture dans l'**enveloppe**) et les parties conductrices connectées à ES3 à l'intérieur du connecteur (ou dans l'**enveloppe**) doit être conforme aux exigences relatives à l'**isolation renforcée**.

A titre d'exception, la **ligne de fuite** peut être conforme aux exigences pour l'**isolation principale** si le connecteur est:

- fixé à l'équipement; et
- situé à l'intérieur de l'**enveloppe électrique** extérieure de l'équipement; et
- **accessible** uniquement après le retrait d'un sous-ensemble qui
 - doit être à sa place dans les conditions normales de fonctionnement, et
 - est fourni avec une protection mise en place sous forme d'instructions pour remplacer le sous-ensemble retiré.

NOTE 1 Les essais de 5.4 s'appliquent à ce type de 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 à l'équipement, les valeurs minimales déterminées conformément au présent paragraphe s'appliquent.

Les **lignes de fuite** minimales ci-dessus pour les connecteurs ne s'appliquent pas aux connecteurs énumérés à l'Article G.20.

NOTE 2 Pour les **lignes de fuite** inférieures à 2 mm, des informations supplémentaires sont disponibles dans la CEI 60664-5.

5.4.3.2 Méthode d'essai

5.4.3.2.1 Conditions d'essai

*Le présent paragraphe spécifie des conditions physiques à prendre en compte lors de la détermination des **lignes de fuite**.*

Les conditions suivantes s'appliquent:

- *les parties mobiles sont placées dans leur position la plus défavorable;*
- *pour l'équipement intégrant des **câbles d'alimentation fixés à demeure** ordinaires, les mesures de **lignes de fuite** sont effectuées avec des conducteurs d'alimentation de la plus forte section spécifiée à l'Article G.9 et aussi sans conducteurs;*
- *lors de la mesure des **lignes de fuite** depuis la surface extérieure d'une **enveloppe** de matériau isolant à travers un intervalle ou une ouverture dans l'**enveloppe** ou à travers une ouverture dans un connecteur **accessible**, la surface isolée **accessible** doit être considérée conductrice comme si elle était recouverte d'une feuille de métal au cours de l'essai décrit en V.1.2, appliquée sans force appréciable (voir la Figure O.13, point X);*
- *les dimensions des **lignes de fuite** jouant le rôle d'**isolation principale**, d'**isolation supplémentaire** et d'**isolation renforcée** sont mesurées après les essais décrits dans l'Annexe T;*
- *pour l'essai de bris de glace, voir l'Article T.9. Les endommagements de la finition, les petits éclats ne réduisant pas les **lignes de fuite** en dessous des valeurs spécifiées, les fissures superficielles et les éléments similaires sont ignorés. Si une fissure profonde apparaît, les **lignes de fuite** ne doivent pas être réduites.*

La conformité est vérifiée par mesure, en prenant en compte les Annexes O, T et V.

5.4.3.2.2 Groupe de matériaux et IRC

Les groupes de matériaux sont fondés sur l'IRC et sont classifiés comme suit:

Groupe de matériaux I	$600 \leq \text{IRC}$
Groupe de matériaux II	$400 \leq \text{IRC} < 600$
Groupe de matériaux IIIa	$175 \leq \text{IRC} < 400$
Groupe de matériaux IIIb	$100 \leq \text{IRC} < 175$

Le groupe de matériaux est vérifié par évaluation des données d'essai pour le matériau conformément à la CEI 60112 en utilisant 50 gouttes de la solution A.

Si le groupe de matériaux n'est pas connu, le groupe de matériaux doit être supposé IIIb.

Si un IRC égal ou supérieur à 175 est nécessaire et si les données ne sont pas disponibles, le groupe de matériaux peut être établi avec un essai pour l'indice de tenue au cheminement (ITC) détaillé dans la CEI 60112. Un matériau peut être inclus dans un groupe si son ITC établi par ces essais est égal ou supérieur à la valeur la plus faible de l'IRC spécifié pour le groupe.

5.4.3.3 Conformité

Les **lignes de fuite** pour une **isolation principale** et une **isolation supplémentaire** ne doivent pas être inférieures aux valeurs minimales spécifiées dans le Tableau 23, en prenant en compte la valeur de la **tension de service efficace**, le **degré de pollution** et le groupe de matériaux.

Pour une **isolation renforcée**, les valeurs pour les **lignes de fuite** représentent le double des valeurs pour une **isolation principale** dans le Tableau 23.

Si la **ligne de fuite** minimale dérivée du Tableau 23 est inférieure à la **distance d'isolement dans l'air** minimale, cette dernière doit être appliquée comme **ligne de fuite** minimale.

Pour le verre, le mica, la céramique vitrifiée ou les matériaux inorganiques similaires, si la **ligne de fuite** minimale est supérieure à la **distance d'isolement dans l'air** minimale applicable, la valeur de la **distance d'isolement dans l'air** minimale peut être appliquée comme **ligne de fuite** minimale.

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**Tableau 23 – Lignes de fuite minimales pour une isolation principale
et une isolation supplémentaire en mm**

Tension de service efficace jusqu'à 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	0,95	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			

Tableau 23 (suite)

Tension de service efficace jusqu'à 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
32 000	125	160	220	320			
40 000	160	200	280	400			
50 000	200	250	360	500			
63 000	250	320	450	600			

NOTE Le groupe de matériaux IIIb n'est pas recommandé pour les applications au **degré de pollution 3** présentant une **tension de service efficace** au-dessus de 630 V.

Une interpolation linéaire peut être utilisée entre les deux points les plus proches, les **lignes de fuite** minimales calculées arrondies au 0,1 mm supérieur ou la valeur de la ligne suivante, la valeur la plus faible étant retenue.

Pour une **isolation renforcée**, un arrondi au 0,1 mm supérieur ou le double de la valeur de la ligne suivante est appliqué après que la valeur calculée pour une **isolation principale** a été doublée.

^a Les valeurs pour le **degré de pollution 1** peuvent être utilisées si un échantillon est conforme aux essais décrits en 5.4.8.

Tableau 24 – Valeurs minimales des lignes de fuite pour les fréquences supérieures à 30 kHz

Valeur de crête de la tension de service kV	Lignes de fuite mm						
	30 kHz < f ≤ 100 kHz	100 kHz < f ≤ 200 kHz	200 kHz < f ≤ 400 kHz	400 kHz < f ≤ 700 kHz	700 kHz < f ≤ 1 MHz	1 MHz < f ≤ 2 MHz	2 MHz < f ≤ 3 MHz
NOTE Les exigences relatives aux lignes de fuite pour des fréquences supérieures à 30 kHz sont prises en considération.							

5.4.4 Isolation réalisée avec un isolant solide

5.4.4.1 Exigences générales

Le présent paragraphe spécifie les exigences générales pour une **isolation réalisée avec un isolant solide**.

Les exigences du présent paragraphe s'appliquent également aux composés et aux matériaux gel utilisés comme isolation. Elles ne s'appliquent pas aux matériaux en fines couches.

Une **isolation réalisée avec un isolant solide** ne doit pas être interrompue:

- en raison de surtensions, y compris les transitoires, qui pénètrent dans l'équipement, et de valeurs crête de la tension qui peuvent être générées à l'intérieur de l'équipement; ni
- en raison de trous d'épingle dans de fines couches d'isolation.

Des revêtements d'email à base de solvant ne doivent pas être utilisés pour une **isolation principale**, une **isolation supplémentaire** ni une **isolation renforcée** à l'exception de ceux indiqués en G.11.1.2.

Excepté pour les cartes imprimées, une **isolation réalisée avec un isolant solide** doit soit:

- être conforme aux distances minimales à travers l'isolation conformément à 5.4.4.2; soit
- répondre aux exigences et satisfaire aux essais décrits de 5.4.4.3 à 5.4.4.7, selon le cas.

Le verre utilisé comme **isolation réalisée avec un isolant solide** doit être conforme à l'essai de bris de glace tel que spécifié à l'Article T.9. Les endommagements de la finition, les petits éclats ne réduisant pas les **distances d'isolement dans l'air** en dessous des valeurs spécifiées, les fissures superficielles et les éléments similaires sont ignorés. Si une fissure apparaît, les **distances d'isolement dans l'air** ne doivent pas être réduites en dessous des valeurs spécifiées.

Pour les cartes imprimées, voir l'Article G.18. Pour les dispositifs de connexion extérieure d'antenne, voir 5.4.5. Pour une **isolation réalisée avec un isolant solide** sur le câblage interne, voir 5.4.6.

5.4.4.2 Distance minimale à travers l'isolation

Sauf lorsqu'un autre paragraphe de l'Article 5 s'applique, les distances à travers l'isolation doivent présenter des dimensions conformes à l'application de l'isolation et comme suit (voir les Figures O.15 et O.16):

- si la **tension de service** ne dépasse pas les limites de tension applicables à ES2, il n'existe pas d'exigence relative à la distance à travers l'isolation;
- si la **tension de service** dépasse les limites de tension applicables à ES2, les règles suivantes s'appliquent:
 - pour une **isolation principale**, il n'existe pas de distance minimale à travers l'isolation spécifiée;
 - pour une **isolation supplémentaire** ou une **isolation renforcée** composée d'une couche unique, la distance minimale à travers l'isolation doit être de 0,4 mm;
 - pour une **isolation supplémentaire** ou une **isolation renforcée** composée de couches multiples, la distance minimale à travers l'isolation doit être conforme à 5.4.4.6.

5.4.4.3 Composé isolant constituant une isolation réalisée avec un isolant solide

Il n'existe pas de **distance d'isolement dans l'air** ni de **ligne de fuite** minimale si le composé isolant remplit entièrement le boîtier d'un composant ou d'un sous-ensemble, y compris un dispositif à semi-conducteurs (par exemple, un optocoupleur) à condition que (voir la Figure O.15):

- le composant ou sous-ensemble réponde aux distances minimales à travers l'isolation de 5.4.4.2; et
- un seul échantillon réussisse les essais de 5.4.8.

NOTE 1 Les autres exigences relatives aux dispositifs à semi-conducteurs sont indiquées en 5.4.4.4, et à l'Article G.16.

Pour les cartes imprimées, voir l'Article G.18 et pour les composants bobinés, voir 5.4.4.7.

NOTE 2 Des exemples de traitements de ce type diversement connus comprennent l'enrobage, la mise sous boîtier rempli et l'imprégnation sous vide.

NOTE 3 Ces constructions peuvent contenir des joints scellés, auquel cas 5.4.4.5 s'applique également.

5.4.4.4 Isolation réalisée avec un isolant solide dans des dispositifs à semi-conducteurs

Il n'existe pas de **distance d'isolement dans l'air** ni de **ligne de fuite** interne minimale, ni de distance minimale à travers l'isolation pour une **isolation supplémentaire** ou une **isolation**

renforcée comprenant un composé isolant remplissant entièrement le boîtier d'un composant à semi-conducteurs (par exemple, un optocoupleur) à condition que le composant satisfasse à l'une des exigences suivantes a) ou b) (voir la Figure O.15):

- a) satisfait aux **essais de type** et aux critères d'examen décrits en 5.4.9, ainsi que les **essais individuels de série** de rigidité diélectrique au cours de la fabrication, selon l'essai approprié décrit en 5.4.11.1; ou
- b) satisfait à l'Article G.16.

Une autre possibilité que a) et b) ci-dessus consiste à évaluer un semi-conducteur conformément à 5.4.4.3, le cas échéant.

NOTE Ces constructions peuvent contenir des joints scellés, auquel cas 5.4.4.5 s'applique également.

5.4.4.5 Composé isolant constituant des joints scellés

Le présent paragraphe spécifie des exigences pour le cas où un composé isolant constitue un joint scellé entre deux parties non conductrices ou entre une autre partie non conductrice et lui-même.

Lorsque le chemin entre des parties conductrices est rempli par un composé isolant, et que le composé isolant constitue un joint scellé entre deux parties non conductrices ou entre une partie non conductrice et lui-même (voir les Figures O.14, O.15 et O.16), soit a), soit b) soit c) s'applique.

- a) La distance le long du chemin entre les deux parties conductrices ne doit pas être inférieure aux **distances d'isolement dans l'air** ni aux **lignes de fuite** minimales pour le **degré de pollution** 2. Les exigences relatives à la distance à travers l'isolation décrites en 5.4.4.2 ne s'appliquent pas le long du joint.
- b) La distance le long du chemin entre les deux parties conductrices ne doit pas être inférieure aux **distances d'isolement dans l'air** ni aux **lignes de fuite** minimales pour le **degré de pollution** 1. De plus, un échantillon doit satisfaire à l'essai décrit en 5.4.8. Les exigences relatives à la distance à travers l'isolation décrites en 5.4.4.2 ne s'appliquent pas le long du joint.
- c) Les exigences relatives à la distance à travers l'isolation décrites en 5.4.4.2 s'appliquent entre les parties conductrices le long du joint. De plus, trois échantillons doivent satisfaire à l'essai décrit en 5.4.9.

Pour a) et b) ci-dessus, si les matériaux isolants impliqués appartiennent à des groupes de matériaux différents, le cas le plus défavorable est utilisé. Lorsqu'un groupe de matériaux n'est pas connu, il doit être considéré comme étant le groupe de matériaux IIIb.

Pour b) et c) ci-dessus, les essais de 5.4.8 et de 5.4.9 ne sont pas appliqués aux couches intérieures d'une carte imprimée réalisée en utilisant du prépreg si la température de la carte imprimée mesurée au cours de l'essai thermique décrit en 5.4.1.5 ne dépasse pas 90 °C.

NOTE 1 Il n'existe pas de **distance d'isolement dans l'air** ni de **ligne de fuite** réelles, à moins que le joint n'éclate (par exemple, en raison du vieillissement). Pour parer à cette éventualité, les exigences et essais décrits en c) s'appliquent si les **distances d'isolement dans l'air** et les **lignes de fuite** minimales conformément à a) ou b) ne sont pas satisfaites.

NOTE 2 Les exemples de joints scellés comprennent les suivants:

- deux parties non conductrices scellées ensemble (par exemple, deux couches d'une carte multicouche, voir la Figure O.14) ou la bobine séparée d'un transformateur dont l'élément central est fixé avec de l'adhésif (voir la Figure O.16);
- une isolation enroulée en spirale sur un fil de bobinage, dont l'étanchéité est assurée par un composé isolant adhésif, est un exemple de PD1;
- le joint entre une partie non conductrice (le boîtier) et le composé isolant lui-même dans un optocoupleur (voir la Figure O.15).

5.4.4.6 Matériau en fines couches

5.4.4.6.1 Exigences générales

Il n'existe pas d'exigences relatives aux dimensions ni à la construction pour l'isolation dans un matériau en fines couches utilisé comme **isolation principale**.

NOTE Un appareil pour l'exécution de l'essai de rigidité diélectrique sur de fines couches de matériau isolant est décrit à la Figure 36.

L'isolation dans des matériaux en fines couches peut être utilisée pour une **isolation supplémentaire** et une **isolation renforcée**, indépendamment de la distance à travers l'isolation, à condition que

- deux couches au moins soient utilisées;
- l'isolation se situe à l'intérieur de l'**enveloppe** de l'équipement;
- l'isolation ne fasse pas l'objet d'une manipulation ni d'une abrasion au cours de l'entretien par une **personne ordinaire** ou par une **personne avertie**; et
- les exigences et essais de 5.4.4.6.2 (pour les couches séparables) ou 5.4.4.6.3 (pour les couches non séparables) soient satisfaites.

Il n'est pas nécessaire que les deux couches ou plus soient fixées à la même partie conductrice. Les deux couches ou plus peuvent être:

- fixées à l'une des parties conductrices exigeant une séparation; ou
- partagées entre les deux parties conductrices; ou
- sans fixation sur aucune des parties conductrices.

Pour l'isolation dans trois couches ou plus de matériaux en fines couches non séparables:

- des distances minimales à travers l'isolation ne sont pas nécessaires; et
- il n'est pas nécessaire que les différentes couches d'isolation soient composées du même matériau.

5.4.4.6.2 Matériau en fines couches séparables

Outre les exigences de 5.4.4.6.1, pour:

- une **isolation supplémentaire** composée de deux couches de matériau, chaque couche doit satisfaire à l'essai de rigidité diélectrique pour une **isolation supplémentaire**; ou
- une **isolation supplémentaire** composée de trois couches de matériau, chaque combinaison de deux couches doit satisfaire à l'essai de rigidité diélectrique pour une **isolation supplémentaire**; ou
- une **isolation renforcée** composée de deux couches de matériau, chaque couche doit satisfaire à l'essai de rigidité diélectrique pour une **isolation renforcée**; ou
- une **isolation renforcée** composée de trois couches de matériau, chaque combinaison de deux couches doit satisfaire à l'essai de rigidité diélectrique pour une **isolation renforcée**.

Si plus de trois couches sont utilisées, les couches peuvent être divisées en deux ou trois groupes de couches. Chaque groupe de couches doit satisfaire à l'essai de rigidité diélectrique pour l'isolation appropriée.

Un essai sur une couche ou un groupe de couches n'est pas répété sur une couche ou un groupe identique.

Il n'existe aucune exigence stipulant que toutes les couches de l'isolation doivent présenter les mêmes matériau et épaisseur.

5.4.4.6.3 Matériau en fines couches non séparables

Pour une isolation composée de matériaux en fines couches non séparables, en plus des exigences de 5.4.4.6.1, les procédures d'essai indiquées dans le Tableau 25 s'appliquent. Il n'existe aucune exigence stipulant que toutes les couches de l'isolation doivent présenter les mêmes matériau et épaisseur.

La conformité est vérifiée par examen et par les essais spécifiés dans le Tableau 25.

Tableau 25 – Essais pour l'isolation dans des couches non séparables

Nombre de couches	Procédure d'essai
isolation supplémentaire	
Deux couches ou plus:	La procédure d'essai décrite en 5.4.4.6.4 s'applique.
isolation renforcée	
Deux couches:	La procédure d'essai décrite en 5.4.4.6.4 s'applique.
Trois couches ou plus:	Les procédures d'essai décrites en 5.4.4.6.4 et 5.4.4.6.5 ^a s'appliquent.
NOTE L'objet des essais de 5.4.4.6.5 est de s'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 décrits en 5.4.4.6.5 ne s'appliquent pas à l' isolation supplémentaire .	
^a Lorsque l'isolation fait partie du fil de bobinage, l'essai ne s'applique pas.	

5.4.4.6.4 Procédure d'essai normalisée pour un matériau en fines couches non séparables

Pour les couches non séparables, les essais de rigidité diélectrique s'appliquent conformément à 5.4.11.1 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 ou plus sont utilisées,

*où U_{essai} est la plus élevée des tensions d'essai spécifiées dans les Tableaux 31, 32 ou 33 pour une **isolation supplémentaire** ou une **isolation renforcée** selon le cas.*

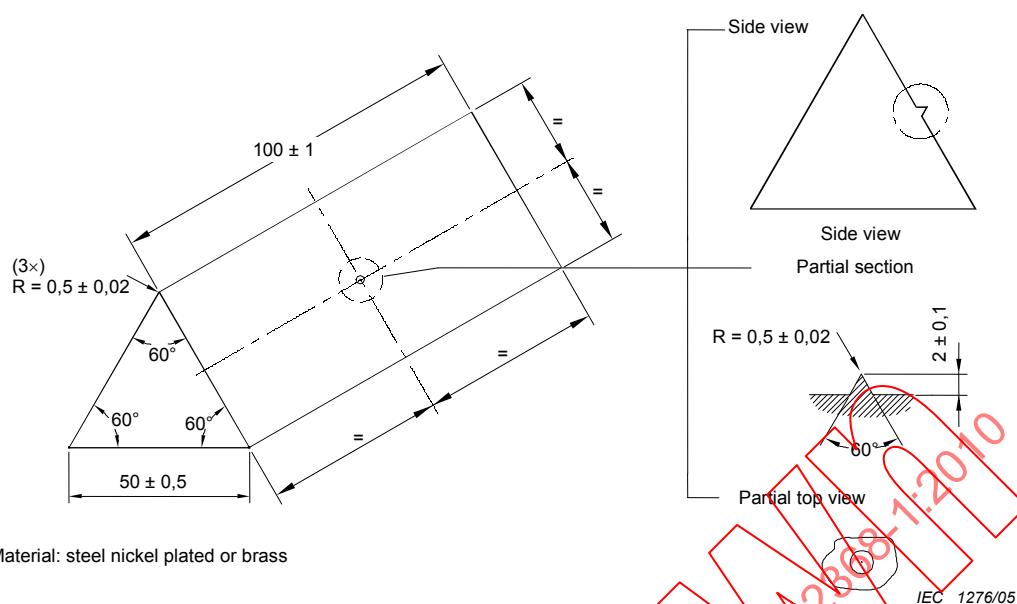
NOTE À moins que toutes les couches ne soient composées du même matériau et présentent la même épaisseur, il existe une possibilité que la tension d'essai soit inégalement répartie entre les couches, provoquant la rupture d'une couche qui aurait satisfait à l'essai séparément.

5.4.4.6.5 Essai du mandrin

*Le présent paragraphe spécifie les exigences d'essai pour une **isolation renforcée** composée de trois fines couches isolantes ou plus de matériau qui ne sont pas séparables.*

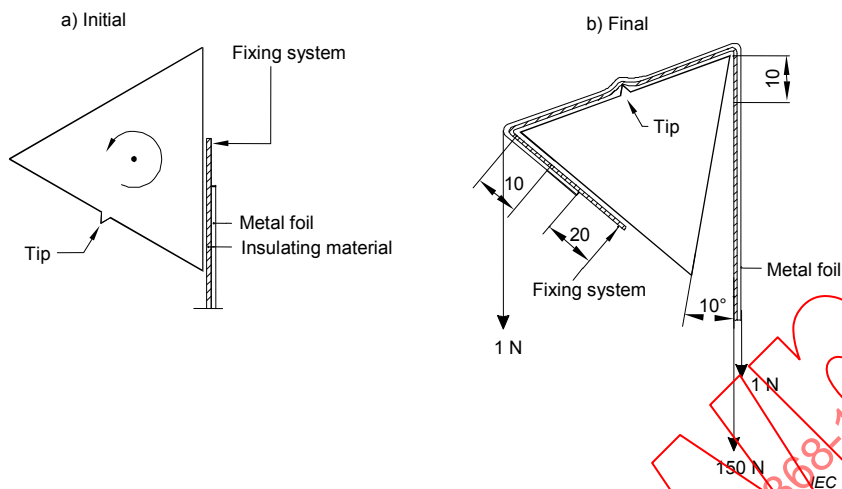
NOTE L'essai est fondé sur la CEI 61558-1 et donne les mêmes résultats.

*Trois échantillons d'essai, chaque échantillon individuel étant composé de trois couches ou plus de matériau en fines feuilles non séparables formant l'**isolation renforcée**, sont utilisés. Un échantillon est fixé au mandrin du dispositif d'essai (Figure 32) comme représenté à la Figure 33.*

**Légende**

Anglais	Français
Side view	Vue de côté
Partial section	Section partielle
Partial top view	Vue du dessus partielle
Material: steel nickel plated or brass	Matériau: acier nickelé ou laiton

Figure 32 – Mandrin



Légende

Anglais	Français
Initial	Position initiale
Final	Position finale
Fixing system	Système de fixation
Tip	Extrémité
Metal foil	Feuille métallique
Insulating material	Matériau isolant

La position finale du mandrin subit une rotation de $230^{\circ} \pm 5^{\circ}$ par rapport à la position initiale.

Figure 33 – Position initiale d'un mandrin

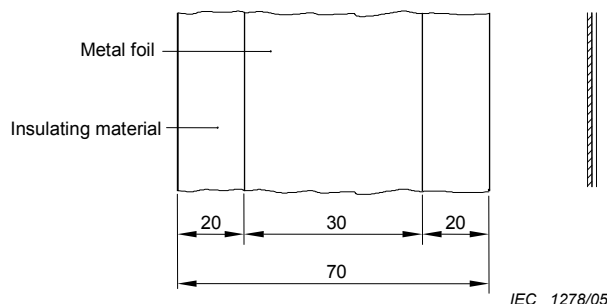
Figure 34 – Position finale d'un mandrin

Une traction est appliquée à l'extrémité libre de l'échantillon, à l'aide d'un dispositif de serrage approprié. Le mandrin subit une rotation:

- de la position initiale (Figure 33) à la position finale (Figure 34) et inversement;
- comme ci-dessus pour une 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, cette rupture ne constitue pas un dysfonctionnement. Si un échantillon se casse à tout autre endroit, l'essai a échoué.

Après l'essai décrit ci-dessus, une feuille métallique, d'une épaisseur de $0,035 \text{ mm} \pm 0,005 \text{ mm}$ et d'une longueur minimale de 200 mm, est placée le long de la surface de l'échantillon, retombant de chaque côté du mandrin (voir la Figure 34). 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 20 mm des bords de l'échantillon (voir la Figure 35). La feuille est ensuite resserrée par deux poids égaux, un à chaque extrémité, en utilisant des dispositifs de serrage appropriés.



Légende

Anglais	Français
Metal foil	Feuille métallique
Insulating material	Matériau isolant

Dimensions en millimètres

Figure 35 – Position de la feuille métallique sur le matériau isolant

Lorsque le mandrin est en position finale, et dans un délai de 60 s suivant le positionnement final, un essai de rigidité diélectrique est appliqué entre le mandrin et la feuille métallique conformément à 5.4.11.1. La tension d'essai est égale à 150 % de U_{essai} , mais pas inférieure à 5 kV efficace, où U_{essai} est la plus élevée des tensions d'essai spécifiées dans les Tableaux 31, 32 ou 33 pour une **isolation renforcée** selon le cas.

L'essai est répété sur les deux autres échantillons.

5.4.4.7 Isolation réalisée avec un isolant solide dans les composants bobinés

Les transformateurs planaires ne sont pas considérés comme des composants bobinés.

NOTE 1 Les transformateurs planaires sont soumis aux exigences de l'Article G.18.

Une **isolation principale**, une **isolation supplémentaire** ou une **isolation renforcée** dans un composant bobiné peuvent être assurées par

- l'isolation sur le fil de bobinage ou sur un autre câble (voir G.11.1); ou
- une autre isolation (voir G.11.2); ou
- une combinaison des deux.

NOTE 2 Les composants bobinés peuvent contenir des joints scellés, auquel cas 5.4.4.5 s'applique également.

Pour une **double isolation** entre le conducteur d'un câble et une autre partie conductrice, une **isolation principale** peut être assurée par une isolation conforme à G.11.1 sur le ou les câbles et une **isolation supplémentaire** par une isolation supplémentaire conforme à G.11.2, ou inversement.

De plus, une **isolation principale**, une **isolation supplémentaire** et une **isolation renforcée** dans le composant bobiné fini doivent satisfaire aux **essais individuels de série** pour la rigidité diélectrique conformément à 5.4.11.1.

5.4.4.8 Conformité

La conformité aux exigences de 5.4.4.2 à 5.4.4.7 pour l'adéquation d'une **isolation réalisée avec un isolant solide** est vérifiée par examen et mesure, en prenant en compte l'Annexe O, par les essais de rigidité diélectrique de 5.4.11.1 et les essais supplémentaires exigés de 5.4.4.2 à 5.4.4.7, selon le cas.

5.4.4.9 Exigences relatives à une isolation réalisée avec un isolant solide à des fréquences supérieures à 30 kHz

Le caractère approprié d'une **isolation réalisée avec un isolant solide** doit être déterminé comme suit.

- Déterminer la valeur de la résistance du champ électrique de rupture du matériau isolant ou de chaque feuille individuelle à la fréquence d'alimentation E_P en kV/mm pour le matériau isolant. Les matériaux choisis sont énumérés dans le Tableau 26.
- Déterminer le facteur de réduction K_R pour la résistance du champ électrique de rupture du matériau isolant ou de chaque feuille individuelle à la fréquence applicable du Tableau 27 ou 28. Si le matériau ne fait pas partie des matériaux énumérés dans le Tableau 27 ou 28, utiliser le facteur de réduction moyen indiqué dans la dernière colonne du Tableau 27 ou 28, selon le cas.
- Déterminer la valeur de la résistance du champ électrique de rupture à la fréquence applicable E_F en multipliant la valeur E_P par le facteur de réduction K_R .

$$E_F = E_P \times K_R$$

- Déterminer la rigidité diélectrique réelle V_W du matériau isolant en multipliant la valeur E_F par l'épaisseur totale (d en mm) du matériau isolant.

$$V_W = E_F \times d$$

- Pour une **isolation principale** ou une **isolation supplémentaire**, V_W doit dépasser de 20 % la **valeur de crête de la tension de service** haute fréquence mesurée V_{PW} .

$$V_W > 1,2 \times V_{PW}$$

- Pour une **isolation renforcée**, V_W doit dépasser deux fois la **valeur de crête de la tension de service** haute fréquence mesurée V_{PW} de 20 %.

$$V_W > 1,2 \times 2 \times V_{PW}$$

**Tableau 26 – Résistance du champ électrique E_p
pour quelques matériaux couramment utilisés**

Matériau	Résistance du champ électrique de rupture E_p kV/mm				
	Épaisseur du matériau mm				
	0,75	0,08	0,06	0,05	0,03
Porcelaine	9,2	-	-	-	-
Silicium-verre	14	-	-	-	-
Phénolique	17	-	-	-	-
Céramique	19	-	-	-	-
Téflon	27	-	-	-	-
Mélamine-verre	27	-	-	-	-
Mica	29	-	-	-	-
Papier phénolique	38	-	-	-	-
Polyéthylène	50	-	-	52	-
Polystyrène	55	65	-	-	-
Verre	60	-	-	-	-
Polyéthylène	49	-	-	-	-
Kapton	303	-	-	-	-
TIW	70	-	-	-	-
FR530L	33	-	-	-	-
Phénolique chargé de mica	28	-	-	-	-
Laminé verre-silicone	18	-	-	-	-
Acétobutyrate de cellulose	-	-	120	-	210
Polycarbonate	-	-	160	-	270
Triacétate de cellulose	-	-	120	-	210
NOTE 1 Il est supposé que les matériaux ont une épaisseur égale ou supérieure à 0,75 mm lorsque aucune épaisseur n'a été mentionnée. Les matériaux qui n'ont pas d'informations E_p à une très faible épaisseur présentent effectivement une meilleure valeur E_p à la faible épaisseur que la valeur E_p à une épaisseur de 0,75 mm. NOTE 2 Les valeurs manquantes font l'objet d'une enquête.					

Tableau 27 – Facteurs de réduction pour la valeur de la résistance du champ électrique de rupture E_p à des fréquences plus élevées

Matériau ^a	Fréquence kHz										
	30	100	200	300	400	500	1 000	2 000	3 000	5 000	10 000
	Facteur de réduction K_R										
Porcelaine	0,52	0,42	0,40	0,39	0,38	0,37	0,36	0,35	0,35	0,34	0,30
Silicium-verre	0,79	0,65	0,57	0,53	0,49	0,46	0,39	0,33	0,31	0,29	0,26
Phénolique	0,82	0,71	0,53	0,42	0,36	0,34	0,24	0,16	0,14	0,13	0,12
Céramique	0,78	0,64	0,62	0,56	0,54	0,51	0,46	0,42	0,37	0,35	0,29
Téflon	0,57	0,54	0,52	0,51	0,48	0,46	0,45	0,44	0,41	0,37	0,22
Mélamine-verre	0,48	0,41	0,31	0,27	0,24	0,22	0,16	0,12	0,10	0,09	0,06
Mica	0,69	0,55	0,48	0,45	0,41	0,38	0,34	0,28	0,26	0,24	0,20
Papier phénolique	0,58	0,47	0,40	0,32	0,26	0,23	0,16	0,11	0,08	0,06	0,05
Polyéthylène	0,36	0,28	0,22	0,21	0,20	0,19	0,16	0,13	0,12	0,12	0,11
Polystyrène	0,35	0,22	0,15	0,13	0,13	0,11	0,08	0,06	0,06	0,06	0,06
Verre	0,37	0,21	0,15	0,13	0,11	0,10	0,08	0,06	0,05	0,05	0,04
Autres matériaux	0,43	0,35	0,30	0,27	0,25	0,24	0,20	0,17	0,16	0,14	0,12

^a Ces données correspondent aux matériaux qui ont une épaisseur de 0,75 mm.

Tableau 28 – Valeurs de réduction de la résistance du champ électrique de rupture à la fréquence du courant alternatif, pour les matériaux en feuilles fines

Matériau en feuilles fines	Fréquence kHz										
	30	100	200	300	400	500	1 000	2 000	3 000	5 000	10 000
	Facteur de réduction K_R										
Acétobutyrate de cellulose (0,03 mm)	0,67	0,43	0,32	0,27	0,24	0,20	0,15	0,11	0,09	0,07	0,06
Acétobutyrate de cellulose (0,06 mm)	0,69	0,49	0,36	0,30	0,26	0,23	0,17	0,13	0,11	0,08	0,06
Polycarbonate (0,03 mm)	0,61	0,39	0,31	0,25	0,23	0,20	0,14	0,10	0,08	0,06	0,05
Polycarbonate (0,06 mm)	0,70	0,49	0,39	0,33	0,28	0,25	0,19	0,13	0,11	0,08	0,06
Triacétate de cellulose (0,03 mm)	0,67	0,43	0,31	0,26	0,23	0,20	0,14	0,10	0,09	0,07	0,06
Triacétate de cellulose (0,06 mm)	0,72	0,50	0,36	0,31	0,27	0,23	0,17	0,13	0,10	0,10	0,06
Autres matériaux à feuilles fines	0,68	0,46	0,34	0,29	0,25	0,22	0,16	0,12	0,10	0,08	0,06

5.4.5 Isolation des dispositifs de connexion extérieure d'antenne

5.4.5.1 Généralités

Le présent paragraphe spécifie les essais pour une isolation

- entre les dispositifs de connexion extérieure d'antenne et le **réseau d'alimentation**, et
- entre les dispositifs de connexion extérieure d'antenne et les circuits ES1 ou ES2
 - isolés des circuits d'antenne, et

- présentant des dispositifs de connexion aux **circuits externes**.

L'isolation doit être capable de supporter les surtensions dues aux surtensions au niveau des dispositifs de connexion extérieure d'antenne.

Cet essai ne s'applique pas aux équipements dont un dispositif de connexion extérieure d'antenne sur l'équipement est connecté à la terre conformément à 5.6.8.2.

NOTE En Chine, la connexion de la télévision par câble à la principale borne de terre de protection de l'équipement n'est pas autorisée.

Si un équipement connecté au **réseau d'alimentation** fournit des tensions d'alimentation ne provenant pas du **réseau d'alimentation** à un autre équipement muni de dispositifs de connexion extérieure d'antenne, l'essai doit s'appliquer entre les bornes du **réseau d'alimentation** et les bornes de tension d'alimentation ne provenant pas du **réseau d'alimentation**.

5.4.5.2 Méthode d'essai

*L'isolation doit être soumise à essai comme décrit en G.14.3.2. L'équipement doit être placé sur une surface isolante. La sortie du générateur d'impulsions d'essai doit être connectée aux dispositifs de connexion extérieure d'antenne connectés ensemble et aux dispositifs de connexion extérieure pour le raccordement au **réseau d'alimentation** connectés ensemble. L'équipement n'est pas alimenté pendant l'essai.*

*Si l'équipement présente des circuits ES1 ou ES2 isolés des circuits d'antenne et munis de dispositifs de connexion extérieure aux **circuits externes**, l'essai est répété alors que le générateur est connecté aux dispositifs de connexion extérieure d'antenne connectés ensemble et aux dispositifs de connexion extérieure du **circuit externe** connectés ensemble.*

NOTE Le personnel d'essai est averti de ne pas toucher l'équipement au cours de l'essai.

5.4.5.3 Conformité

La conformité est vérifiée en mesurant la résistance de l'isolation avec 500 V en courant continu.

L'appareil est considéré comme satisfaisant aux exigences si la résistance de l'isolation, mesurée après 1 min, n'est pas inférieure aux valeurs indiquées au Tableau 29.

Tableau 29 – Valeurs pour la résistance de l'isolation

Exigences relatives à l'isolation entre les parties	Résistance de l'isolation MΩ
Entre les parties séparées par une isolation principale ou une isolation supplémentaire .	2
Entre les parties séparées par une double isolation ou une isolation renforcée	4

5.4.6 Isolation du câblage interne en tant que partie d'une protection supplémentaire

Les exigences présentées dans ce paragraphe s'appliquent lorsque l'isolation d'un câblage interne, seule, satisfait aux exigences pour une **isolation principale**, mais ne satisfait pas à celles pour une **isolation supplémentaire**.

Un exemple de ce type de câblage interne est le câblage d'un circuit isolé du **réseau d'alimentation** à un niveau de tension ne dépassant pas le niveau de tension ES1.

Ces exigences s'appliquent à un fil situé dans un circuit isolé du **réseau d'alimentation** à un niveau de tension ne dépassant pas le niveau de tension ES1, qui est isolé de ES3 par une **protection principale** uniquement.

Lorsqu'une isolation de fils est utilisée en tant que partie d'un système d'**isolation supplémentaire** et que l'isolation de fils est **accessible** à une **personne ordinaire**:

- il n'est pas nécessaire que l'isolation de fils soit manipulée par la **personne ordinaire**;
- le fil est placé de telle sorte qu'il soit improbable qu'une **personne ordinaire** tire sur le fil, ou le fil doit être fixé de telle sorte que les points de raccordement ne soient soumis à aucun effort de traction;
- le fil est dirigé et fixé de telle sorte qu'il ne touche pas les parties conductrices **accessibles** non mises à la terre;
- l'isolation du fil satisfait à l'essai de rigidité diélectrique de 5.4.11.1 pour l'**isolation supplémentaire**;
- la distance à travers l'isolation du fil doit être au moins celle indiquée dans le Tableau 30.

Tableau 30 – 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 de crête ou c.c.	V en valeur efficace (sinusoïdale)	mm
$>71 \leq 350$	$>50 \leq 250$	0,17
>350	>250	0,31

La conformité est vérifiée par examen, par des mesures et par l'exécution de l'essai de 5.4.11.1.

5.4.7 Procédure d'essai de cycles thermiques

Un échantillon d'un composant ou d'un sous-ensemble est soumis à la séquence suivante d'essais. L'échantillon est soumis 10 fois à la séquence suivante de cycles thermiques:

68 h à $T_1 \pm 2^\circ\text{C}$;
 1 h à $25^\circ\text{C} \pm 2^\circ\text{C}$;
 2 h à $0^\circ\text{C} \pm 2^\circ\text{C}$;
 ≥ 1 h à $25^\circ\text{C} \pm 2^\circ\text{C}$.

$T_1 = T_2 + T_{\text{ma}} - T_{\text{amb}} + 10$ K, mesuré conformément à B.1.7, ou 85°C , la valeur la plus élevée étant retenue. Cependant, 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 au cours de l'essai décrit en 5.4.1.5.

La signification de T_{ma} et T_{amb} est donnée en B.2.6.1.

Le temps nécessaire pour le passage d'une température à une autre n'est pas spécifié, mais il est permis que le passage soit progressif.

5.4.8 Essai pour l'environnement de degré de pollution 1 et pour un composé isolant

Cet essai est effectué lorsqu'il est nécessaire de vérifier un environnement de **degré de pollution 1** et lorsqu'il est exigé par 5.4.4.3.

Un échantillon est soumis à la séquence de cycles thermiques de 5.4.7.

Après refroidissement jusqu'à la température ambiante, l'échantillon est soumis à l'épreuve hygroscopique de 5.4.10, suivie immédiatement les essais de rigidité diélectrique décrits en 5.4.11.1.

La conformité est vérifiée par examen et par des mesures. Le matériau isolant ne doit pas présenter de craquelures. Pour la conformité avec 5.4.4.3, l'échantillon est également divisé en sections et il ne doit pas y avoir de vides apparents dans le matériau isolant.

5.4.9 Essais pour les composants à semi-conducteurs et pour les joints scellés

Trois échantillons sont soumis à la séquence de cycles thermiques décrite en 5.4.7. Avant de soumettre un joint scellé à l'essai, les enroulements de fils en émail à base de solvant du composant sont remplacés par une feuille métallique ou par quelques tours de fils nu, à proximité du joint scellé.

Les trois échantillons sont ensuite soumis à essai comme suit:

- un des échantillons est soumis à l'essai de rigidité diélectrique de 5.4.11.1, immédiatement après la dernière période à $T_1 \pm 2^\circ\text{C}$ au cours du cycle thermique, à cette exception près que la tension d'essai est multipliée par 1,6;
- les autres échantillons sont soumis à l'essai de rigidité diélectrique adapté décrit en 5.4.11.1 après l'épreuve hygroscopique de 5.4.10, à cette exception près que la tension d'essai est multipliée par 1,6.

La conformité est vérifiée par examen de la section et par des mesures. Le matériau isolant ne doit pas présenter de vides apparents, de trous ou de craquelures. Dans le cas de cartes imprimées multicouches, il ne doit pas y avoir de délaminage.

5.4.10 Épreuve hygroscopique

L'épreuve hygroscopique est effectuée pendant 48 h dans une enceinte ou une pièce contenant de l'air et présentant une humidité relative de $93\% \pm 3\%$. La température de l'air, à tous les endroits où les échantillons peuvent être situés, est maintenue à 2°C près à une valeur t comprise entre 20°C et 30°C de telle sorte qu'il ne se produise pas de condensation. Au cours de cette épreuve, le composant ou le sous-ensemble n'est pas alimenté.

Dans des conditions tropicales, la durée de l'essai doit être de 120 h à une température de $40^\circ\text{C} \pm 2^\circ\text{C}$ et une humidité relative de $93\% \pm 3\%$.

Avant l'épreuve hygroscopique, l'échantillon est amené à une température comprise entre la température spécifiée t et $(t + 4)^\circ\text{C}$.

5.4.11 Essai de rigidité diélectrique

5.4.11.1 Procédure d'essai pour un essai de type d'isolation réalisée avec un isolant solide

Sauf spécification contraire, la conformité est vérifiée soit

- immédiatement après l'essai de température décrit en 5.4.1.5, ou
- si un composant ou un sous-ensemble est soumis à essai séparément à l'extérieur de l'équipement, il est amené à la température atteinte par cette partie au cours de l'essai de température décrit en 5.4.1.5 (par exemple, en étant placé dans un four) avant que l'essai de rigidité diélectrique ne soit effectué.

Une autre possibilité consiste à soumettre à essai le matériau à fines couches pour une **isolation supplémentaire** ou une **isolation renforcée** à la température ambiante.

Sauf spécification contraire dans d'autres articles de la présente norme, la tension d'essai pour la rigidité diélectrique d'une **isolation principale**, d'une **isolation supplémentaire** ou d'une **isolation renforcée** est la valeur la plus élevée des trois méthodes suivantes:

Méthode 1: Déterminer la tension d'essai conformément au Tableau 31 à l'aide de la **tension de tenue prescrite** (fondée sur les tensions transitoires du **réseau d'alimentation** en courant alternatif ou du **réseau d'alimentation** en courant continu ou des **circuits externes**).

Méthode 2: Déterminer la tension d'essai conformément au Tableau 32 à l'aide de la **valeur de crête de la tension de service**.

Méthode 3: Déterminer la tension d'essai conformément au Tableau 33 à l'aide de la tension nominale du **réseau d'alimentation** (pour couvrir les surtensions temporaires).

L'isolation est soumise à la tension d'essai la plus élevée comme suit:

- en appliquant une tension en courant alternatif de forme pratiquement sinusoïdale ayant une fréquence de 50 Hz ou 60 Hz; ou
- en appliquant une **tension en courant continu** dans une polarité, puis dans la polarité inverse.

La tension appliquée à l'isolation soumise à essai est progressivement élevée de zéro à la tension prescrite et maintenue à cette valeur pendant 60 s (pour les **essais individuels de série**, voir 5.4.11.2).

Les revêtements d'isolation sont soumis à essai en mettant une feuille métallique en contact avec la surface isolante. Cette procédure d'essai est limitée aux zones où l'isolation est susceptible d'être faible (par exemple, où il y a des arêtes vives en métal sous l'isolation). Si possible, des doublures isolantes sont soumises à essai séparément. La feuille métallique est placée avec soin de sorte qu'il ne se produise pas de contournement aux arêtes de l'isolation. Lorsqu'une feuille métallique adhésive est utilisée, l'adhésif doit être conducteur.

Pour éviter l'endommagement des composants ou des isolations qui ne sont pas concernés par l'essai, les circuits intégrés ou les éléments similaires peuvent être déconnectés et une liaison équipotentielle peut être utilisée. Une varistance à oxyde métallique (MOV) conforme à l'Article G.10 peut être retirée pendant l'essai.

Pour les équipements intégrant une **isolation principale** et une **isolation supplémentaire** en parallèle avec une **isolation renforcée**, la tension est appliquée avec soin à l'**isolation renforcée** afin de ne pas surcharger l'**isolation principale** ni l'**isolation supplémentaire**.

NOTE 1 Lorsque les condensateurs sont mis en parallèle avec l'isolation soumise à essai (par exemple, des condensateurs à filtre radioélectriques), il convient d'utiliser des tensions d'essai en courant continu.

NOTE 2 Il convient de déconnecter les composants fournissant un chemin en courant continu en parallèle avec l'isolation soumise à essai, comme les résistances de décharge des condensateurs à filtre et les dispositifs de limitation de tension.

Lorsque l'isolation d'un enroulement de transformateur varie le long de l'enroulement conformément à 5.4.1.7, une méthode d'essai de rigidité diélectrique est utilisée et appliquée selon le type d'isolation le long de l'enroulement.

NOTE 3 Un exemple de méthode d'essai est un essai de tension induite appliquée à une fréquence suffisamment élevée pour éviter la saturation du transformateur. La tension d'entrée est élevée à une valeur qui induise une tension de sortie égale à la tension d'essai prescrite.

Tableau 31 – Tensions d'essai pour les essais de rigidité diélectrique basés sur les tensions transitoires

Tension de tenue prescrite jusqu'à et y compris kV de crête	Tension d'essai pour l'isolation principale ou l'isolation supplémentaire	Tension d'essai pour l'isolation renforcée
	kV de crête c.a. ou c.c.	
0,33	0,33	0,5
0,5	0,5	0,8
0,8	0,8	1,5
1,5	1,5	2,5
2,5	2,5	4
4,0	4	6
6,0	6	8
8,0	8	12
12	12	18
U_R^a	U_R^a	$1,5 \times U_R^a$
Une interpolation linéaire peut être utilisée entre les deux points les plus proches.		
^a U_R correspond à toute tension de tenue prescrite supérieure à 12,0 kV.		

Tableau 32 – Tensions d'essai pour les essais de rigidité diélectrique basés sur les valeurs crête de la tension de service

Valeur de crête de la tension de service jusqu'à et y compris kV de crête	Tension d'essai pour l'isolation principale ou l'isolation supplémentaire	Tension d'essai pour l'isolation renforcée
	kV de crête ou c.c.	
0,33	0,43	0,53
0,5	0,65	0,80
0,8	1,04	1,28
1,5	1,95	2,4
2,5	3,25	4,0
4,0	5,20	6,40
6,0	7,80	9,60
8,0	10,40	12,8
12,0	15,60	19,2
U_P^a	$1,3 \times U_P^a$	$1,6 \times U_P^a$
^a U_P correspond à toute valeur de crête de la tension de service supérieure à 12,0 kV.		

Tableau 33 – Tensions d'essai pour les essais de rigidité diélectrique basés sur les surtensions temporaires

Tension nominale du réseau d'alimentation	Tension d'essai pour l'isolation principale ou l'isolation supplémentaire	Tension d'essai pour l'isolation renforcée
V en valeur efficace	V de crête ou cc	
Jusque à et y compris 250	2 000	4 000
Plus de 250 Jusque à et y compris 600	2 500	5 000

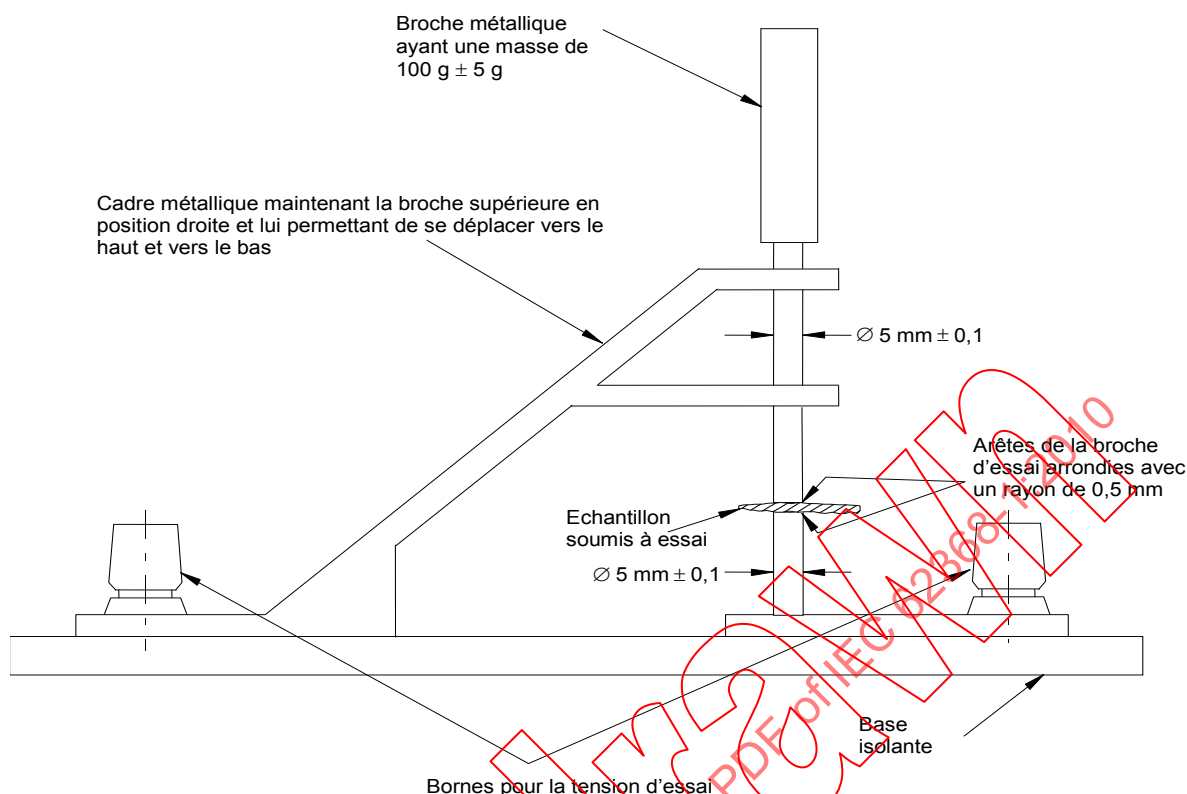


Figure 36 – Exemple d'instrument d'essai de rigidité diélectrique pour une isolation réalisée avec un isolant solide

NOTE 4 L'instrument de la Figure 36 peut être utilisé pour soumettre à essai des échantillons d'isolation à fines couches.

Il ne doit pas y avoir de rupture d'isolation pendant l'essai. Il est considéré qu'une rupture d'isolation se produit lorsque le courant qui s'écoule à la suite de l'application de la tension d'essai augmente rapidement de manière incontrôlée, c'est-à-dire lorsque l'isolation n'empêche pas le passage du courant. Une décharge en couronne ou un simple contournement momentané n'est pas considéré(e) comme une rupture d'isolation.

5.4.11.2 Procédure d'essai pour les essais individuels de série

Les essais individuels de série sont effectués conformément à 5.4.11.1, à l'exception des éléments suivants:

- l'essai peut être effectué à la température ambiante; et
- la durée de l'essai de rigidité diélectrique doit être comprise entre 1 s et 4 s; et
- les tensions d'essai spécifiées dans les Tableaux 31, 32 et 33 peuvent être réduites de 10 %.

NOTE La condition d'essai ci-dessus s'applique également aux **essais individuels de série** dans la production de l'équipement ou des sous-ensembles.

Il ne doit pas y avoir de rupture d'isolation pendant l'essai. Il est considéré qu'une rupture d'isolation se produit lorsque le courant qui s'écoule à la suite de l'application de la tension d'essai augmente rapidement de manière incontrôlée, c'est-à-dire lorsque l'isolation n'empêche pas le passage du courant. Une décharge en couronne ou un simple contournement momentané n'est pas considéré(e) comme une rupture d'isolation.

5.4.12 Protection contre les tensions transitoires des circuits externes

5.4.12.1 Exigences

Les équipements comportant des **circuits externes** tel qu'indiqué dans le Tableau 16, avec les numéros d'identification 11, 12, 13, 14, 15, 16 et 17, doivent fournir une séparation électrique appropriée entre un circuit externe et:

- les parties conductrices non mises à la terre; ou
- les parties non conductrices de l'équipement supposées être tenues ou maintenues en contact continu avec le corps en utilisation normale (par exemple, un combiné ou un casque de téléphone ou la surface d'un ordinateur portable sur laquelle s'appuie la paume de la main); ou
- une autre partie ES1 ou ES2 séparée du **circuit externe**; ou
- des parties et des circuits **accessibles**, à l'exception des broches des connecteurs. Cependant, ce type de broches ne doit pas être **accessible** dans les **conditions normales de fonctionnement** à la sonde mousse de la Figure V 3.

5.4.12.2 Conformité et méthode d'essai

*La conformité est vérifiée par l'essai de rigidité diélectrique pour une **isolation principale** conformément à 5.4.11.1 appliqué sur la séparation électrique. Pour les essais, tous les conducteurs, y compris le blindage du câble coaxial, prévus pour être raccordés au **circuit externe** sont raccordés ensemble, y compris les conducteurs qui peuvent être raccordés à la terre dans le **circuit externe**. De manière similaire, tous les conducteurs prévus pour être raccordés à d'autres **circuits externes** sont raccordés ensemble.*

Les parties non conductrices sont soumises à essai par une feuille métallique mise en contact avec la surface.

*La tension d'essai doit être choisie parmi les valeurs de tension les plus élevées indiquées dans les Tableaux 31, 32 et 33. Pour les parties supposées être tenues ou touchées dans les **conditions normales de fonctionnement**, la tension d'essai doit être celle pour une **isolation renforcée**.*

5.4.13 Séparation entre des circuits externes et la terre

5.4.13.1 Généralités

Ces exigences s'appliquent uniquement aux **circuits externes** indiqués dans le Tableau 16, numéros d'identification 11, 12, 13 et 14.

Ces exigences ne s'appliquent pas aux **circuits externes**:

- des **équipements reliés en permanence**, ou
- des **équipements enfichables de type B**; ou
- des **équipements enfichables de type A stationnaires** qui sont conçus pour être utilisés dans un endroit ayant une liaison équipotentielle (telle qu'un centre de télécommunication, une salle d'ordinateurs dédiée ou une **zone à accès limité**) et dont les instructions d'installation exigent une vérification de la **connexion de terre de protection** du socle de prise de courant par une **personne qualifiée**; ou
- des **équipements enfichables de type A stationnaires** destinés à être utilisés avec un **conducteur de mise à la terre de protection** relié en permanence, y compris les instructions d'installation de ce conducteur pour la mise à la terre par une **personne qualifiée**.

NOTE En Norvège et en Suède, les exclusions s'appliquent aux **équipements reliés en permanence**, **équipements enfichables de type B** et équipements destinés à être utilisés dans une **zone à accès limité** soumise à une liaison équipotentielle, par exemple dans un centre de télécommunications, et prévus pour être connectés à un **conducteur de mise à la terre de protection** relié en permanence, et disposant des instructions d'installation de ce conducteur par une **personne qualifiée**.

5.4.13.2 Exigences

Une isolation doit être prévue entre les circuits prévus pour être raccordés aux **circuits externes** mentionnés ci-dessus et les parties ou circuits qui sont mis à la terre dans certaines applications, soit dans l'équipement soumis à essai (EUT), soit par l'intermédiaire d'un autre équipement.

Les dispositifs de protection contre les surtensions (SPD) qui mettent en parallèle l'isolation entre les **circuits externes** ES1 ou ES2 et la terre doivent présenter une tension de fonctionnement assignée minimale U_{op} (par exemple, la tension de claquage d'un tube à décharge de gaz) de:

$$U_{op} = U_{crête} + \Delta U_{sp} + \Delta U_{sa}$$

où

$U_{crête}$ est l'une des valeurs suivantes:

- pour l'équipement destiné à être installé dans une zone où la tension nominale du **réseau d'alimentation** en courant alternatif dépasse 130 V: 360 V
- pour tous les autres équipements: 180 V.

ΔU_{sp} est l'augmentation maximale de la tension de fonctionnement assignée due aux variations dans la production des SPD. Si cela n'est pas spécifié par le fabricant du SPD, ΔU_{sp} doit être prise égale à 10 % de la tension de fonctionnement assignée du SPD.

ΔU_{sa} est l'augmentation maximale de la tension de fonctionnement assignée due au vieillissement du SPD au-delà de la durée de vie prévue de l'équipement. Si cela n'est pas spécifié par le fabricant du SPD, ΔU_{sa} doit être prise égale à 10 % de la tension de fonctionnement assignée du SPD.

NOTE ($\Delta U_{sp} + \Delta U_{sa}$) peut être une seule valeur fournie par le fabricant du composant.

5.4.13.3 Conformité et méthode d'essai

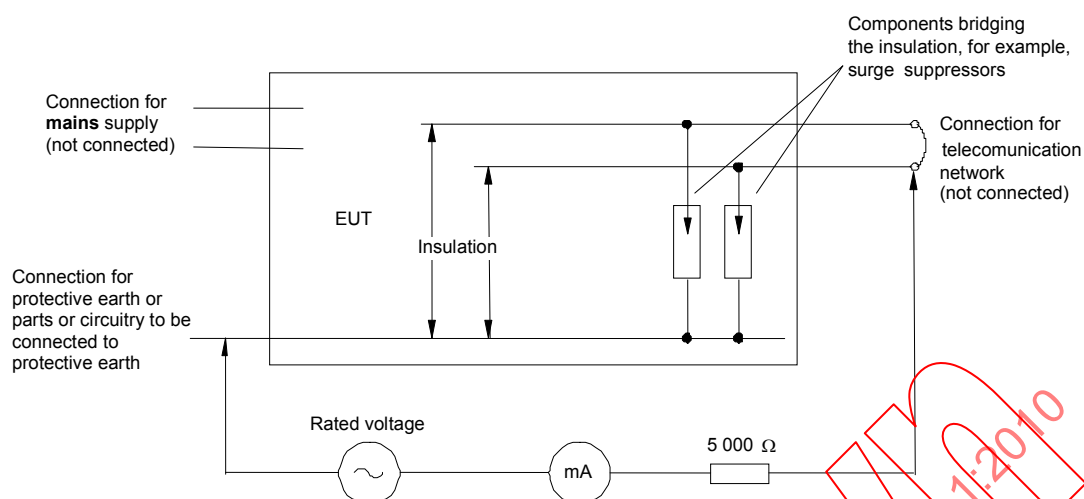
La conformité est vérifiée par examen et par l'essai de rigidité diélectrique défini en 5.4.11.1.

Les composants qui mettent en parallèle l'isolation, autres que les condensateurs, peuvent être enlevés au cours de l'essai de rigidité diélectrique. Les composants laissés en place pendant l'essai ne doivent pas être endommagés.

Si les composants sont retirés, l'essai supplémentaire suivant avec un circuit d'essai conforme à la Figure 37 est effectué avec l'ensemble des composants en place.

*Pour l'équipement alimenté par un **réseau d'alimentation** en courant alternatif, l'essai est effectué avec une tension égale à la **tension assignée** de l'équipement ou à la tension supérieure de la **plage de tensions assignées**. Pour l'équipement alimenté par un **réseau d'alimentation** en courant continu, l'essai est effectué avec une tension égale à la tension nominale la plus élevée du **réseau d'alimentation** en courant alternatif dans la région où l'équipement doit être utilisé (par exemple, 230 V pour l'Europe ou 120 V pour l'Amérique du Nord).*

Le courant passant dans le circuit d'essai de la Figure 37 ne doit pas dépasser 10 mA.



Légende

Anglais	Français
Connection for mains supply (not connected)	Connexion pour réseau d'alimentation (non connecté)
EUT	Équipement soumis à essai
Insulation	Isolation
Components bridging the insulation, for example, surge suppressors	Composants mettant en parallèle l'isolation, par exemple, parasurtensions
Connection for telecommunication network (not connected)	Connexion pour réseau de télécommunications (non connecté)
Connection for protective earth or parts or circuitry to be connected to protective earth	Connexion de terre de protection ou parties ou circuits à connecter à la mise à la terre de protection
Rated voltage	Tension assignée

Figure 37 – Essai de séparation entre un réseau de télécommunications et la terre

5.5 Composants comme protections

5.5.1 Généralités

Le présent paragraphe spécifie des applications de composants qui servent de **protections** (électriques) ou qui mettent en parallèle les **protections**.

NOTE Voir l'Annexe G pour la qualification des composants de sécurité.

Si un composant met en parallèle une **protection**, il doit alors être également conforme à toutes les exigences pour cette **protection** suivant le cas.

5.5.2 Composants comme protection principale et protection supplémentaire

5.5.2.1 Exigences générales

Pour les composants utilisés comme **protection principale**, l'isolation doit être conforme à l'**isolation principale**.

Pour les composants utilisés comme **protection supplémentaire**, l'isolation doit être conforme à l'**isolation supplémentaire**.

Les composants peuvent être utilisés comme une **protection principale** ou une **protection supplémentaire**, mais uniquement s'ils sont utilisés selon leurs caractéristiques assignées.

5.5.2.2 Condensateurs et cellules RC comme protection principale et protection supplémentaire

Les condensateurs et cellules RC peuvent être utilisés comme **protections principales**. Si des condensateurs et cellules RC sont utilisés comme **protections principales**, ils doivent alors être conformes aux exigences relatives à une **isolation principale** entre leurs extrémités pour la **tension de service** totale à travers l'isolation ainsi qu'aux exigences spécifiées à l'Article G.15.

NOTE 1 Les cellules RC peuvent consister en des composants discrets.

Les exigences de l'Article G.15 ne s'appliquent pas à l'**isolation principale** prévue entre:

- ES3 isolé du **réseau d'alimentation** et la terre de protection; et
- ES2 et la terre de protection; et
- ES2 et ES1.

L'essai décrit en 5.4.11.1 s'applique toujours aux condensateurs ci-dessus.

Les condensateurs et cellules RC peuvent être utilisés comme **protection supplémentaire**. Si des condensateurs et cellules RC sont utilisés comme **protection supplémentaire**, ils doivent alors être conformes aux exigences relatives à une **isolation supplémentaire** entre leurs extrémités pour la **tension de service** totale à travers l'isolation ainsi qu'aux exigences de sécurité spécifiées à l'Article G.15.

Pour un condensateur utilisé comme **protection principale** ou comme **protection supplémentaire**, la tension d'essai de l'impulsion de crête du condensateur doit être au moins égale à la **tension de tenue prescrite**.

Si une **protection principale** ou une **protection supplémentaire** est composée de plus d'un condensateur, toutes les exigences suivantes s'appliquent:

- dans les **conditions de premier défaut**, la tension appliquée à chacun des condensateurs individuels restants ne doit pas dépasser la valeur assignée de la tension des condensateurs individuels appropriés.
- la somme des tensions d'essai de l'impulsion de crête de tous les condensateurs ne doit pas être inférieure à la **tension de tenue prescrite**;
- la somme des tensions d'essai efficaces de tous les condensateurs ne doit pas être inférieure à la tension la plus élevée de la tension d'essai prescrite indiquée dans les Tableaux 31, 32 et 33.

NOTE 2 Il est courant d'avoir la même valeur de capacité assignée et la même tension assignée pour tous les condensateurs montés en série.

NOTE 3 En Norvège, en raison du système d'alimentation IT utilisé, les condensateurs doivent être assignés pour la tension entre phases applicable (230 V).

Les condensateurs de classe X peuvent être utilisés comme **protections principales** dans des circuits isolés du **réseau d'alimentation**, mais ne doivent pas être utilisés comme:

- **protection principale** dans les circuits connectés au **réseau d'alimentation**; ou
- **protection supplémentaire**.

5.5.2.3 Protections contre une décharge du condensateur

Dans le cas d'une **personne ordinaire**, lorsqu'une tension de condensateur est **accessible**, ou devient **accessible** lors de la déconnexion d'un connecteur (par exemple, le connecteur du **réseau d'alimentation**), soit

- la combinaison de la capacité et de la tension doit être conforme aux limites ES1 du Tableau 7, soit
- le circuit doit disposer d'un moyen de décharger le condensateur aux limites ES1 du Tableau 7 dans un délai de 2 s.

Dans le cas d'une **personne avertie**, lorsqu'une tension de condensateur est **accessible** ou devient **accessible** lors de la déconnexion d'un connecteur (par exemple, le connecteur du **réseau d'alimentation**), soit

- la combinaison de la capacité et de la tension doit être conforme aux limites ES2 du Tableau 7, soit
- le circuit doit disposer d'un moyen de décharger le condensateur aux limites ES2 du Tableau 7 dans un délai de 2 s.

NOTE Les limites s'appliquent à la fois au condensateur lui-même et au circuit qui le charge.

5.5.2.4 Transformateurs utilisés comme protection principale et protection supplémentaire

L'isolation des transformateurs utilisés comme **protection principale** doit être conforme aux exigences relatives à une **isolation principale** ou aux exigences relatives à la sécurité de la norme CEI appropriée décrites à l'Article G.7. L'isolation des transformateurs utilisés comme **protection supplémentaire** doit être conforme aux exigences relatives à une **isolation supplémentaire**, ainsi qu'aux exigences de l'Article G.7, ou aux exigences relatives à la sécurité de la norme CEI appropriée décrites à l'Article G.7.

5.5.2.5 Optocoupleurs utilisés comme protection principale et protection supplémentaire

L'isolation des optocoupleurs utilisés comme **protection principale** doit être conforme aux exigences relatives à une **isolation principale** ou aux exigences relatives à la sécurité de la norme CEI (voir l'Article G.16). L'isolation des optocoupleurs utilisés comme **protection supplémentaire** doit être conforme aux exigences relatives à une **isolation supplémentaire** ou aux exigences relatives à la sécurité de la norme CEI (voir l'Article G.16).

5.5.2.6 Relais utilisés comme protection principale et protection supplémentaire

L'isolation des relais utilisés comme **protection principale** doit être conforme aux exigences relatives à une **isolation principale** ou aux exigences relatives à la sécurité de la norme CEI décrites à l'Article G.17.

L'isolation des relais utilisés comme **protection supplémentaire** doit être conforme aux exigences relatives à une **isolation supplémentaire** ou aux exigences relatives à la sécurité de la norme CEI décrites à l'Article G.17.

5.5.2.7 Résistances utilisées comme protection principale et protection supplémentaire

Les résistances peuvent être utilisées comme **protection principale**. Si des résistances sont utilisées comme **protection principale**, elles doivent alors être conformes aux exigences relatives aux **distances d'isolement dans l'air** et aux **lignes de fuite** applicables à une **isolation principale** entre ses extrémités pour la **tension de service** totale à travers l'isolation.

Les résistances peuvent être utilisées comme **protection supplémentaire**. Si des résistances sont utilisées comme **protection supplémentaire**, elles doivent être conformes aux exigences relatives aux **distances d'isolement dans l'air** et aux **lignes de fuite** applicables à une **isolation supplémentaire** entre leurs extrémités pour la **tension de service** totale à travers l'isolation.

Une **isolation principale** ou une **isolation supplémentaire** peut être mise en parallèle par une résistance ou par un groupe de deux résistances ou plus en série dans les conditions suivantes.

La résistance ou le groupe de résistances doit être conforme aux **distances d'isolement dans l'air** minimales de 5.4.2 et aux **lignes de fuite** minimales de 5.4.3 pour une **isolation principale** ou une **isolation supplémentaire** selon le cas, pour la **tension de service** totale à travers la résistance ou le groupe. Pour un groupe de résistances, voir la Figure O.4.

Si une seule résistance est utilisée, elle doit satisfaire à l'essai de résistance décrit en G.14.2.

Si un groupe de résistances est utilisé, la **distance d'isolement dans l'air** et la **ligne de fuite** sont évaluées comme si chaque résistance était court-circuitée à son tour, à moins que le groupe ne satisfasse à l'essai de résistance de G.14.2.

5.5.2.8 SPD utilisé comme protection principale

Un SPD peut être utilisé comme **protection principale** à condition qu'un côté du SPD soit mis à la terre conformément à 5.6.8.2.

Une varistance à oxyde métallique (MOV) utilisée comme **protection principale** doit satisfaire aux exigences de l'Article G.10.

5.5.2.9 Autres composants utilisés comme protection principale entre ES1 et ES2

Tous les types de composant peuvent être utilisés comme **protection principale** à condition que:

- deux composants soient en série si une séparation est exigée; ou
- deux composants soient en parallèle si une liaison (connexion) est exigée.

Chaque composant doit être utilisé selon ses caractéristiques assignées.

Les composants mettant en parallèle une **isolation principale** servant de **protection principale** entre ES1 et ES2 doivent satisfaire à l'essai de rigidité diélectrique applicable conformément à 5.4.11.1.

5.5.3 Composants utilisés comme protection renforcée

5.5.3.1 Exigences générales

Pour les composants utilisés comme **protection renforcée**, l'isolation doit être conforme à l'**isolation renforcée**.

Un composant utilisé comme **protection renforcée** doit être utilisé selon ses caractéristiques assignées.

5.5.3.2 Condensateurs et cellules RC

Des condensateurs et cellules RC peuvent être utilisés comme **protection renforcée** à condition qu'ils soient conformes aux exigences relatives à une **isolation renforcée** entre leurs extrémités pour la **tension de service** totale à travers l'isolation. Les condensateurs et cellules RC doivent être conformes à la CEI 60384-14 comme indiqué à l'Article G.15.

Les condensateurs de classe X ne doivent pas être utilisés comme **protection renforcée**.

Si une **protection renforcée** est composée de plus d'un condensateur, toutes les exigences suivantes s'appliquent:

- dans les **conditions de premier défaut**, la tension appliquée à chacun des condensateurs individuels restants ne doit pas dépasser la valeur assignée de la tension des condensateurs individuels appropriés;
- la somme des tensions d'essai de l'impulsion de crête de tous les condensateurs ne doit pas être inférieure au double de la **tension de tenue prescrite**;
- la somme des tensions d'essai efficaces de tous les condensateurs ne doit pas être inférieure à la tension la plus élevée de la tension d'essai prescrite indiquée dans les Tableaux 31, 32 et 33.

5.5.3.3 Transformateurs

Les transformateurs utilisés comme **protection renforcée** doivent être conformes aux exigences relatives à une **isolation renforcée** et décrites à l'Article G.7.

5.5.3.4 Optocoupleurs

L'isolation des optocoupleurs utilisés comme **protection renforcée** ou comme **double protection** doit être conforme aux exigences relatives à une **isolation renforcée** ou aux exigences relatives à la sécurité de la norme CEI décrites à l'Article G.16.

5.5.3.5 Relais

L'isolation des relais utilisés comme **protection renforcée** ou comme **double protection** doit être conforme aux exigences relatives à une **isolation renforcée** ou aux exigences relatives à la sécurité de la norme CEI telles que décrites à l'Article G.17.

5.5.3.6 Résistances

Des résistances peuvent être utilisées comme **protection renforcée** à condition qu'elles soient conformes aux exigences relatives aux **distances d'isolement dans l'air** et aux **lignes de fuite** applicables à une **isolation renforcée** entre leurs extrémités pour la **tension de service** totale à travers l'isolation.

Une **double isolation** ou une **isolation renforcée** peut être fournie par une résistance ou par un groupe de deux résistances ou plus en série dans les conditions suivantes:

- la résistance ou le groupe de résistances doit être conforme aux **distances d'isolement dans l'air** minimales décrites en 5.4.2; et
- les **lignes de fuite** minimales de 5.4.3 pour une **isolation renforcée**, applicables le cas échéant à la **tension de service** totale à travers la résistance ou le groupe. Pour un groupe de résistances, voir la Figure O.4.

Si une seule résistance est utilisée, elle doit satisfaire à l'essai de résistance décrit en G.14.2.

Si un groupe de résistances est utilisé, la **distance d'isolement dans l'air** et la **ligne de fuite** sont évaluées comme si chaque résistance était court-circuitée à son tour, à moins que le groupe ne satisfasse à l'essai de résistance de G.14.2.

5.5.4 Isolation entre le réseau d'alimentation et un circuit externe composé d'un câble coaxial

À l'exception des spécifications ci-dessous, l'isolation entre le **réseau d'alimentation** et la borne ou le fil fourni(e) pour la connexion à un câble coaxial, y compris la résistance mettant en parallèle cette isolation, le cas échéant, doit satisfaire soit:

- à l'essai de surtension décrit en G.14.3.2 pour l'équipement destiné à être connecté à un câble coaxial connecté à une antenne extérieure; ou
- à l'essai d'impulsion de G.14.3.3 pour l'équipement destiné à être connecté à un autre câble coaxial.

Si l'isolation et la résistance de mise en parallèle sont soumises aux surtensions provenant à la fois d'une antenne extérieure et d'un autre câble coaxial, elles doivent satisfaire aux essais de G.14.3.2 et G.14.3.3.

L'exigence ci-dessus ne s'applique ni à l'isolation ni à la résistance mettant en parallèle l'isolation, le cas échéant, dans l'un des équipements suivants.

- un équipement à usage intérieur, fourni avec une antenne (intégrée) encastrée et sans connexion à un câble coaxial; ou
- un équipement connecté à une terre fiable conformément à 5.6.8.3.

La conformité est vérifiée par examen et, si nécessaire, par l'essai de surtension décrit en G.14.3.2 ou l'essai d'impulsion de G.14.3.3 référencé en G.14.3.

NOTE Les **distances d'isolement dans l'air** sont déterminées par les exigences décrites en 5.4.2. Il peut se révéler nécessaire d'augmenter les **distances d'isolement dans l'air** entre le **réseau d'alimentation** et les circuits isolés du **réseau d'alimentation** destinés à être connectés à une antenne ou à un câble coaxial.

5.5.5 Composants et parties susceptibles de court-circuiter l'isolation

5.5.5.1 Exigence

Lorsqu'un composant ou une partie du composant peut court-circuiter l'isolation où la défaillance de cette isolation entraînerait l'accessibilité des sources d'énergie de classe 2 ou des sources d'énergie de classe 3, le composant ou la partie du composant doit résister à l'essai de l'Article T.2.

5.5.5.2 Conformité

*Aucun court-circuit ne doit se produire pendant l'essai. Après l'essai, aucune **protection de l'équipement** ne doit présenter de dysfonctionnement.*

5.6 Conducteur de protection

5.6.1 Exigences générales

Le présent paragraphe spécifie les exigences générales, de performances et de dimensions pour les **conducteurs de protection** qui servent de **protection principale**, de **protection supplémentaire** ou de **protection renforcée**.

Les **conducteurs de protection** et leurs extrémités ne doivent pas avoir de résistance excessive (voir 5.6.6.4).

L'intensité de courant admissible des **conducteurs de protection** doit être appropriée à la durée du courant de défaut dans les **conditions de premier défaut**.

Les **conducteurs de protection** ne doivent contenir aucun interrupteur et aucun dispositif de protection contre les surintensités.

Les **conducteurs de liaison de protection** doivent être tels que la déconnexion (par exemple, pour l'entretien) d'un **conducteur de protection** à un point dans une unité ou un système ne coupe pas la connexion de la liaison de protection avec d'autres parties ou unités dans un système, à moins que la déconnexion ne coupe également l'alimentation de cette partie ou unité en même temps.

Les **conducteurs de protection** doivent établir un contact plus tôt et une déconnexion plus tard que les connexions d'alimentation dans chacun des cas suivants:

- un connecteur (sur un câble) ou un connecteur lié à une partie ou à un sous-ensemble qui peut être retiré par une personne autre qu'une **personne qualifiée**;
- une fiche sur un câble d'alimentation;
- une prise d'appareil.

NOTE Il est recommandé que cette construction s'applique également lorsqu'il est attendu qu'une **personne qualifiée** remplace les parties et les ensembles alimentés alors que l'équipement est opérationnel.

Pour les **conducteurs de protection** supportant les courants faibles, seules les exigences de 5.6.3 et l'essai de 5.6.4 sont requises.

La conformité est vérifiée par examen et, si nécessaire, par des mesures.

5.6.2 Corrosion

Les parties conductrices en contact au niveau de la borne principale de mise à la terre de protection, des bornes de liaison de protection et des connexions doivent être choisies conformément à l'Annexe N de telle sorte que la différence de potentiel entre deux métaux différents est de 0,6 V ou moins.

La conformité est vérifiée par examen.

5.6.3 Couleur de l'isolation

L'isolation du **conducteur de mise à la terre de protection** doit être de couleur jaune/verte.

Si un **conducteur de liaison de protection** est isolé, l'isolation doit être de couleur jaune/verte à l'exception des deux cas suivants:

- pour une tresse de mise à la terre, l'isolation, le cas échéant, peut être transparente;
- un **conducteur de liaison de protection** dans des ensembles tels que des câbles en ruban, des barres omnibus, des câblages imprimés, etc., peut-être de n'importe quelle couleur à condition qu'il n'y ait aucun risque de mauvaise interprétation de l'utilisation du conducteur.

La conformité est vérifiée par examen.

5.6.4 Essai pour les conducteurs de protection supportant les courants faibles

*Pour une partie alimentée par un **circuit externe**, le courant d'essai représente 1,5 fois le courant maximal disponible à partir du **circuit externe** pendant une durée de 120 s.*

*Pour les parties connectées au **conducteur de liaison de protection** afin de limiter les transitoires ou de limiter le **courant de contact** avec un **circuit externe** et ne dépassant pas un niveau ES2 dans les **conditions de premier défaut**, l'essai est réalisé conformément à 5.6.6.4.2. La méthode d'essai appropriée et les critères soit de a), b), c) ou d) doivent s'appliquer sur la base de la source d'alimentation présumée.*

La conformité est vérifiée par la mesure de la baisse de tension ou de la résistance selon le cas, entre la borne principale de terre de protection et le point de l'équipement qui doit être mis à la terre.

5.6.5 Conducteurs de protection utilisés comme protection principale entre ES1 et ES2

5.6.5.1 Généralités

Le présent paragraphe spécifie les exigences générales, de performances et de dimensions pour les **conducteurs de protection** qui servent de **protection principale** entre ES1 et ES2.

5.6.5.2 Conducteurs de protection supportant les courants de défaut

5.6.5.2.1 Généralités

Le présent paragraphe spécifie l'application de **conducteurs de protection** qui servent de **protection principale** mais peuvent avoir à porter des courants de défaut.

5.6.5.2.2 Exigences

Des **conducteurs de protection** peuvent servir de **protections principales** entre ES1 et ES2:

- pour les parties conductrices **accessibles** ne dépassant pas un niveau ES2 pendant les **conditions de premier défaut**;
- pour maintenir l'intégrité des parties au niveau ES1 dans les **conditions normales de fonctionnement** à condition que les parties ne dépassent pas un niveau ES2 dans les **conditions de premier défaut**;
- pour maintenir l'intégrité des parties au niveau ES2 dans les **conditions normales de fonctionnement** à condition que les parties ne dépassent pas un niveau ES2 dans les **conditions de premier défaut**.

Les dimensions des **conducteurs de mise à la terre de protection** doivent être conformes à 5.6.6.2 et les **conducteurs de liaison de protection** à 5.6.6.3.

5.6.5.2.3 Conformité

*La conformité est vérifiée par examen et mesure des dimensions du **conducteur de mise à la terre de protection** et du **conducteur de liaison de protection** conformément à 5.6.6.2 ou 5.6.6.3 suivant le cas.*

5.6.6 Conducteurs de protection utilisés comme protection supplémentaire

5.6.6.1 Généralités

Les **conducteurs de protection** peuvent servir de **protection supplémentaire**:

- pour les parties susceptibles autrement de présenter un niveau ES3 dans les **conditions de premier défaut** (si une **protection supplémentaire** n'était pas prévue), ou
- pour limiter les tensions transitoires susceptibles d'altérer une **isolation principale** pour les parties qui ne peuvent pas dépasser un niveau ES2 dans les **conditions de premier défaut**, ou

– pour limiter le **courant de contact** à un **circuit externe**.

5.6.6.2 Dimensions des conducteurs de mise à la terre de protection et des bornes

Les **conducteurs de mise à la terre de protection** doivent être conformes aux dimensions minimales des conducteurs indiquées dans le Tableau 34.

Les bornes utilisées dans une connexion d'un **conducteur de mise à la terre de protection** doivent être conformes aux dimensions minimales des conducteurs indiquées dans le Tableau 36.

La conformité est vérifiée par examen et mesure des dimensions du **conducteur de liaison de protection** conformément au Tableau 34 et des dimensions de borne dans le Tableau 36, suivant le cas.

Tableau 34 – Dimensions des conducteurs

Courant d'équipement assigné A jusqu'à et y compris	Dimensions minimales des conducteurs	
	Section nominale mm ²	AWG [section en mm ²] voir NOTE 2
6	0,75 ^a	18 [0,8]
10	1,00 (0,75) ^b	16 [1,3]
16	1,50 (1,0) ^c	14 [2]
25	2,5	12 [3]
32	4	10 [5]
40	6	8 [8]
63	10	6 [13]
80	16	4 [21]
100	25	2 [33]
125	35	1 [42]
160	50	0 [53]
190	70	000 [85]
230	95	0000 [107]
		kcmil [section en mm²] voir NOTE 2
260	120	250 [126]
300	150	300 [152]
340	185	400 [202]
400	240	500 [253]
460	300	600 [304]

NOTE 1 La CEI 60320-1 spécifie les combinaisons acceptables des connecteurs d'appareil et des câbles souples, y compris les câbles concernés par les conditions a, b et c. Cependant, certains pays ont précisé qu'ils n'acceptaient pas toutes les valeurs indiquées dans le Tableau 34, en particulier les valeurs concernées par les conditions a, b et c.

NOTE 2 Les dimensions AWG et kcmil sont données à titre informatif uniquement. Les sections concernées, entre crochets, ont été arrondies uniquement pour présenter des chiffres significatifs. AWG signifie American Wire Gauge et le terme « c mil » fait référence aux mils circulaires pour un mil circulaire équivalent à la zone d'un cercle ayant un diamètre d'un mil (un millième de pouce). Ces termes sont communément utilisés pour désigner les dimensions des câbles en Amérique du Nord.

NOTE 3 Pour les courants plus élevés, voir la série CEI 60364.

Tableau 34 (suite)

^a	Pour un courant assigné jusqu'à 3 A, une section nominale de 0,5 mm ² peut être utilisée dans certains pays à condition que la longueur du câble ne dépasse pas 2 m.
^b	La valeur entre parenthèses s'applique aux câbles d'alimentation non fixés à demeure munis de connecteurs de courant assigné de 10 A, conformément à la CEI 60320-1 (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 aux câbles d'alimentation non fixés à demeure munis de connecteurs de courant assigné de 16 A, conformément à la CEI 60320-1 (types C19, C21 et C23) à condition que la longueur du câble ne dépasse pas 2 m.

5.6.6.3 Dimensions des conducteurs de liaison de protection et des bornes

Les **conducteurs de liaison de protection** et leurs bornes doivent être conformes à l'une des exigences suivantes:

- les dimensions minimales des conducteurs indiquées dans le Tableau 34 et les dimensions de bornes indiquées dans le Tableau 36; ou
- les exigences décrites en 5.6.6.4 ainsi que, si la **valeur assignée du courant de protection** du circuit est supérieure à 16 A, les dimensions minimales des conducteurs indiquées dans le Tableau 35 et les dimensions des bornes dont les valeurs minimales correspondent aux premières dimensions inférieures à celles indiquées dans le Tableau 36; ou
- les exigences décrites en 5.6.6.4 ainsi que, si la **valeur assignée du courant de protection** du circuit ne dépasse pas 16 A; soit
 - les dimensions minimales des conducteurs indiquées dans le Tableau 35 et les dimensions des bornes dont les valeurs minimales correspondent aux premières dimensions inférieures à celles indiquées dans le Tableau 36; soit
 - l'essai de court-circuit limité décrit à l'Annexe R;
- pour les composants uniquement, être supérieur aux conducteurs alimentant le composant.

NOTE 1 La **valeur assignée du courant de protection** (ci-dessus) est utilisée dans le Tableau 35 et dans l'essai décrit en 5.4.5.2.

Lorsque la source est le **réseau d'alimentation**, la **valeur assignée du courant de protection** du circuit est la valeur assignée du dispositif de protection contre les surintensités intégré, ou faisant partie de l'équipement. Lorsque le dispositif de protection contre les surintensités est ainsi fourni, alors:

- pour un **équipement enfichable de type A**, la **valeur assignée du courant de protection** est la valeur assignée d'un dispositif de protection contre les surintensités fourni comme élément externe à l'équipement (par exemple, dans le câblage du bâtiment, dans la fiche de raccordement au **réseau d'alimentation** ou dans un casier de l'équipement) pour protéger l'équipement, avec un courant minimal de 16 A;

NOTE 2 Dans la majorité des pays, 16 A est considéré comme une valeur appropriée pour la **valeur assignée du courant de protection** du circuit.

NOTE 3 Au Canada et aux Etats-Unis, la **valeur assignée du courant de protection** du circuit est prise égale à 20 A.

NOTE 4 Au Royaume-Uni et en Irlande, la **valeur assignée du courant de protection** est prise égale à 13 A, cette valeur étant la valeur assignée la plus importante du fusible utilisé dans la fiche de raccordement au **réseau d'alimentation**.

- pour un **équipement enfichable de type B**, et un **équipement relié en permanence**, la **valeur assignée du courant de protection** est la valeur assignée maximale du dispositif de protection contre les surintensités spécifiée dans les instructions d'installation de l'équipement qui doit être fourni comme élément externe à l'équipement.

Lorsque la source est une alimentation externe présentant le courant maximal limité naturellement par l'impédance de la source interne (comme un transformateur protégé par impédance), la **valeur assignée du courant de protection** du circuit est le courant le plus

élevé disponible à partir de cette alimentation dans une charge. Lorsque le courant maximal de la source d'alimentation externe est limité par des composants électroniques dans la source, la **valeur assignée du courant de protection** doit être considérée comme le courant de sortie maximal avec une charge résistive, y compris un court-circuit mesuré 60 s après l'application de la charge si le courant est limité par impédance ou si le dispositif de limitation du courant est un fusible, un disjoncteur ou un dispositif à coefficient positif de température, ou 5 s dans les autres cas.

Le dispositif de limitation du courant ou le dispositif de protection contre les surintensités (un fusible, un disjoncteur ou un dispositif à coefficient positif de température) ne doit pas être connecté en parallèle avec un autre composant susceptible d'entraîner une défaillance à un état de faible résistance.

Lorsque la source est un circuit à l'intérieur de l'équipement, la **valeur assignée du courant de protection** du circuit est:

- la caractéristique assignée du dispositif de protection contre les surintensités si le courant est limité par un dispositif de protection contre les surintensités; ou
- le courant de sortie maximal, si le courant est limité par l'impédance de la source de l'alimentation. Le courant de sortie est mesuré avec une charge résistive, y compris un court-circuit mesuré 60 s après l'application de la charge si le courant est limité par impédance ou si le dispositif de limitation du courant est un fusible, un disjoncteur ou un dispositif à coefficient positif de température, ou 5 s dans les autres cas.

Le dispositif de limitation du courant ou le dispositif de protection contre les surintensités (un fusible, un disjoncteur ou un dispositif à coefficient positif de température) ne doit pas être connecté en parallèle avec un autre composant susceptible d'entraîner une défaillance à un état de faible résistance.

Tableau 35 – Dimensions minimales du conducteur de liaison de protection des conducteurs en cuivre

Valeur assignée du courant de protection du circuit considéré A jusqu'à et y compris	Dimensions minimales des conducteurs	
	Section mm ²	AWG ou kcmil [section en mm ²]
6	0,5	20 [0,519]
10	0,75	18 [0,8]
13	1,0	16 [1,3]
16	1,25	16 [1,3]
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	3 [33]
160	35	1 [42]
190	50	0 [53]
230	70	000 [85]
260	95	0000 [107]
		kcmil [section en mm²]
300	120	250 [126]
340	150	300 [152]
400	185	400 [202]
460	240	500 [253]

NOTE Les dimensions AWG et kcmil sont données à titre informatif uniquement. Les sections concernées ont été arrondies uniquement pour indiquer des chiffres significatifs. AWG signifie American Wire Gauge et le terme « cmil » fait référence aux mils circulaires pour un mil circulaire égal à (diamètre en mils)². Ces termes sont communément utilisés pour désigner les dimensions des câbles en Amérique du Nord.

La conformité est vérifiée par examen et mesure des dimensions du **conducteur de liaison de protection** et des dimensions de bornes.

5.6.6.4 Résistance des conducteurs de protection et de leurs extrémités

5.6.6.4.1 Exigences

Les **conducteurs de protection** et leurs extrémités ne doivent pas avoir de résistance excessive. Les **conducteurs de protection** qui répondent aux dimensions minimales de conducteurs du Tableau 34 dans leur longueur et dont les bornes répondent toutes aux dimensions minimales du Tableau 36 sont considérés comme conformes, sans essai.

Tableau 36 – Dimensions des bornes pour les conducteurs de protection

Courant assigné A jusqu'à et y compris	Dimension de conducteur mm ² (indiquée dans le Tableau 34)	Diamètre de filetage nominal minimal mm		Section mm ²	
		Type pilier ou à tige	Type à vis ^a	Type pilier ou à tige	Type à vis ^a
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	6,0	6,0	28	28
80	16	7,9	7,9	49	49

^a "Type à vis" désigne une borne qui fixe le conducteur sous la tête d'une vis, avec ou sans rondelle.

Pour les **courants assignés** supérieurs à 80 A, le **conducteur de mise à la terre de protection** doit être fixé à des connecteurs spéciaux ou à des moyens de serrage adaptés (par exemple, une fourche renversée ou une pression en boucle fermée; un organe de serrage; un organe de serrage à selle serre-fils, un organe de serrage à capot taraudé; etc.) qui sont fixés par une vis et un mécanisme d'écrou au châssis en métal de l'équipement. La somme des sections transversales de la vis et de l'écrou ne doit pas être inférieure à trois fois la section transversale de la dimension du conducteur du Tableau 34 ou 35 suivant le cas.

Les bornes doivent être conformes à la CEI 60998-1 et CEI 60999-1 ou CEI 60999-2.

5.6.6.4.2 Conformité et méthode d'essai

Le présent paragraphe stipule les exigences d'essai pour les **conducteurs de liaison de protection** qui ne sont pas conformes aux exigences de dimension des Tableaux 34 et 36.

La conformité est vérifiée par examen, mesures et, pour les **conducteurs de liaison de protection** qui ne répondent pas aux dimensions minimales de conducteurs du Tableau 34, par leur longueur ou ceux dont les bornes ne répondent pas toutes aux dimensions minimales du Tableau 36, par l'essai suivant.

La baisse de tension dans un **conducteur de liaison de protection** est mesurée après la conduction du courant d'essai pendant la période spécifiée ci-dessous. Le courant d'essai peut être alternatif ou continu et la tension d'essai ne doit pas dépasser 12 V. Les mesures sont réalisées entre la borne principale de mise à la terre et le point de l'équipement qui doit être mis à la terre. La résistance du **conducteur de mise à la terre de protection** n'est pas incluse dans les mesures. Cependant, si le **conducteur de mise à la terre de protection** est fourni avec l'équipement, il peut être inclus dans le circuit d'essai mais les mesures de baisse de tension sont réalisées uniquement depuis la borne principale de mise à la terre vers la partie qui doit être mise à la terre.

Sur les équipements où la connexion de terre de protection à un sous-ensemble ou à un organe séparé s'effectue au moyen d'un câble unipolaire ou multipolaire qui alimente également le sous-ensemble ou l'organe, la résistance du **conducteur de liaison de protection** dans ce câble n'est pas incluse dans cette mesure. Cependant, cette option ne peut être utilisée que si le câble est protégé par un dispositif de protection assigné adapté qui prend en compte la dimension du conducteur.

Il y a lieu de s'assurer que la résistance de contact entre l'extrémité de la sonde d'essai et la partie conductrice à l'essai n'influence pas les résultats de l'essai.

Le courant d'essai, la durée de l'essai et les résultats de l'essai sont les suivants:

- a) Pour les équipements alimentés par le **réseau d'alimentation**, si la **valeur assignée du courant de protection** du circuit soumis à l'essai est inférieure ou égale à 16 A, le courant d'essai correspond à 200 % de la **valeur assignée du courant de protection** appliquée pendant 120 s.

La résistance du **conducteur de liaison de protection**, calculée depuis la baisse de tension, ne doit pas dépasser 0,1 Ω . Après l'essai, le **conducteur de liaison de protection** ne doit pas être endommagé.

- b) Pour les équipements alimentés par le **réseau d'alimentation**, si la **valeur assignée du courant de protection** du circuit soumis à l'essai dépasse 16 A, le courant d'essai correspond à 200 % de la **valeur assignée du courant de protection** ou est de 500 A, selon la plus petite valeur, et la durée de l'essai est telle qu'indiquée dans le Tableau 37.

Tableau 37 – Durée de l'essai, équipements connectés au réseau d'alimentation

Valeur assignée du courant de protection du circuit A jusqu'à et y compris	Durée de l'essai min
30	2
60	4
100	6
200	8
supérieure à 200	10

La baisse de tension dans le **conducteur de liaison de protection** pour des courants d'essai jusqu'à 500 A ne doit pas dépasser 2,5 V. Pour les équipements nécessitant des fusibles de circuit de dérivation d'un courant supérieur à 250 A, la baisse de tension potentielle mesurée multipliée par le nombre de fusibles requis et divisée par 250 ne doit pas dépasser 2,5 V. Après l'essai, le **conducteur de liaison de protection** ne doit pas être endommagé.

- c) Une autre possibilité que b) ci-dessus consiste à fonder les essais sur les caractéristiques temps-courant du dispositif de protection contre les surintensités qui limite le courant de défaut dans le **conducteur de liaison de protection**. Ce dispositif est soit fourni par l'équipement soumis à essai, soit spécifié dans les instructions d'installation à l'extérieur de l'équipement. Les essais sont réalisés à 200 % de la **valeur assignée du courant de protection**, pour la durée correspondant à 200 % des caractéristiques temps-courant. Si la durée de 200 % n'est pas indiquée, on peut utiliser le point le plus près des caractéristiques temps-courant.

La baisse de tension dans le **conducteur de liaison de protection** ne doit pas dépasser 2,5 V. Après l'essai, le **conducteur de liaison de protection** ne doit pas être endommagé.

- d) Pour les équipements alimentés par un système d'alimentation en courant continu, si la **valeur assignée du courant de protection** du circuit soumis à l'essai dépasse 16 A, le courant d'essai et la durée sont tels que spécifiés par le fabricant.

La baisse de tension dans le **conducteur de liaison de protection** ne doit pas dépasser 2,5 V. Après l'essai, le **conducteur de liaison de protection** ne doit pas être endommagé.

5.6.7 Conducteurs de mise à la terre de protection servant de double protection ou de protection renforcée

5.6.7.1 Généralités

Le présent paragraphe spécifie les exigences pour les **conducteurs de mise à la terre de protection** améliorés et leurs extrémités (par exemple, lorsque le **courant de contact** dépasse les limites ES2 du Tableau 4, voir aussi 5.7.6).

Les **conducteurs de protection** servant de **double protection** ou de **protection renforcée** doivent être conformes aux exigences applicables de 5.6.1, 5.6.3 et 5.6.6.

5.6.7.2 Exigences relatives aux conducteurs de mise à la terre de protection servant de protection renforcée

Un **conducteur de mise à la terre de protection** servant de **protection renforcée** peut être employé sur un **équipement enfichable de type B** ou sur un **équipement relié en permanence** uniquement et doit:

- être inclus dans et protégé par un câble d'alimentation gainé pas plus léger que les cordons renforcés:
 - être un câble souple gainé en PVC conformément à la CEI 60227-1 (désignations 60227; IEC 52 ou CEI 53) ou
 - être un câble souple gainé en caoutchouc conformément à la CEI 60245-1 (désignations 60245; IEC 53, CEI 57 ou CEI 58);
- ou
- avoir une dimension de conducteur minimale supérieure à 10 mm^2 (pour résister aux dommages mécaniques); ou
- être protégé par un conduit et avoir une dimension minimale conforme au Tableau 38.

NOTE Pour les câbles d'alimentation du **réseau d'alimentation**, voir aussi l'Article G.9.

Tableau 38 – Dimension des conducteurs de mise à la terre de protection des protections renforcées pour les équipements reliés en permanence

Protection assurée par	Dimension minimale de conducteur de mise à la terre de protection mm^2
Conduit souple non métallique	4 ^a
Conduit souple métallique	2,5 ^a
Conduit métallique non flexible	1,5 ^a
^a Le conducteur de mise à la terre de protection est installé par une personne qualifiée .	

5.6.7.3 Exigences relatives aux extrémités

Les extrémités doivent avoir une solidité fiable et doivent être conformes au Tableau 36.

5.6.7.4 Conformité

La conformité est vérifiée par examen et par des mesures.

5.6.8 Mise à la terre fiable

5.6.8.1 Généralités

Le présent paragraphe spécifie les situations où la connexion à la terre des équipements est considérée comme fiable (par exemple, lorsqu'un SPD est fourni conformément à 5.5.2.8).

5.6.8.2 Mise à la terre fiable pour protection

Pour les équipements connectés au **réseau d'alimentation** et connectés aux **circuits externes** indiqués dans le Tableau 16, numéros d'identification 11, 12, 13, 14, 15, 16 et 17, la mise à la terre est considérée comme fiable pour les éléments suivants:

- les **équipements reliés en permanence**; ou
- un **équipement enfichable de type B**; ou
- les **équipements enfichables de type A stationnaires** qui sont conçus pour être utilisés en un emplacement ayant une liaison équipotentielle (telle qu'un centre de télécommunications, une salle d'ordinateurs dédiée ou une **zone à accès limité**) et dont les instructions d'installation exigent une vérification de la **connexion de terre de protection** du socle de prise de courant par une **personne qualifiée**; ou
- les **équipements enfichables de type A stationnaires** destinés à être utilisés avec un **conducteur de mise à la terre de protection** relié en permanence, y compris les instructions d'installation de ce conducteur pour la mise à la terre par une **personne qualifiée**.

5.6.8.3 Mise à la terre fiable lorsque la protection principale entre ES1 et ES2 est assurée par la mise à la terre de ES1

Pour les équipements connectés à un **circuit externe**, tel qu'indiqué dans le Tableau 16, numéros d'identification 11, 12, 13, 14, 15, 16 et 17, la mise à la terre est considérée comme fiable pour les éléments suivants:

- les **équipements reliés en permanence**; ou
- les **équipements enfichables de type A** et les **équipements enfichables de type B** destinés à être utilisés avec un **conducteur de mise à la terre de protection** relié en permanence, y compris les instructions d'installation de ce conducteur pour la mise à la terre par une **personne qualifiée**.

5.7 Tension de contact présumée, courant de contact et courant du conducteur de protection

5.7.1 Généralités

Le présent paragraphe spécifie l'environnement d'essai de l'équipement, la configuration de l'équipement, la mise à la terre de l'équipement, les connexions du système d'alimentation de l'équipement et les procédés de mesure de la **tension de contact présumée**, du **courant de contact** et du **courant du conducteur de protection**.

5.7.2 Dispositifs de mesure et réseaux

Pour les mesures de **courant de contact**, l'instrument utilisé pour mesurer U_2 et U_3 , spécifié dans les Figures 4 et 5 respectivement de la CEI 60990:1999, doit indiquer la tension de crête. Si la forme d'onde du **courant de contact** est sinusoïdale, on peut utiliser un instrument indiquant la valeur efficace.

NOTE 1 Il convient que l'effet de l'impédance de l'instrument sur la tension mesurée soit négligeable.

NOTE 2 De nombreux instruments de **courant de contact** vendus dans le commerce assurent une lecture directe de la valeur efficace pondérée du courant, ne nécessitant ainsi pas le calcul de la tension au courant. Certains instruments de **courant de contact** vendus dans le commerce assurent aussi une lecture directe de la valeur de crête du courant pondéré.

5.7.3 Réglage de l'équipement, connexions d'alimentation et connexions de mise à la terre

Le réglage de l'équipement, les connexions d'alimentation de l'équipement et la mise à la terre de l'équipement doivent être conformes aux Articles 4, 5.3 et 5.4 de la CEI 60990:1999.

Les équipements pourvus d'une connexion à la terre indépendante du **conducteur de protection** doivent être soumis à essai avec cette connexion déconnectée.

Les mesures des systèmes d'équipements interconnectés avec des connexions indépendantes raccordées au **réseau d'alimentation** doivent être effectuées sur chaque équipement séparément.

Les systèmes d'équipements interconnectés avec une seule connexion au **réseau d'alimentation** doivent être soumis à essai comme un seul équipement.

NOTE Les systèmes d'équipements interconnectés sont spécifiés plus en détail dans l'Annexe A de la CEI 60990:1999.

L'essai des équipements conçus pour avoir des connexions multiples au **réseau d'alimentation**, où une seule connexion à la fois est nécessaire, doit être effectué sur chacune des connexions tandis que les autres connexions sont déconnectées.

L'essai des équipements conçus pour avoir des connexions multiples au **réseau d'alimentation**, où plus d'une connexion est nécessaire, doit être effectué sur chacune des connexions tandis que les autres connexions sont connectées, avec les **conducteurs de mise à la terre de protection** connectés entre eux. Si le **courant de contact** dépasse la limite spécifiée en 5.2.2.2, le **courant de contact** doit être mesuré individuellement.

5.7.4 Parties conductrices non mises à la terre et accessibles

5.7.4.1 Parties conductrices non mises à la terre et accessibles aux personnes ordinaires

Toutes les parties conductrices non mises à la terre et **accessibles** aux **personnes ordinaires** doivent d'abord être soumises à essai pour la **tension de contact présumée** par rapport à la terre et à d'autres parties conductrices non mises à la terre et **accessibles** aux **personnes ordinaires**.

Si la **tension de contact présumée** dépasse les limites de ES1 spécifiées en 5.2.2.2, ces parties doivent être soumises à essai pour le **courant de contact** conformément à 5.1.1 et 6.2.1 de la CEI 60990:1999. Le **courant de contact** ne doit pas dépasser les limites de ES1 spécifiées en 5.2.2.2.

Si la **tension de contact présumée** ou le **courant de contact** ne dépasse pas les limites de ES1 spécifiées en 5.2.2.2, la partie doit alors être également soumise à essai pour la **tension de contact présumée**

- suivant le défaut simulé ou réel de la **protection principale** applicable, et
- suivant le défaut simulé ou réel de la **protection supplémentaire** applicable.

Les défauts de **protection** sont introduits un par un; la **protection principale** et la **protection supplémentaire** ne sont pas mises en défaut en même temps.

Si la **tension de contact présumée** ne dépasse pas les limites de ES2 spécifiées en 5.2.2.2, l'essai est terminé.

Si la **tension de contact présumée** dépasse les limites de ES2 spécifiées en 5.2.2.2, ces parties doivent être soumises à essai pour le **courant de contact** conformément à 6.2.2 de la

CEI 60990:1999, à l'exception de 6.2.2.7. Le **courant de contact** ne doit pas dépasser les limites de ES2 spécifiées en 5.2.2.2.

NOTE 1 Pour les parties connectées à un point commun, seule une de ces parties nécessite d'être soumise à essai.

NOTE 2 Si les parties non mises à la terre **accessibles** sont isolées du **réseau d'alimentation** afin que les conditions de défaut spécifiées en 6.2.2 de la CEI 60990:1999 n'altèrent pas la **tension de contact présumée** ou le **courant de contact**, il n'est alors pas nécessaire de réaliser les essais de conditions de défaut.

5.7.4.2 Parties conductrices non mises à la terre et accessibles uniquement aux personnes averties

Toutes les parties conductrices non mises à la terre et **accessibles** uniquement aux personnes averties doivent d'abord être soumises à essai pour la **tension de contact présumée** par rapport à la terre et à d'autres parties conductrices non mises à la terre et **accessibles** aux personnes averties.

Si la **tension de contact présumée** ne dépasse pas les limites de ES2 spécifiées en 5.2.2.2, l'essai est terminé.

Si la **tension de contact présumée** dépasse les limites de ES2 spécifiées en 5.2.2.2, ces parties doivent être soumises à essai pour le **courant de contact** conformément à 5.1.2 et 6.2.2 de la CEI 60990:1999, à l'exception de 6.2.2.7. Le **courant de contact** ne doit pas dépasser les limites de ES2 spécifiées en 5.2.2.2.

NOTE Pour les parties connectées à un point commun, seule une de ces parties nécessite d'être soumise à essai.

5.7.5 Parties conductrices mises à la terre et accessibles

Au moins une partie conductrice mise à la terre et **accessible** doit être soumise à essai pour le **courant de contact** suivant les défauts de connexion d'alimentation conformément à 6.1 et 6.2.2 de la CEI 60990:1999, à l'exception de 6.2.2.7. A l'exception de ce qui est permis en 5.7.6, le **courant de contact** ne doit pas dépasser les limites de ES2 spécifiées en 5.2.2.2.

Le Paragraphe 6.2.2.2 de la CEI 60990:1999 ne s'applique pas aux équipements munis d'un interrupteur ou d'un autre **dispositif de déconnexion** qui déconnecte tous les pôles de l'alimentation.

NOTE Une prise d'appareil est un exemple de **dispositif de déconnexion**.

5.7.6 Courant de conducteur de protection

Le **courant de conducteur de protection** doit être mesuré conformément à l'Article 8 de la CEI 60990:1999.

A l'exception de ce qui est stipulé ci-dessous, le **courant de conducteur de protection** ne doit pas dépasser les limites de ES2 spécifiées en 5.2.2.2.

Si le **courant de conducteur de protection** dépasse les limites de ES2 spécifiées en 5.2.2.2, le courant ne doit pas dépasser 5 % du courant mesuré en entrée et la construction du circuit de **conducteur de protection** et ses connexions doivent comprendre une **protection renforcée** (voir 5.6.7.2).

Le courant en entrée est mesuré dans les mêmes conditions que le **courant de contact**.

Lorsque le **courant de conducteur de protection** dépasse les limites de ES2 du Tableau 4, une **protection mise en place sous forme d'instructions** doit être apposée à l'équipement adjacent à la connexion d'alimentation de l'équipement, conformément à l'Article F.5. La **protection mise en place sous forme d'instructions** doit indiquer un **courant de contact** élevé et doit nécessiter une connexion du **conducteur de protection** préalable à une connexion de la tension d'alimentation avec le libellé suivant ou équivalent:

ATTENTION

Courant de contact élevé.
Connecter à la terre avant de connecter à l'alimentation.

5.7.7 Tension de contact présumée et courant de contact causés par des circuits externes

Pour les **circuits externes** connectés à un câble coaxial, le fabricant doit fournir des instructions pour connecter le blindage du câble coaxial à la terre conformément à 6.2 g) et 6.2 l) de la CEI 60728-11:2005.

NOTE Pour la Norvège et la Suède, voir la NOTE 1 du Tableau 16.

5.7.8 Somme des courants de contact provenant de circuits externes

Le présent paragraphe détermine la nécessité d'un **conducteur de mise à la terre de protection** relié en permanence pour l'**équipement enfichable de type A** ou l'**équipement enfichable de type B**, si la connexion du **réseau d'alimentation** venait à être interrompue.

Le présent paragraphe s'applique uniquement aux équipements avec des **circuits externes** comme indiqué dans le Tableau 16, numéros d'identification 11, 12, 13, 14, 15, 16 et 17.

NOTE Ces types de **circuits externes** sont généralement des réseaux de télécommunication.

La somme des **courants de contact** des équipements qui alimentent les **circuits externes** multiples ne doit pas dépasser les limites de ES2 (voir Tableau 4).

Dans le présent paragraphe, les abréviations suivantes sont utilisées:

- I_1 : **courant de contact** reçu d'autres équipements via un réseau à un **circuit externe** des équipements;
- $S(I_1)$: somme des **courants de contact** reçus d'autres équipements à l'ensemble de ces **circuits externes** des équipements;
- I_2 : **courant de contact** créé par le **réseau d'alimentation** de l'équipement.

Il doit être supposé que chaque **circuit externe** reçoit 0,25 mA (I_1) de l'autre équipement, à moins que l'on sache que le courant réel de l'autre équipement est plus faible.

Les exigences suivantes, a) ou b) suivant le cas, doivent être satisfaites:

a) Les équipements avec un **circuit externe** mis à la terre

Pour les équipements dans lesquels chaque **circuit externe** est connecté à une borne pour le **conducteur de mise à la terre de protection** de l'équipement, les éléments suivants 1) et 2) doivent être pris en compte:

1) Si $S(I_1)$ (à l'exclusion de I_2) dépasse les limites de ES2 du Tableau 4:

- l'équipement doit être pourvu d'une connexion permanente à la terre de protection en plus du **conducteur de mise à la terre de protection** dans le cordon

d'alimentation de l'**équipement enfichable de type A** ou de l'**équipement enfichable de type B**; et

- les instructions d'installation doivent spécifier l'installation d'une connexion permanente à la terre de protection avec une section d'au moins 2,5 mm² en cas de protection mécanique ou à défaut 4,0 mm²; et
- fournir un marquage conforme à 5.7.6 et à l'Article F.3.

2) Ce type d'équipement doit être conforme à 5.7.6. La valeur de I_2 doit être utilisée pour calculer la limite de courant en entrée de 5 % par phase spécifiée en 5.7.6.

La conformité avec le point a) est vérifiée par examen et, si nécessaire, par essai.

Si l'équipement est pourvu d'une connexion de terre de protection permanente conformément au point 1) ci-dessus, il n'est pas nécessaire d'effectuer des mesures, sauf que I_2 doit être conforme aux exigences pertinentes de 5.7.

*Les essais de **courant de contact**, si nécessaire, sont réalisés en utilisant l'instrument de mesure adapté décrit dans la CEI 60990:1999, à la Figure 4, ou tout autre instrument donnant les mêmes résultats. Une source de courant alternatif couplée capacitivement de la même phase et fréquence de lignes que le **réseau d'alimentation** en courant alternatif est appliquée à chaque **circuit externe** de manière à ce que 0,25 mA, ou le courant réel d'un autre équipement, si on sait qu'il est plus faible, soit disponible pour circuler au sein de ce **circuit externe**. Le courant circulant dans le conducteur de terre est alors mesuré.*

b) Les équipements dont le **circuit externe** n'a pas de référence à la terre de protection

Si chaque **circuit externe** n'a pas de connexion commune, le **courant de contact** pour chaque **circuit externe** ne doit pas dépasser les limites de ES2 du Tableau 4.

Si tous les **circuits externes** ou les groupes de ces ports ont une connexion commune, le **courant de contact** total de chaque connexion commune ne doit pas dépasser les limites de ES2 du Tableau 4.

La conformité avec le point b) est vérifiée par examen et s'il y a des points de connexion communs, par l'essai suivant.

*Une source de courant alternatif couplée capacitivement de la même phase et fréquence de lignes que le **réseau d'alimentation** en courant alternatif est appliquée à chaque **circuit externe** de manière à ce que 0,25 mA, ou le courant réel de l'autre équipement si on sait qu'il est plus faible, soit disponible pour circuler au sein de ce **circuit externe**. Les points de connexion commune sont soumis à essai conformément à 5.7.3, que les points soient **accessibles** ou non.*

6 Incendie d'origine électrique

6.1 Généralités

Le présent paragraphe spécifie des **protections** visant à réduire la probabilité de blessures ou de dommages matériels résultant d'un incendie d'origine électrique survenant dans l'équipement.

6.2 Classification des sources de puissance (PS) et des sources potentielles d'incendie (PIS)

6.2.1 Généralités

Le présent paragraphe décrit la manière de classer les différentes sources de puissance et les **sources potentielles d'incendie (PIS – potential ignition source)** pouvant exister dans l'équipement.

Les sources de chaleur électriques peuvent être classifiées en niveaux de puissance disponibles PS1, PS2 et PS3 (voir 6.2.2.4, 6.2.2.5 et 6.2.2.6) pouvant causer le chauffage résistif des composants et des connexions. Ces sources d'alimentation sont basées sur l'énergie disponible d'un circuit.

Dans une source de puissance, une **PIS (source potentielle d'incendie)** peut survenir à cause d'un arc électrique au niveau de connexions rompues ou de l'ouverture des contacts (**source potentielle d'incendie causé par la formation d'un arc électrique**) ou à cause de composants dissipant plus de 15 W (**source potentielle d'incendie causé par un phénomène de résistivité**).

Selon la classification de la source de puissance de chaque circuit, une ou plusieurs **protections** sont nécessaires, soit pour réduire la probabilité d'inflammation, soit pour réduire la probabilité de propagation du feu au-delà de l'équipement.

6.2.2 Classifications du circuit de source de puissance

6.2.2.1 Généralités

Un circuit électrique est classifié PS1, PS2 ou PS3, selon la puissance électrique disponible pour le circuit depuis la source de puissance

NOTE Une source de puissance peut être une source d'alimentation identifiée et ses circuits de charge associés ou un circuit fonctionnel servant de source de puissance à un autre circuit.

La classification de la source de puissance électrique doit correspondre à la puissance maximale mesurée dans chacune des conditions suivantes:

- pour les circuits de charge: une source de puissance dans les **conditions normales de fonctionnement** comme spécifié par le fabricant dans le cas de défaut le plus défavorable du circuit de charge (voir 6.2.2.2);
- pour les circuits de source de puissance: le cas de défaut le plus défavorable de la source de puissance dans le circuit de charge normale spécifié (voir 6.2.2.3).

La puissance est mesurée aux points X et Y dans les Figures 38 et 39.

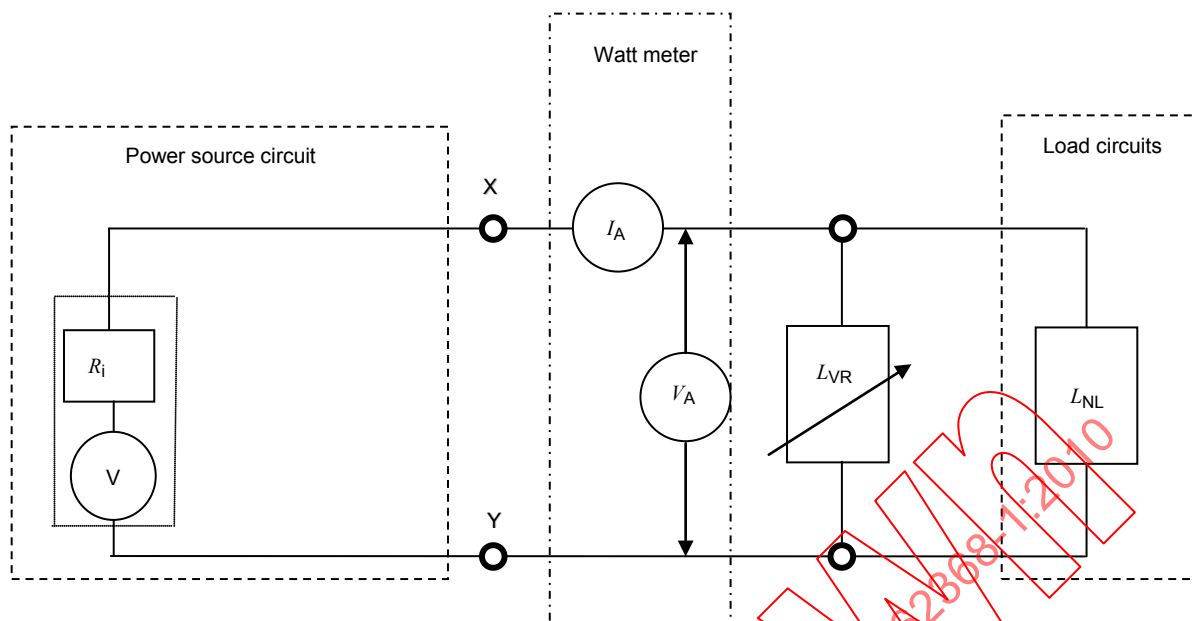
6.2.2.2 Mesure de la puissance pour le cas de défaut de charge le plus défavorable

Avec référence à la Figure 38:

- la mesure peut être réalisée sans le circuit de charge L_{NL} connecté, à moins que la puissance maximale ne dépende de la connexion de la charge;
- aux points X et Y, insérer un wattmètre (ou un voltmètre, V_A et un ampèremètre, I_A);
- connecter une résistance variable, L_{VR} comme indiqué;
- ajuster la résistance variable, L_{VR} , à la puissance maximale. Mesurer la puissance maximale et classifier la source de puissance conformément à 6.2.2.4, 6.2.2.5 ou 6.2.2.6.

Si un dispositif ou un circuit de protection contre les surintensités fonctionne lors de l'essai, la mesure doit être répétée au point juste en dessous du courant de déclenchement.

NOTE Lors de l'évaluation des accessoires connectés via les câbles de l'équipement, l'impédance du câble peut être prise en compte pour déterminer la PS1 ou PS2 côté accessoire.



Légende

Anglais	Français
Wattmeter	Wattmètre
Power source circuit	Circuit de la source de puissance
Load circuits	Circuits de charge

Légende

- V source de tension
- R_i résistance interne de la source de puissance
- I_A courant de la source de puissance
- V_A tension aux points où l'énergie de la source de puissance est déterminée
- L_{VR} charge de résistance variable
- L_{NL} charge normale

Figure 38 – Mesure de la puissance dans le cas de défaut de charge le plus défavorable

6.2.2.3 Mesure de la puissance dans le cas de défaut de la source de puissance le plus défavorable

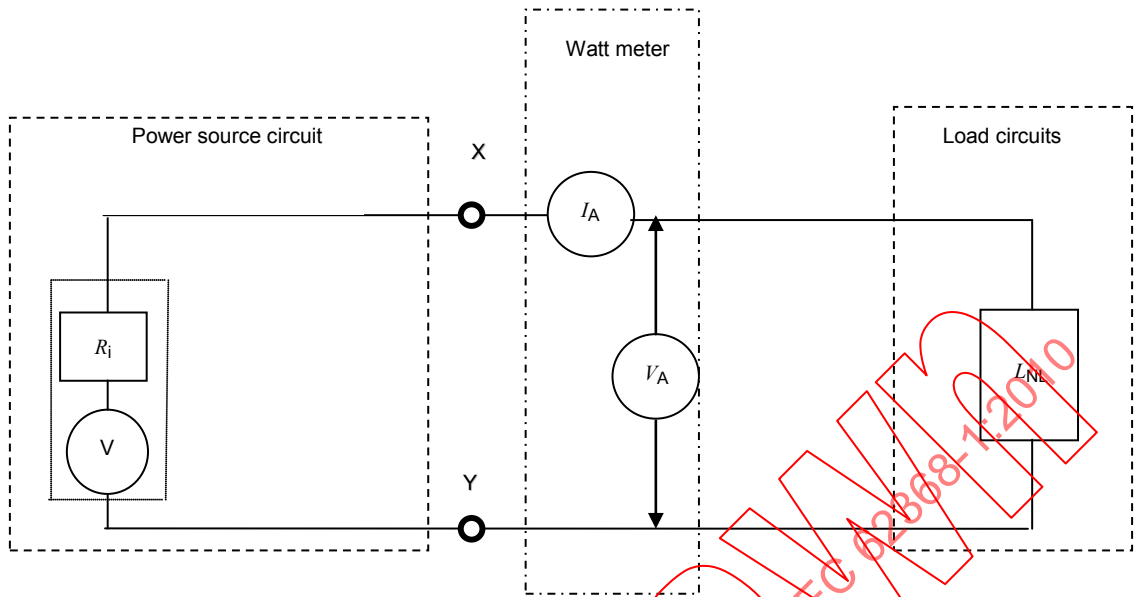
Avec référence à la Figure 39

- Aux points X et Y, insérer un wattmètre (ou un voltmètre, V_A et un ampèremètre, I_A).
- Dans le circuit de la source de puissance, simuler les **conditions de premier défaut** qui créent la puissance maximale dans le circuit en cours de classification. Tous les composants adaptés dans les circuits de la source de puissance doivent être court-circuités ou déconnectés un par un à chaque mesure.
- Mesurer la puissance maximale tel que spécifié et classer les circuits alimentés par la source de puissance conformément à 6.2.2.4, 6.2.2.5 ou 6.2.2.6.

Si un dispositif ou un circuit de protection contre les surintensités fonctionne lors de l'essai, la mesure doit être répétée au point juste en dessous du courant de déclenchement.

NOTE 1 Afin d'éviter d'endommager les composants de la charge normale, une résistance (égale à la charge normale) peut être substituée à la charge normale.

NOTE 2 Des expériences peuvent être nécessaires pour identifier le défaut du composant unique qui produit l'énergie maximale.



Légende

Anglais	Français
wattmeter	wattmètre
power source circuit	circuit de la source <i>de puissance</i>
load circuits	circuits de charge

Légende

- V source de tension
- R_i résistance interne de la source *de puissance*
- I_A courant de la source *de puissance*
- V_A tension aux points où l'énergie de la source d'alimentation est déterminée.
- L_{NL} charge normale

Figure 39 – Mesure de la puissance dans le cas de défaut de la source de puissance le plus défavorable

6.2.2.4 PS1

PS1 est un circuit où la source de puissance (voir la Figure 40) mesurée conformément à 6.2.2, ne dépasse pas:

- 500 W mesuré pendant les 3 premières secondes; et
- 15 W mesuré après 3 s.

Pour les besoins de la présente norme, la puissance disponible des **circuits externes**, décrite dans le Tableau 16, numéro d'identification 11, 12, 13 et 14, est considérée être égale à PS1.

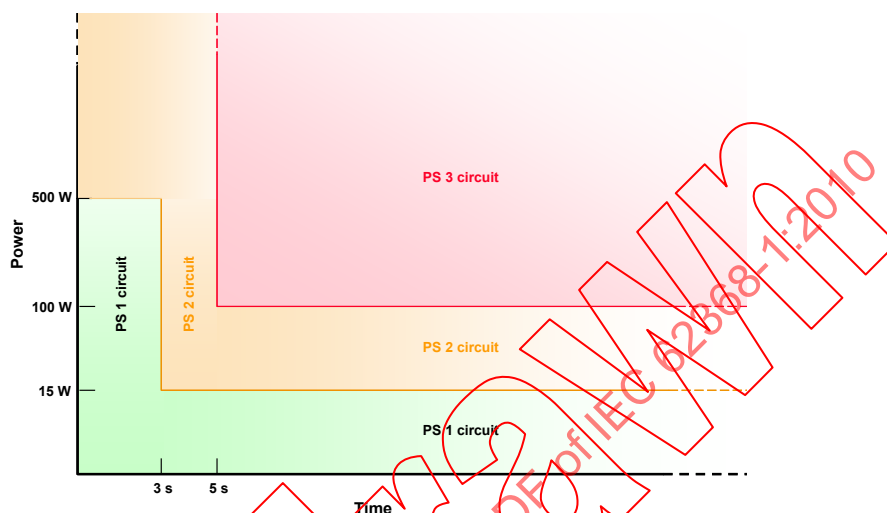
6.2.2.5 PS2

PS2 est un circuit où la source de puissance (voir la Figure 40) mesurée conformément à 6.2.2:

- dépasse les limites de PS1; et
- ne dépasse pas 100 W mesuré après 5 s.

6.2.2.6 PS3

PS3 est un circuit dont la source de puissance dépasse les limites de PS2, ou tout circuit dont la source de puissance n'a pas été classifiée (voir la Figure 40).



Légende

Anglais	Français
Power	Énergie
PS1 circuit	Circuit PS1
PS2 circuit	Circuit PS2
PS3 circuit	Circuit PS3
Time	Temps

Figure 40 – Illustration de la classification des sources de puissance

6.2.3 Classification des sources potentielles d'incendie

6.2.3.1 Source potentielle d'incendie causé par la formation d'un arc électrique

La détermination d'une **source potentielle d'incendie causé par la formation d'un arc électrique** s'effectue dans les **conditions normales de fonctionnement**, sauf spécification contraire.

Une **source potentielle d'incendie causé par la formation d'un arc électrique** est un point (du circuit) qui présente les caractéristiques suivantes:

- une tension de circuit ouvert (mesurée après 3 s) passant dans un conducteur ouvert ou un contact électrique ouvert dépassant 50 V (valeur de crête) en courant alternatif ou continu; et
- le produit de la valeur de crête de la tension de circuit ouvert (V_p) et la mesure du courant en valeur efficace (I_{eff}) dépasse 15 (soit, $V_p \times I_{eff} > 15$) pour chacun des éléments suivants:
 - un contact, tel qu'un interrupteur ou un connecteur;
 - une extrémité, telle que celle créée par une extrémité sertie, soudée ou à ressort;
 - l'ouverture d'un conducteur, telle qu'une trace d'une carte câblée imprimée, causée par des **conditions de premier défaut**. Cette condition ne s'applique pas si des

circuits de protection électroniques ou des mesures de construction supplémentaires sont utilisés pour réduire la probabilité qu'un tel défaut ne devienne une **source potentielle d'incendie causé par la formation d'un arc électrique**.

Une **source potentielle d'incendie causé par la formation d'un arc électrique** est considérée comme inexistante dans un circuit PS1 à cause des limites de la source de puissance.

NOTE 1 Un conducteur ouvert dans un circuit électrique comprend les ruptures susceptibles de se produire dans des impressions conductrices sur des cartes imprimées.

Les connexions fiables ou redondantes ne sont pas considérées comme des **sources potentielles d'incendie causé par la formation d'un arc électrique**.

Les connexions redondantes constituent toutes sortes de connexions parallèles doubles ou multiples pour lesquelles, en cas de défaillance d'une connexion, les connexions restantes sont toujours capables de gérer l'intégralité de l'énergie.

Les connexions fiables sont les connexions considérées comme non ouvertes.

NOTE 2 Les exemples de connexions pouvant être considérées comme fiables sont:

- les trous apparents dans les plages d'accueil sur une carte imprimée qui sont entièrement métallisées;
- les rivets/œilletons tubulaires soudés;
- les sertissures usinées ou les connexions enroulées.

NOTE 3 Si d'autres moyens sont utilisés pour éviter l'apparition d'une **source potentielle d'incendie causé par la formation d'un arc électrique** et si ces moyens ont prouvé leur efficacité, ils peuvent aussi être utilisés.

NOTE 4 Une défaillance de connexion causée par des phénomènes de fatigue thermique peut être évitée en sélectionnant des composants ayant un coefficient d'expansion thermique similaire à celui du matériau des cartes imprimées. Il convient d'accorder une attention toute particulière à l'emplacement où se trouve le composant par rapport à la direction des fibres du matériau des cartes.

6.2.3.2 Source potentielle d'incendie causé par un phénomène de résistivité

La détermination d'une **source potentielle d'incendie causé par un phénomène de résistivité** s'effectue dans les **conditions normales de fonctionnement**, sauf spécification contraire.

Une **source potentielle d'incendie causé par un phénomène de résistivité** correspond à toute partie d'un circuit PS2 ou PS3 qui:

- a une capacité d'énergie à dissiper de plus de 15 W mesuré après 30 s de fonctionnement normal; ou

NOTE Pendant les 30 premières secondes, il n'y a pas de limite.

- dans les **conditions de premier défaut**

- a une énergie supérieure à 100 W mesurée pendant les 30 s suivant immédiatement l'introduction du défaut si des circuits électroniques, des régulateurs ou des dispositifs CTP sont utilisés; ou
- a une énergie disponible supérieure à 15 W mesurée 30 s après l'introduction du défaut

et dont la partie peut s'enflammer à cause d'une dissipation d'énergie excessive ou enflammer des matériaux ou composants adjacents.

Une **source potentielle d'incendie causé par la formation d'un arc électrique** est considérée comme inexistante dans un circuit PS1 à cause des limites de la source d'alimentation.

6.3 Protections contre les incendies dans les conditions normales de fonctionnement et des conditions anormales de fonctionnement

6.3.1 Exigences

Dans les **conditions normales de fonctionnement** et les **conditions anormales de fonctionnement**, les **protections principales** suivantes sont nécessaires:

- une inflammation ne doit pas se produire; et
- aucune partie de l'équipement ne doit atteindre une température supérieure à 90 % de la limite de température d'inflammation spontanée, en Celsius, de la partie telle que définie par l'ISO 871. Lorsque la température d'inflammation spontanée du matériau n'est pas connue, la température doit être limitée à 300 °C; et

NOTE 1 Actuellement, la présente norme ne spécifie aucune exigence relative aux liquides et poussières inflammables.

- les **matériaux combustibles** pour les composants et les autres parties extérieurs aux **enveloppes ignifuges** (y compris les **enceintes électriques** et **mécaniques** et les parties décoratives), doivent avoir une **classification d'inflammabilité du matériau** d'au moins:
 - **HB75** si l'épaisseur significative la plus fine de ce matériau est < 3 mm, ou
 - **HB40** si l'épaisseur significative la plus fine de ce matériau est ≥ 3 mm, ou
 - **HBF**.

NOTE 2 Lorsqu'une **enveloppe** sert également d'**enveloppe ignifuge**, les exigences relatives à ce type d'**enveloppe** s'appliquent.

Ces exigences ne s'appliquent pas:

- aux parties ayant une taille inférieure à 1 750 mm³;
- aux alimentations, **matériaux consommables**, supports et matériaux d'enregistrement;
- aux parties qui nécessitent des propriétés particulières pour remplir des fonctions prévues, tels que les rouleaux en caoutchouc synthétique et les tubes d'encre;
- aux engrenages, cames, courroies, roulements et autres parties pouvant avoir une influence négligeable sur l'alimentation du feu, y compris les étiquettes, pieds de fixation, capuchons de clés, boutons et similaires.

6.3.2 Conformité

*La conformité est vérifiée par examen des fiches techniques et par un essai dans les **conditions normales de fonctionnement** conformément à l'Article B.2 et dans les **conditions anormales de fonctionnement** conformément à l'Article B.3. Les températures des matériaux sont mesurées en continu jusqu'à ce qu'un équilibre thermique soit atteint.*

NOTE Voir B.1.7 pour plus de détails sur l'équilibre thermique.

*Les **protections principales** limitant la température qui sont conformes aux exigences applicables de la présente norme ou de la norme du dispositif de sécurité applicable doivent être conservées dans le circuit en cours d'évaluation.*

6.4 Protections contre les incendies dans les conditions de premier défaut

6.4.1 Généralités

Le présent paragraphe définit les méthodes de **protection** possibles pouvant être utilisées pour réduire la probabilité d'inflammation ou de propagation du feu dans les **conditions de premier défaut**.

Il existe deux méthodes de protection. Toutes deux peuvent être appliquées à différents circuits dans le même équipement dans les conditions suivantes:

- **Réduire la probabilité d'inflammation:** L'équipement est conçu de telle manière que dans les **conditions de premier défaut**, aucune partie ne doit s'enflammer. Cette méthode peut être utilisée pour tout circuit dans lequel la puissance disponible en régime constant du circuit ne dépasse pas 4 000 W. Les exigences et essais adaptés sont détaillés en 6.4.2 et 6.4.3.
 - Les **équipements enfichables de type A** sont considérés comme n'excédant pas la valeur stable de 4 000 W.
 - Les **équipements enfichables de type B** et les **équipements reliés en permanence** sont considérés comme n'excédant pas la valeur stable de 4 000 W si le produit de la tension nominale du **réseau d'alimentation** et la **valeur assignée du courant du dispositif de protection** contre les surintensités de l'installation ($V_{\text{réseau d'alimentation}} \times I_{\text{max}}$) ne dépasse pas 4 000 W.
- **Contrôler la propagation du feu:** Sélection et application des **protections supplémentaires** pour les composants, le câblage, les matériaux et les mesures de construction qui réduisent la propagation du feu et, le cas échéant, par l'utilisation d'une deuxième **protection supplémentaire**, telle qu'une **enveloppe ignifuge**. Cette méthode peut être utilisée pour tout type d'équipement. Les exigences adaptées sont détaillées en 6.4.4, 6.4.5 et 6.4.6.

6.4.2 Réduction de la probabilité d'inflammation dans les conditions de premier défaut dans les circuits PS1

Aucune **protection supplémentaire** n'est requise pour la protection contre PS1. On estime qu'un PS1 ne contient pas assez d'énergie pour que les matériaux atteignent les températures d'inflammation.

6.4.3 Réduction de la probabilité d'inflammation dans les conditions de premier défaut dans les circuits PS2 et PS3

6.4.3.1 Généralités

Le présent paragraphe définit les **protections supplémentaires** nécessaires afin de réduire la probabilité d'inflammation dans les **conditions de premier défaut** dans les circuits PS2 et PS3 lorsque la puissance disponible ne dépasse pas 4 000 W (voir 6.4.1).

6.4.3.2 Exigences

La probabilité d'inflammation peut être réduite en utilisant les **protections supplémentaires** suivantes, selon le cas:

- l'inflammation ne doit pas se produire au-delà de 5 s;
- mise en place d'une séparation d'une **source potentielle d'incendie causé par la formation d'un arc électrique** ou d'une **source potentielle d'incendie causé par un phénomène de résistivité** comme spécifié en 6.4.7;
- utilisation de dispositifs de protection conformes aux Articles G.2 à G.5 ou application des normes CEI correspondantes sur les composants pour ce type de dispositifs;
- utilisation des composants conformes aux Articles G.7 et G.8 ou application de la norme CEI correspondante sur les composants;
- pour les composants associés au **réseau d'alimentation**, utilisation des composants conformes aux normes CEI correspondantes sur les composants et aux exigences d'autres parties de la présente norme.

NOTE Les exemples de composants associés au **réseau d'alimentation** sont les cordons d'alimentation, les prises d'appareils, les composants de filtrage CEM, les interrupteurs, etc.

L'ouverture d'un conducteur sur une carte imprimée, à l'exception de ce qui est stipulé dans le présent paragraphe, ne doit pas être utilisée comme une **protection**.

Les conducteurs d'une carte imprimée d'un **matériau de classe V-1** peuvent s'ouvrir dans des **conditions de surcharge** à condition que le circuit ouvert ne soit pas une **source potentielle d'incendie causé par la formation d'un arc électrique**. Les conducteurs du matériau d'une carte imprimée qui n'a pas de **classification d'inflammabilité du matériau** ou dont la classification est inférieure au **matériau de classe V-1** ne doivent pas s'ouvrir.

Dans les **conditions de premier défaut**, le pelage des conducteurs sur une carte imprimée ne doit provoquer la défaillance d'aucune **protection supplémentaire** ou **protection renforcée**.

6.4.3.3 Méthode d'essai

Les conditions de l'Article B.4 susceptibles de causer un incendie sont appliquées tour à tour. Un défaut indirect peut interrompre ou court-circuiter un composant. En cas de doute, l'essai doit être répété deux autres fois en remplaçant les composants afin de vérifier que le feu n'est pas entretenu.

*L'équipement fonctionne dans les **conditions de premier défaut** et les températures des matériaux sont mesurées en continu jusqu'à ce que l'équilibre thermique soit atteint.*

*Si un conducteur s'ouvre lors d'une simulation des **conditions de premier défaut**, le conducteur doit être mis en parallèle et la simulation de **condition de premier défaut** doit être poursuivie. Dans tous les autres cas, si les **conditions de premier défaut** appliquées provoquent une interruption du courant avant que l'équilibre thermique ait été atteint, la température est mesurée immédiatement après l'interruption. Le circuit doit toujours être conforme au présent paragraphe.*

NOTE 1 Voir B.1.7 pour plus de détails sur l'équilibre thermique.

NOTE 2 Les essais des **conditions de premier défaut** peuvent identifier une situation applicable à un autre article de la présente norme.

NOTE 3 Il convient de prendre en considération les températures d'inflammation spontanée des matériaux proches de la source de chaleur. On peut observer un échauffement après l'interruption du courant, à cause de l'inertie thermique.

Si la température est limitée par des fusibles conformes à la série CEI 60127, l'essai suivant est effectué, si nécessaire, en tenant compte des caractéristiques du fusible.

*Le fusible est court-circuité et le courant qui serait passé à travers le fusible dans les **conditions de premier défaut** correspondantes est mesuré.*

- *Si le courant du fusible reste inférieur à 2,1 fois la valeur assignée du courant du fusible, les températures sont mesurées après qu'un état stable ait été atteint.*
- *Si le courant atteint immédiatement 2,1 fois la valeur assignée du courant du fusible ou plus, ou si cette valeur est atteinte après un temps égal au temps maximal de préarc pour l'établissement du courant approprié à travers le fusible considéré, le fusible et le court-circuit sont retirés après un temps supplémentaire correspondant au temps maximal de préarc du fusible considéré, et les températures sont immédiatement mesurées.*

Si la résistance du fusible influence la valeur du courant dans le circuit correspondant, on doit prendre en compte la valeur maximale de la résistance du fusible lors de la détermination de la valeur du courant.

*Les conducteurs des cartes imprimées sont soumis à essai en appliquant les **conditions de premier défaut** correspondantes de B.4.4.*

6.4.3.4 Conformité

La conformité est vérifiée par examen, essais et mesures.

6.4.4 Contrôle de la propagation du feu dans les circuits PS1

Aucune **protection supplémentaire** n'est requise pour la protection contre PS1. On estime qu'un PS1 ne contient pas assez d'énergie pour que les matériaux atteignent les températures d'inflammation.

6.4.5 Contrôle de la propagation du feu dans les circuits PS2

6.4.5.1 Généralités

Le présent paragraphe décrit les **protections supplémentaires** nécessaires afin de réduire la probabilité de propagation du feu dans les circuits PS2 aux **matériaux combustibles** à proximité.

6.4.5.2 Exigences

Une **protection supplémentaire** est nécessaire pour contrôler la propagation du feu à partir de toute **PIS** potentielle vers les autres parties de l'équipement indiquées ci-dessous.

Pour les conducteurs et les dispositifs constituant une **PIS**, les exigences suivantes s'appliquent:

- les cartes imprimées doivent être constituées de **matériaux de classe V-1**;
- l'isolation et l'enrobage des fils doivent être conformes aux CEI 60332-1-2, CEI 60332-2-2 ou CEI/TS 60695-11-21;
- les dispositifs soumis à la formation d'arc ou au changement de résistance de contact (par exemple, les connecteurs enfichables) doivent être conformes à l'une des exigences suivantes:
 - être constitués d'un **matériau de classe V-1**; ou
 - être conformes aux exigences d'inflammabilité de la norme CEI correspondante sur les composants; ou
 - être montés sur des matériaux composés de **matériaux de classe V-1** et avoir un volume inférieur ou égal à 1 750 mm³.

Les piles et blocs de piles doivent être conformes à toutes les exigences de l'Annexe M.

Tous les autres composants d'un circuit PS2 doivent:

- être montés sur des **matériaux de classe V-1**; ou
- être composés d'un **matériau de classe V-2**, d'un **matériau de classe VTM-2** ou d'un **matériau plastique cellulaire de classe HF-2**; ou
- avoir une masse de **matériau combustible** inférieure à 4 g, à condition que lorsque la partie est enflammée, le feu ne se propage pas à une autre partie; ou
- être séparés d'une **PIS** d'après les exigences de 6.4.7; ou
- être conformes aux exigences de la norme CEI correspondante sur les composants; ou
- les moteurs conformes à l'Article G.8; ou
- les transformateurs conformes à l'Article G.7; ou
- être dans une **enveloppe** étanche de 0,06 m³ ou moins, composée entièrement de **matériaux non combustibles** et sans ouvertures de ventilation.

Les matériaux suivants doivent être séparés de la **PIS** selon les exigences de 6.4.7, ou les matériaux ne doivent pas s'enflammer dans les **conditions de premier défaut** spécifiées en 6.4.3.3:

- alimentations, **matériaux consommables**, supports et matériaux d'enregistrement;
- parties qui nécessitent des propriétés particulières pour remplir des fonctions prévues, telles que les rouleaux en caoutchouc synthétique et les tubes d'encre.

6.4.5.3 Conformité

La conformité est vérifiée par essai ou par examen de l'équipement et fiches techniques des matériaux.

6.4.6 Contrôle de la propagation du feu dans un circuit PS3

6.4.6.1 Généralités

Le présent paragraphe définit les **protections supplémentaires** nécessaires afin de réduire la probabilité de propagation du feu dans les circuits PS3 aux **matériaux combustibles** à proximité.

6.4.6.2 Exigences

La propagation du feu dans les circuits PS3 doit être contrôlée comme stipulé pour les circuits PS2 en 6.4.5 et avec une **enveloppe ignifuge** comme stipulé en 6.4.8.

Avec les **enveloppes ignifuges**, les **matériaux combustibles** qui ne font pas partie d'un circuit PS2 et PS3 doivent être conformes à l'essai d'inflammabilité de l'Article S.1 ou doivent être composés de **matériaux de classe V-2**, de **matériaux de classe VTM-2** ou de **matériaux plastiques cellulaires de classe HF-2**. Ces exigences ne s'appliquent pas:

- aux parties ayant une dimension inférieure à 1 750 mm³;
- aux alimentations, **matériaux consommables**, supports et matériaux d'enregistrement;
- aux parties qui nécessitent des propriétés particulières pour remplir des fonctions prévues, telles que les rouleaux en caoutchouc synthétique et les tubes d'encre;
- aux engrenages, cames, courroies, roulements et autres parties pouvant avoir une influence négligeable sur l'alimentation du feu, y compris les étiquettes, pieds de fixation, capuchons de clés, boutons et similaires.
- aux tubes à air ou aux systèmes pour fluides, conteneurs pour poudres ou liquides et aux parties de matériau plastique cellulaire, à condition qu'ils soient de **classe HB75** si l'épaisseur significative la plus fine du matériau est < 3 mm, ou de **classe HB40** si l'épaisseur significative la plus fine du matériau est ≥ 3 mm ou de **matériau plastique cellulaire de classe HBF**.

Une **enveloppe ignifuge** n'est pas nécessaire pour les composants et matériaux suivants:

- l'isolation et l'enrobage des fils conformes aux CEI 60332-1-2, CEI 60332-2-2 ou CEI/TS 60695-11-21;
- les composants, y compris les connecteurs, conformes aux exigences de 6.4.8.1.1 qui remplissent une ouverture dans une **enveloppe ignifuge**;
- les fiches et connecteurs qui font partie intégrante d'un câble d'alimentation ou d'un câble d'interconnexion, conformes à 6.5, aux Articles G.9 et G.20;
- les moteurs conformes à l'Article G.8;
- les transformateurs conformes à l'Article G.7.

6.4.6.3 Conformité

La conformité est vérifiée par examen des fiches techniques des matériaux ou par essai, ou les deux.

6.4.7 Séparation des matériaux combustibles d'une PIS

6.4.7.1 Généralités

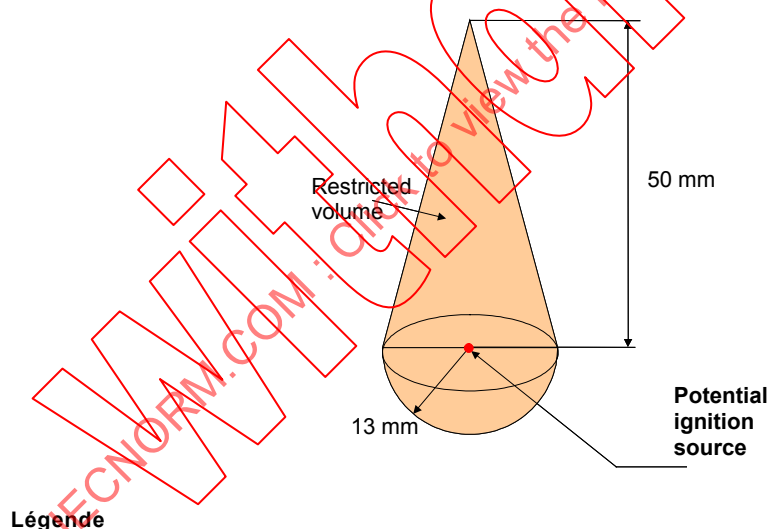
Le présent paragraphe spécifie les exigences de séparation minimales entre une **PIS** et des **matériaux combustibles** afin de réduire la probabilité de feu entretenu ou de propagation du feu. Cela peut être accompli soit par une séparation par la distance (6.4.7.2), soit pas une séparation à l'aide d'une barrière (6.4.7.3).

Les exigences de séparation d'une PIS à une **enveloppe ignifuge** sont spécifiées en 6.4.8.3.

6.4.7.2 Séparation par la distance

Les **matériaux combustibles**, sauf les matériaux sur lesquels se trouve la **PIS**, doivent être séparés d'une **source potentielle d'incendie causé par la formation d'un arc électrique** ou une **source potentielle d'incendie causé par un phénomène de résistivité** conformément aux Figures 41, 42, 43 et 44.

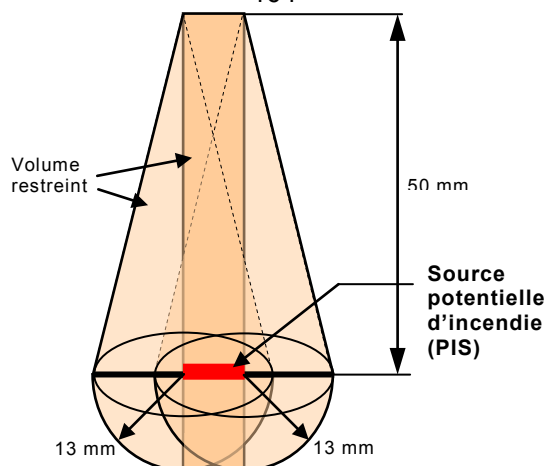
Les matériaux principaux des cartes imprimées, sur lesquels se situe une **source potentielle d'incendie causé par la formation d'un arc électrique**, doivent être constitués de **matériaux de classe V-1**, **matériaux de classe VTM-1** ou de **matériaux plastiques cellulaires de classe HF-1**.



Légende

Anglais	Français
Restricted volume	Volume restreint
Potential ignition source	Source potentielle d'incendie (PIS)

Figure 41 – Exigences minimales de séparation applicables à une source potentielle d'incendie causé par la formation d'un arc électrique

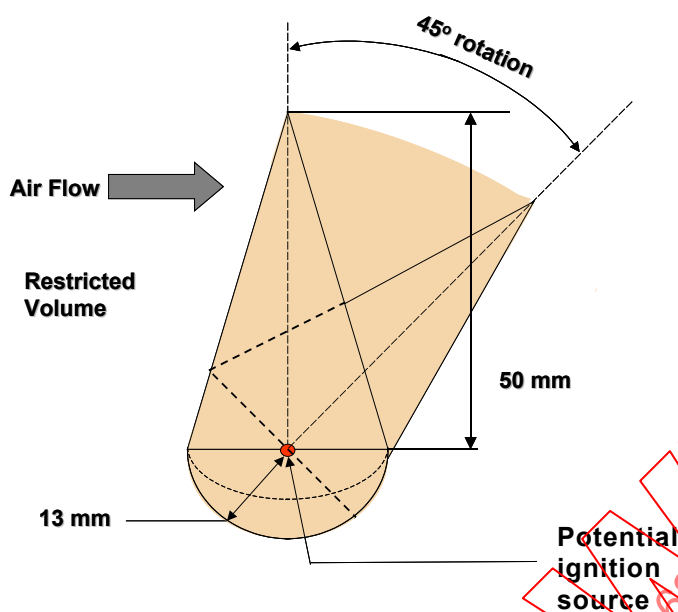


NOTE Cette figure peut être utilisée pour:

- une **source potentielle d'incendie causé par la formation d'un arc électrique** constituée de voies ou de zones sur des cartes imprimées;
- les zones de composants d'une **source potentielle d'incendie causé par un phénomène de résistivité**. Les mesures sont réalisées à partir de l'élément de dissipation d'énergie le plus proche du composant concerné. Si, dans la pratique, il n'est pas possible de définir immédiatement la partie de dissipation de l'énergie, alors l'**enveloppe** extérieure du composant est utilisée.

Figure 42 – Exigences étendues de séparation d'une source potentielle d'incendie

Lorsque le flux d'air forcé à travers un circuit se déplace du fait des appareils de ventilation, l'orientation verticale des volumes restreints décrits aux Figures 41, 42 et 44 doit entrer en rotation pour refléter l'effet du flux d'air sur le chemin de la flamme. Lorsque l'on détermine les volumes restreints pour chaque figure, chaque cône doit entrer en rotation (incliné) autour de l'emplacement de la **source potentielle d'incendie** de 0° (orientation verticale indiquée à la Figure 43), à 45° dans la direction du flux d'air forcé.



Légende

Anglais	Français
Restricted volume	Volume restreint
Potential ignition source	Source potentielle d'incendie
45° rotation	Rotation de 45°
Air flow	Flux d'air

Figure 43 – Exigences de séparation en rotation causée par un flux d'air forcé

Lorsque la distance entre une **source potentielle d'incendie** et des **matériaux combustibles** est inférieure à la distance spécifiée aux Figures 41, 42 et 43 suivant les cas, les **matériaux combustibles** doivent:

- avoir une masse inférieure à 4 g, à condition que, lorsque la partie est enflammée, le feu ne se propage pas à une autre partie; ou
- être conformes aux exigences d'inflammabilité suivantes:
 - exigences de la norme CEI correspondante sur les composants; ou
 - être constitués de **matériaux de classe V-1**, **matériaux de classe VTM-1** ou **matériaux plastiques cellulaires de classe HF-1** ou être conformes à la CEI 60695-11-5. Les sévérités sont identifiées à l'Article S.2.

6.4.7.3 Séparation ignifuge

Les **matériaux combustibles** doivent être séparés d'une **source potentielle d'incendie causé par la formation d'un arc électrique** ou d'une **source potentielle d'incendie causé par un phénomène de résistivité** par une séparation ignifuge telle que définie au 6.4.8.1.1 (voir la Figure 44).

Les cartes imprimées ne sont pas considérées comme une séparation ignifuge contre une **source potentielle d'incendie causé par la formation d'un arc électrique** située sur la même carte. Les cartes imprimées conformes à 6.4.8 peuvent être considérées comme des séparations ignifuges contre une **source potentielle d'incendie causé par la formation d'un arc électrique** située sur une carte différente.

Des cartes imprimées peuvent être considérées comme des séparations ignifuges contre une **source potentielle d'incendie causé par un phénomène de résistivité** à condition que les conditions suivantes soient remplies:

- La carte imprimée doit:
 - être conforme à l'essai d'inflammabilité de l'Article S.1 tel qu'utilisé dans l'application; ou
 - être composée d'un **matériau de classe V-1**, d'un **matériau de classe VTM-1** ou d'un **matériau plastique cellulaire de classe HF-1**;
- dans le volume restreint, aucun **matériau** de classe assignée inférieure à la **classe V-1** ne doit être monté du même côté sur la carte imprimée que celui où se trouve la **source potentielle d'incendie causé par un phénomène de résistivité**;
- dans le volume restreint, la carte imprimée ne doit pas comporter de conducteurs PS2 ou de conducteurs PS3 (à l'exception des conducteurs qui alimentent le circuit en question). Cela s'applique à tous les côtés de la carte imprimée, y compris la couche intérieure de la carte imprimée.

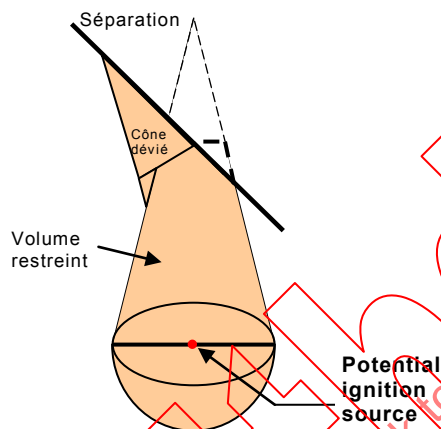


Figure 44a – Illustration montrant une séparation oblique

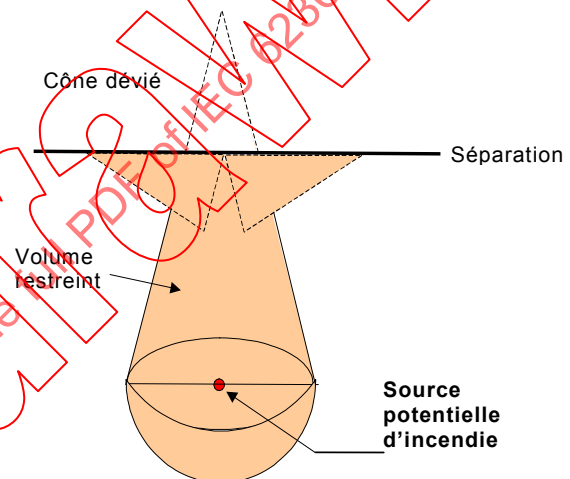


Figure 44b – Illustration montrant une séparation horizontale

NOTE 1 Le volume de la flamme est quasi constant; par conséquent, la forme de la flamme dépend de la position et de la forme de la séparation. Il convient de tenir compte du fait que différentes formes de séparation peuvent engendrer différentes formes de flamme. Il est nécessaire d'adapter en conséquence les exigences sur la séparation et la zone restreinte, par l'utilisateur de la norme.

NOTE 2 Les dimensions sont identiques aux Figures 41 et 42, mais, à l'exception de ce qui est exigé en 6.4.8.3, la distance entre la séparation et la **source potentielle d'incendie** n'est pas importante.

Figure 44 – Exigences sur la déviation de la séparation par rapport à une source potentielle d'incendie lorsqu'une séparation ignifuge est utilisée

6.4.7.4 Conformité

La conformité est vérifiée par examen ou par mesure ou par les deux.

6.4.8 Enveloppes ignifuges et séparations ignifuges

La fonction de **protection** de l'**enveloppe ignifuge** et de la séparation ignifuge consiste à freiner la propagation du feu à travers l'**enveloppe** ou la séparation.

NOTE L'**enveloppe ignifuge** peut être l'**enveloppe** totale, ou elle peut faire partie de cette dernière. L'**enveloppe ignifuge** peut ne pas avoir une fonction exclusive, mais peut avoir d'autres fonctions en plus de celle d'**enveloppe ignifuge**.

6.4.8.1 Propriétés du matériau des enveloppes ignifuges et des séparations ignifuges

6.4.8.1.1 Exigences relatives à une séparation ignifuge

Une séparation ignifuge doit être conforme aux exigences de l'Article S.1.

Ces exigences ne s'appliquent pas à condition que le matériau soit:

- constitué d'un **matériau non combustible** (par exemple, métal, verre, céramique, etc.); ou
- constitué d'un **matériau de classe V-1** ou **VTM-1**.

6.4.8.1.2 Exigences relatives à une enveloppe ignifuge

Pour les circuits où la puissance disponible ne dépasse pas 4 000 W (voir 6.4.1), l'**enveloppe ignifuge** doit être conforme aux exigences de l'Article S.1.

Pour les circuits où la puissance disponible dépasse 4 000 W, l'**enveloppe ignifuge** doit être conforme aux exigences de l'Article S.5.

Ces exigences ne s'appliquent pas à condition que le matériau soit:

- constitué d'un **matériau non combustible** (par exemple, métal, verre, céramique, etc.); ou
- constitué
 - d'un **matériau de classe V-1** si la puissance disponible ne dépasse pas 4 000 W; ou
 - d'un **matériau de classe 5VA** ou **5VB** si la puissance disponible dépasse 4 000 W.

Les matériaux des composants qui remplissent une ouverture dans une **enveloppe ignifuge** ou qui doivent être montés dans des ouvertures semblables doivent:

- être conformes aux exigences d'inflammabilité de la norme CEI correspondante sur les composants; ou
- être constitués d'un **matériau de classe V-1**; ou
- satisfaire à l'Article S.1.

6.4.8.1.3 Conformité

La conformité est vérifiée par examen des fiches techniques applicables ou par essai.

La **classification d'inflammabilité du matériau** est vérifiée dans l'épaisseur significative la plus fine utilisée.

6.4.8.2 Exigences de construction relatives à une enveloppe ignifuge et à une séparation ignifuge

6.4.8.2.1 Ouvertures d'enveloppes ignifuges et de séparations ignifuges

Les dimensions des ouvertures dans une **enveloppe ignifuge** ou dans une séparation ignifuge doivent être telles que le feu et les produits de combustion passant à travers les ouvertures ne sont pas susceptibles d'enflammer le matériau se trouvant à l'extérieur de l'**enveloppe** ou sur le côté d'une séparation ignifuge à l'opposé de la **source potentielle d'incendie**.

Les ouvertures auxquelles ces propriétés s'appliquent sont liées à l'endroit ou l'emplacement où se trouvent la **source potentielle d'incendie** et les **matériaux combustibles**. Les emplacements des ouvertures liées à la propriété de la flamme sont illustrés aux Figures 45 et 46.

Indépendamment de l'orientation de l'équipement, l'orientation de la flamme de la **source potentielle d'incendie** est toujours verticale, sauf si l'équipement est le siège d'un flux d'air forcé. Lorsque l'équipement a deux orientations ou plus dans les **conditions normales de fonctionnement**, les propriétés sur les ouvertures s'appliquent pour chaque orientation possible et à chaque direction du flux d'air.

NOTE Lorsque le flux d'air forcé à travers une **source potentielle d'incendie** se déplace du fait de l'appareil de ventilation, l'orientation verticale du volume décrit à la Figure 42 entre en rotation (inclinée) autour de l'emplacement de la **source potentielle d'incendie** à partir de 0° (orientation verticale illustrée sur la figure) à 45° dans la direction du flux d'air forcé (voir également la Figure 43).

6.4.8.2.2 Dimensions relatives à une séparation ignifuge

Une séparation ignifuge doit avoir des dimensions suffisantes pour éviter l'inflammation des bords de la séparation. Les bords des séparations ignifuges doivent s'étendre au-delà du cône de feu (voir la Figure 44).

6.4.8.2.3 Ouvertures supérieures et propriétés des ouvertures supérieures

Les propriétés des ouvertures supérieures d'une **enveloppe ignifuge** et d'une séparation ignifuge doivent s'appliquer aux ouvertures situées au-dessus d'une **source potentielle d'incendie** comme indiqué sur la Figure 45.

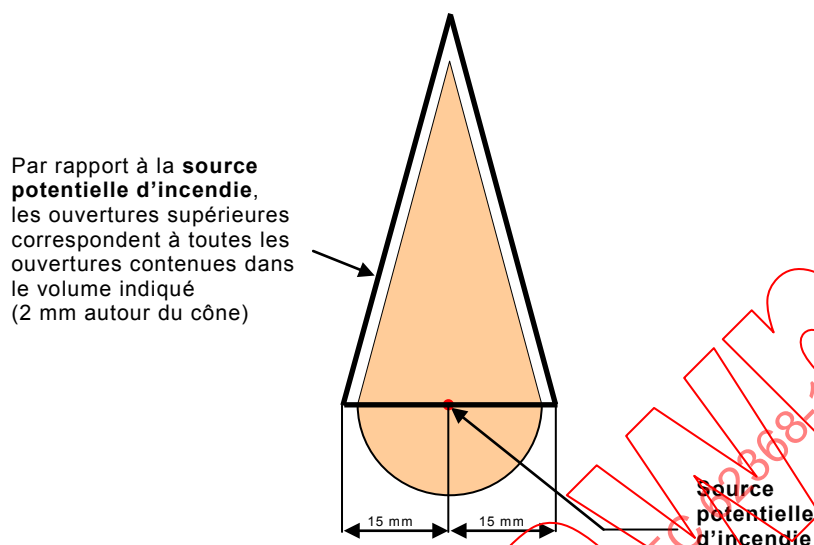
NOTE Toutes les ouvertures situées dans la zone indiquée sur la Figure 45 sont considérées comme des ouvertures supérieures, y compris les ouvertures latérales.

Les ouvertures supérieures qui aboutissent dans le volume défini à la Figure 45 doivent être conformes à l'essai suivant.

*L'essai est effectué à l'aide d'un brûleur aiguille, tel que spécifié à l'Article S.2, placé verticalement en un emplacement exempt de courant d'air. La distance entre le côté interne des ouvertures supérieures et le centre du tube du brûleur est de $7\text{ mm} \pm 1\text{ mm}$. L'échantillon est placé dans sa position de fonctionnement normal. Les ouvertures dans la partie supérieure sont recouvertes d'une seule couche d'**étamine**.*

*La flamme est appliquée pendant une minute. L'**étamine** ne doit pas s'enflammer.*

En cas d'ouvertures ayant des dimensions différentes, l'essai doit être effectué sur une ouverture de chaque groupe d'ouvertures supérieures ayant les mêmes dimensions.



NOTE Les dimensions du cône sont identiques à celles des Figures 41 et 42.

Figure 45 – Ouvertures supérieures

Aucun essai n'est nécessaire à condition que les ouvertures ne dépassent pas:

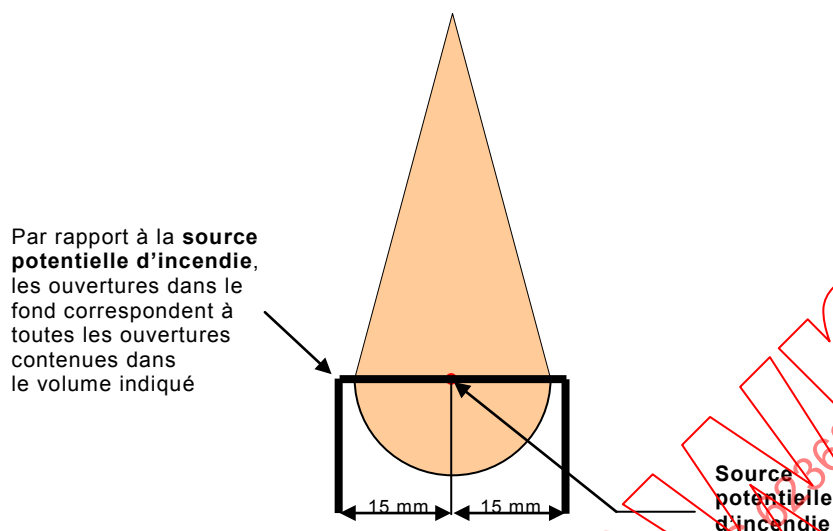
- 5 mm dans toutes les dimensions; ou
- 1 mm de largeur quelle que soit la longueur.

6.4.8.2.4 Ouvertures dans le fond et propriétés des ouvertures dans le fond

Les propriétés des ouvertures dans le fond d'une **enveloppe ignifuge** et d'une séparation ignifuge doivent s'appliquer aux ouvertures situées dans le volume indiqué sur la Figure 46.

NOTE Toutes les ouvertures situées dans la zone indiquée sur la Figure 46 sont considérées comme des ouvertures dans le fond, y compris les ouvertures latérales.

Les ouvertures dans le fond sont les ouvertures situées en dessous d'une **source potentielle d'incendie** et comprises dans un cylindre de 30 mm de diamètre s'étendant indéfiniment en dessous de la **source potentielle d'incendie**.



NOTE Les dimensions du cône sont identiques à celles des Figures 41 et 42.

Figure 46 – Ouvertures dans le fond

Les ouvertures dans le fond doivent être conformes à l'Article S.3.

Aucun essai n'est nécessaire à condition que l'une des conditions suivantes soit remplie:

- les ouvertures dans le fond ne dépassent pas:
 - 3 mm dans toutes les dimensions; ou
 - 1 mm de largeur quelle que soit la longueur;
- sous des composants et des pièces satisfaisant aux exigences relatives aux **matériaux de classe V-1** ou aux **matériaux plastiques cellulaires de classe HF-1** ou sous des composants satisfaisant à l'essai au brûleur-aiguille de la CEI 60695-11-5 avec application d'une flamme pendant 30 s, les ouvertures dans le fond ne doivent pas dépasser:
 - 6 mm dans toutes les dimensions; ou
 - 2 mm de largeur quelle que soit la longueur;
- les dimensions de la maille des ouvertures dans le fond ne doivent pas dépasser une surface de 2 mm par 2 mm pour un fil métallique ayant un diamètre d'au moins 0,45 mm.

Lorsqu'il existe un risque que des liquides enflammés s'échappent de l'équipement, le fond de l'**enveloppe ignifuge** doit être conforme au Tableau 39.

Tableau 39 – Dimensions et espacement des trous dans le fond des enveloppes ignifuges métalliques

Épaisseur minimale du fond métallique mm	Trous circulaires		Ouvertures de formes différentes	
	Diamètre maximal des trous mm	Espacement minimal centre-à-centre entre les trous mm	Surface maximale mm ²	Espacement minimal bord-à-bord entre les ouvertures mm
0,66	1,1	1,7	1,1	0,56
0,66	1,2	2,4	1,2	1,1
0,76	1,1	1,7	1,1	0,55
0,76	1,2	2,4	1,2	1,1
0,81	1,9	3,2	2,9	1,1
0,89	1,9	3,2	2,9	1,2
0,91	1,6	2,8	2,1	1,1
0,91	2,0	3,2	3,1	1,2
1,0	1,6	2,8	2,1	1,1
1,0	2,0	3,0	3,2	1,0

Il n'est pas nécessaire que les équipements destinés à n'être utilisés que dans des installations fixes et destinés à être posés sur le sol sur une surface non combustible soient équipés d'un fond à **enveloppe ignifuge**. De tels équipements doivent comporter un marquage conformément à l'Article F.5 à un endroit facilement visible avec le libellé suivant ou équivalent:

RISQUE D'INCENDIE

Installer seulement sur du béton ou tout autre sol en matériau non combustible

6.4.8.2.5 Intégrité de l'enveloppe ignifuge

Si une partie d'une **enveloppe ignifuge** se compose d'une porte ou d'un couvercle qui peut être ouvert par une **personne ordinaire**, la porte ou le couvercle doit satisfaire aux exigences a), b) ou c):

- a) la porte ou le couvercle doit être verrouillé et satisfaire aux exigences relatives au **verrouillage de sécurité** de l'Annexe K;
- b) une porte ou un couvercle, destiné à être régulièrement ouverts par une **personne ordinaire**, doit satisfaire aux deux conditions suivantes:
 - il ne doit pas pouvoir être déposé à partir d'autres parties de l'**enveloppe ignifuge** par la **personne ordinaire**; et
 - il doit être équipé d'un dispositif le gardant fermé dans les **conditions normales de fonctionnement**;
- c) une porte ou un couvercle destiné seulement à être utilisé occasionnellement par la **personne ordinaire**, par exemple pour l'installation d'accessoires, peut être déposé à condition que des instructions pour une dépose et une pose correctes de la porte ou du couvercle soient disponibles.

6.4.8.2.6 Conformité

La conformité est vérifiée par examen des fiches techniques applicables et, le cas échéant, par essai.

6.4.8.3 Distances de séparation entre une source potentielle d'incendie et une enveloppe ignifuge ou une séparation ignifuge

Une **enveloppe ignifuge** ou une séparation ignifuge composées d'un **matériau combustible** doivent avoir:

- a) une distance de séparation minimale de 13 mm par rapport à une **source potentielle d'incendie causé par la formation d'un arc électrique**; et
- b) une distance de séparation minimale de 5 mm par rapport à une **source potentielle d'incendie causé par un phénomène de résistivité**.

Les distances inférieures sont autorisées sous réserve que la partie de l'**enveloppe ignifuge** ou de la séparation ignifuge située à la distance de séparation nécessaire soit conforme à l'une des exigences suivantes:

- l'**enveloppe ignifuge** ou la séparation ignifuge satisfait à l'essai au brûleur aiguille selon la CEI 60695-11-5. Les degrés de sévérité sont identifiés à l'Article S.2. Après l'essai, le matériau de l'**enveloppe ignifuge** ou de la séparation ignifuge ne doit présenter aucun trou dont la dimension est supérieure à celle autorisée en 6.4.8.2.3 ou en 6.4.8.2.4 selon le cas; ou
- l'**enveloppe ignifuge** ou la séparation ignifuge sont composées d'un **matériau de classe V-0**.

6.5 Câblage interne et externe

6.5.1 Généralités

Le présent paragraphe spécifie les exigences permettant de réduire la probabilité d'un incendie provenant de câblages internes et externes dans les circuits PS2 et PS3.

6.5.2 Exigences

Dans les circuits PS2 ou PS3, l'isolation sur les câblages internes ou externes doit satisfaire aux méthodes d'essai décrites ci-dessous.

Pour les conducteurs dont la section est supérieure à 0,5 mm², les méthodes d'essai des CEI 60332-1-2 et 60332-1-3 doivent être appliquées.

Pour les conducteurs dont la section est inférieure ou égale à 0,5 mm², les méthodes d'essai des CEI 60332-2-1 et 60332-2-2 doivent être appliquées.

NOTE Concernant les câblages internes et externes, la méthode d'essai décrite dans la CEI/TS 60695-11-21 peut se substituer aux méthodes d'essai décrites dans les CEI 60332-1-2, 60332-1-3, 60332-2-1 ou 60332-2-2.

6.5.3 Conformité

Le conducteur ou le câble isolé doit être acceptable si:

- *la distance entre le bord inférieur du support supérieur et le début de la zone de carbonisation est supérieure à 50 mm; et*
- *le papier filtre ne s'est pas enflammé pendant le déroulement de l'essai; et*
- *la zone de carbonisation s'étend vers le bas vers un point situé à moins de 540 mm du bord inférieur du support supérieur.*

Si le conducteur ou le câble isolé ne satisfait pas au premier essai, deux essais supplémentaires doivent être effectués. Si le deuxième essai et le troisième essai sont acceptables, le conducteur ou le câble isolé doit être considéré comme acceptable.

NOTE Ces exigences sont actuellement présentes dans les normes référencées en tant qu'annexes informatives.

6.5.4 Exigences relatives à l'interconnexion avec le câblage du bâtiment

Les équipements destinés à fournir de la puissance électrique par le biais du réseau de câblage aux équipements déportés doivent limiter le courant de sortie à une valeur qui ne détériore pas le réseau de câblage, du fait d'une surchauffe, quelles que soient les conditions de charge externe. Le courant continu maximal en provenance de l'équipement ne doit pas dépasser une limite de courant qui est appropriée à la section minimale du fil spécifiée dans les instructions d'installation de l'équipement.

NOTE 1 Ce câblage n'est généralement pas soumis aux exigences figurant dans les instructions d'installation de l'équipement car il est souvent installé de façon indépendante par rapport à l'installation de l'équipement.

Les circuits PS2 ou PS3 qui assurent l'alimentation en puissance électrique et qui sont destinés à être compatibles avec des sources d'alimentation limitée (LPS) vers des **circuits externes** (voir Annexe Q) doivent avoir leur puissance de sortie limitée à des valeurs qui réduisent la probabilité d'inflammation dans le câblage du bâtiment ou dans des dispositifs externes situés dans une pièce différente.

La conformité est vérifiée conformément aux Articles Q.1 et Q.2.

NOTE 2 Les circuits servant à alimenter des dispositifs ou des composants externes qui sont conçus pour être utilisés dans le même local que l'équipement soumis à l'essai ne sont pas concernés par cette exigence. Voir 6.7 pour la connexion aux équipements secondaires.

Les circuits externes à câbles conducteurs à paires tels que ceux décrits dans le Tableau 16 avec les numéros d'identification 11, 12, 13 et 14 et ayant un diamètre minimal de fil de 0,4 mm doivent avoir un courant limité à 1,3 A.

NOTE 3 Les caractéristiques courant-durée des fusibles de type gD et gN spécifiés dans la CEI 60269-2 répondent à la limite mentionnée ci-dessus. Les fusibles de type gD ou gN calibrés à 1 A satisfont à la limite de courant de 1,3 A.

La conformité est vérifiée conformément à l'Article Q.3.

6.5.5 Conformité

La conformité est vérifiée par essai, par examen et, lorsque nécessaire, selon les exigences de l'Annexe Q.

6.6 Probabilité d'incendie dû à l'entrée d'objets étrangers

Le présent paragraphe spécifie les **protections** qui réduisent la probabilité qu'un incendie ne survienne en raison de l'entrée dans l'équipement d'objets étrangers qui soient conducteurs.

Des objets conducteurs étrangers ne doivent pas provoquer la mise en parallèle des circuits PS2 ou des circuits PS3. Les ouvertures supérieures et latérales situées au-dessus de ces circuits et à une hauteur inférieure à 1,8 m au-dessus du sol doivent être conformes à l'Annexe P.

Si l'entrée d'un objet étranger peut provoquer la mise en parallèle des circuits PS2 ou des circuits PS3, une des solutions suivantes doit être appliquée:

- une ou plusieurs barrières internes doivent être installées pour dévier la trajectoire d'entrée d'objets afin de les éloigner des circuits concernés; ou
- des ouvertures dans l'équipement au-dessus des circuits concernés doivent être situées à plus de 1,8 m au-dessus du sol; ou
- la construction au-dessus des circuits concernés doit être conforme à l'Annexe P.

La conformité est vérifiée par examen ou conformément à l'Annexe P.

6.7 Protections contre les incendies dus à la connexion des équipements secondaires

Le présent paragraphe spécifie les exigences pour réduire la probabilité d'incendie dû à la connexion des équipements secondaires.

Lorsqu'on ne sait pas si les équipements ou les accessoires connectés (par exemple, un scanner, une souris, un clavier, un lecteur de DVD ou de CD-ROM ou un joystick) sont susceptibles d'être conformes à la présente norme, la puissance délivrée doit être limitée à PS2.

La conformité est vérifiée par examen ou par des mesures.

7 Blessures dues à une exposition à des substances chimiques

7.1 Généralités

Le présent article décrit des **protections** pour réduire la probabilité de blessure due à une exposition à des substances chimiques. Ces exigences ne sont pas considérées comme étant les seuls moyens de réduire la probabilité de blessure due à une exposition à des substances chimiques.

7.2 Maîtrise du risque d'exposition à des substances chimiques dangereuses

Le risque d'exposition à des **substances chimiques dangereuses** doit être maîtrisé. La maîtrise de ce risque d'exposition à des **substances chimiques dangereuses** doit être contrôlée en confinant les **substances chimiques dangereuses**. Les conteneurs doivent être suffisamment robustes et ne doivent pas être endommagés ou dégradés par le contenu pendant la durée de vie du produit.

La conformité est vérifiée par

- *l'examen des effets qu'ont les substances chimiques sur le matériau du conteneur, et*
- *les essais appropriés éventuels de l'Annexe T à la suite desquels il convient que le conteneur ne présente aucune fuite.*

7.3 Exposition à l'ozone

Concernant les équipements qui produisent de l'ozone, les instructions d'installation et de fonctionnement doivent indiquer le fait que des précautions doivent être prises pour s'assurer que la concentration d'ozone est limitée à une valeur ne présentant pas de danger.

NOTE 1 La limite d'exposition à long terme actuelle recommandée concernant l'ozone est de $0,1 \times 10^{-6}$ ($0,2 \text{ mg/m}^3$) calculée comme une concentration moyenne pondérée dans le temps sur une durée de 8 h. La moyenne pondérée dans le temps est le niveau moyen d'exposition sur une période de temps donnée.

NOTE 2 L'ozone est un gaz plus lourd que l'air.

La conformité est vérifiée par examen des instructions ou des documents d'accompagnement.

7.4 Utilisation d'un EPI (équipement de protection individuelle)

Lorsque des **protections**, telles le confinement d'une substance chimique, ne sont pas applicables d'un point de vue pratique, un **EPI** doit être spécifié dans les documents d'accompagnement.

Il convient de choisir des **EPI** appropriés compte tenu des recommandations du fabricant.

La conformité est vérifiée par examen des instructions ou des documents d'accompagnement.

7.5 Utilisation de protections mises en place sous forme d'instructions et d'instructions d'utilisation

Lorsqu'une substance chimique peut provoquer une blessure, des **protections mises en place sous forme d'instructions** telles que spécifiées dans l'ISO 7010 et des instructions doivent être appliquées à l'équipement conformément à l'Article F.5.

La conformité est vérifiée par examen des instructions ou des documents d'accompagnement.

7.6 Piles et batteries

Les piles et les batteries doivent être conformes à l'Annexe M.

8 Blessures dues à un choc mécanique

8.1 Généralités

Le présent article décrit des **protections** pour réduire la probabilité de blessures telles que les coupures, les ecchymoses, les fractures osseuses, etc. dues au transfert d'énergie d'une source d'alimentation mécanique vers une partie du corps.

Une blessure due à un choc mécanique est provoquée par un mouvement relatif entre le corps et les parties **accessibles** de l'équipement, ou par les parties éjectées de l'équipement qui entrent en collision avec une partie du corps.

NOTE 1 Dans certains cas, la personne peut être la source d'alimentation cinétique.

NOTE 2 Lorsque cela n'est pas spécifiquement mentionné dans le présent article, les termes « produits » et « équipements » incluent également les chariots et les supports utilisés avec ces produits ou ces équipements.

8.2 Classification des sources d'énergie mécanique

8.2.1 Classification générale

Les différentes catégories de sources d'énergie mécanique sont données dans le Tableau 40.

Tableau 40 – Classification des différentes catégories de sources d'énergie mécanique

Ligne	Catégorie	MS1	MS2	MS3
1	Arêtes vives et angles vifs	Ne provoque pas de douleur ou blessure ^b	Ne provoque pas de blessure ^b mais peut être douloureux	Peut provoquer une blessure ^c
2	Parties mobiles	Ne provoque pas de douleur ou blessure ^b	Ne provoque pas de blessure ^b mais peut être douloureux	Peut provoquer une blessure ^c
3	Pales mobiles de ventilateur ^a Voir la Figure 47.	$\frac{RPM}{15\ 000} + \frac{K\ Factor}{2\ 400} \leq 1$ rpm = r/min	>MS1; et $\frac{RPM}{22\ 000} + \frac{K\ Factor}{3\ 600} \leq 1$ rpm = r/min	>MS2
4	Desserrage, explosion ou implosion de parties.	NA	NA	Exemples ^d
5	Masse de l'équipement	≤7 kg	7 kg < masse ≤ 25 kg	>25 kg
6	Montage sur un mur/plafond	Masse de l'équipement ≤7 kg montage <2 m ^e	Masse de l'équipement > 7 kg montage <2 m ^e	Tous équipements montés ≥2 m

^a Le facteur K est déterminé à partir de la formule $K = 6 \times 10^{-7} (m \cdot r^2 \cdot N^2)$, où m est la masse (kg) de la partie mobile de l'ensemble de ventilation (pale, arbre et rotor), r est le rayon (mm) de la pale du ventilateur entre l'axe du moteur (arbre) et l'extrémité de la zone externe avec laquelle un contact est possible, N est la vitesse de rotation (r/min) de la pale du ventilateur.

Dans le produit fini, la tension de service maximale du ventilateur peut être différente de la tension assignée du ventilateur, et il convient de tenir compte de cette différence.

^b L'expression « Ne provoque pas de blessure » signifie que l'intervention d'un docteur ou l'envoi aux urgences d'un hôpital n'est pas nécessaire.

^c L'expression « Peut provoquer une blessure » signifie que l'intervention d'un docteur ou l'envoi aux urgences d'un hôpital peut être nécessaire.

^d Les équipements ayant les conceptions suivantes sont des exemples considérés comme équipement du type MS3:

- les supports solides amovibles en plastique fonctionnant à des vitesses élevées tels que ceux utilisés dans les lecteurs CD ou DVD dont la vitesse de rotation peut atteindre plus de 8 000 r/min; et
- les tubes cathodiques (CRT) dont la face a une dimension maximale dépassant 160 mm; et
- les lampes dans lesquelles la pression dépasse 0,2 MPa lorsqu'elles sont froides ou 0,4 MPa en fonctionnement sont considérées comme des lampes haute pression et doivent être classées comme éléments du type MS3.

^e Les instructions d'installation du fabricant doivent indiquer que l'équipement convient uniquement à un montage à des hauteurs < 2 m.

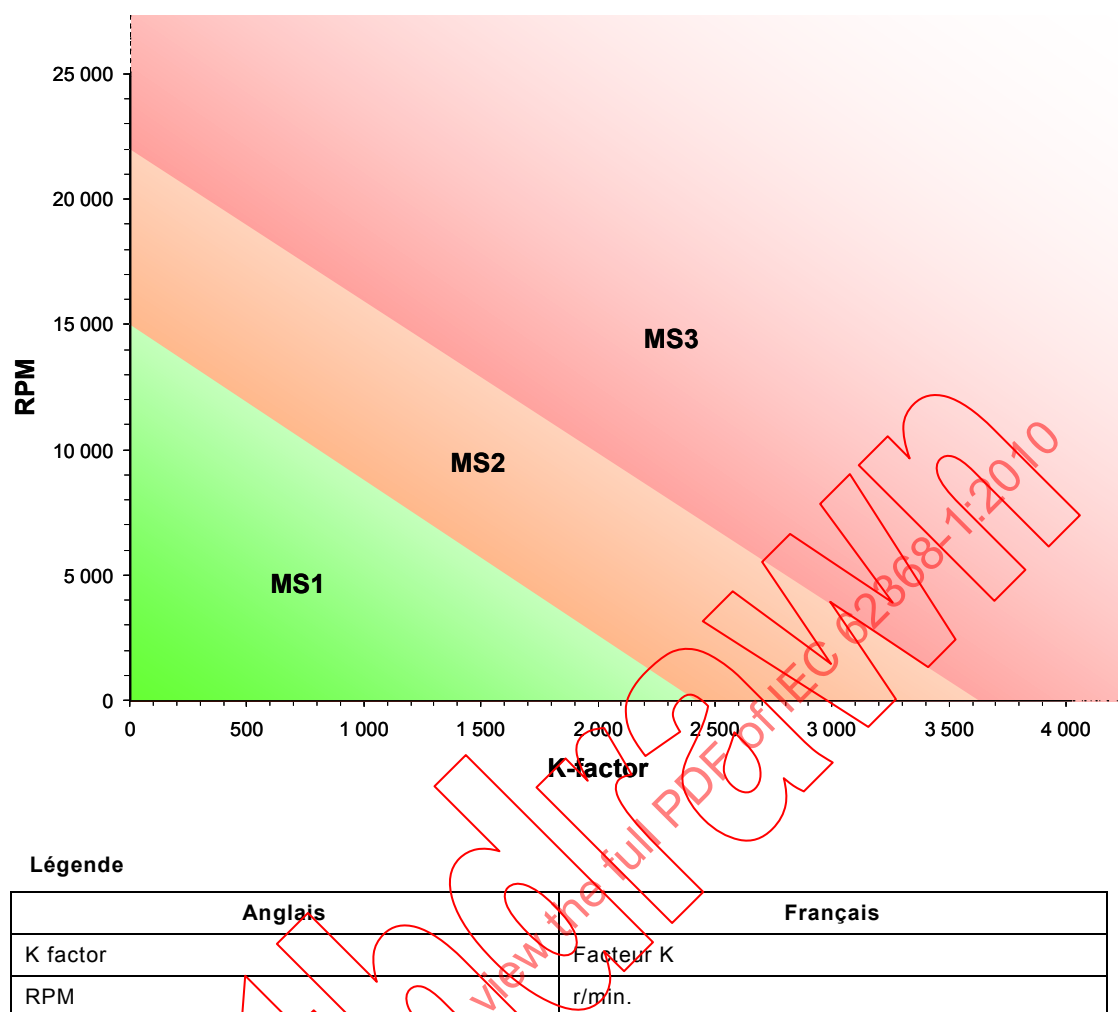


Figure 47 – Illustration montrant les limites MS pour les pales mobiles de ventilateurs

8.2.2 MS1

MS1 est une source d'énergie mécanique dont les niveaux ne dépassent pas les limites de MS1 dans les **conditions normales de fonctionnement** et les **conditions anormales de fonctionnement** et ne dépassent pas les limites de MS2 dans les **conditions de premier défaut**.

NOTE MS1 peut être **accessible** à une **personne ordinaire**.

8.2.3 MS2

MS2 est une source d'énergie mécanique dont les niveaux ne dépassent pas les limites de MS2 dans les **conditions normales de fonctionnement**, les **conditions anormales de fonctionnement** et les **conditions de premier défaut**, mais n'est pas une source MS1.

NOTE MS2 peut être **accessible** à une **personne avertie**, et dans les **conditions de premier défaut**, à une **personne ordinaire**.

8.2.4 MS3

MS3 est une source d'énergie mécanique dont les niveaux dépassent les limites de MS2 dans les **conditions normales de fonctionnement**, les **conditions anormales de fonctionnement** et les **conditions de premier défaut**, ou toute source d'alimentation mécanique déclarée comme devant être traitée comme une source MS3 par le fabricant.

NOTE Les parties classées MS3 peuvent être **accessibles** à une **personne qualifiée**.

8.3 Protection contre les sources d'énergie mécanique

8.3.1 Généralités

Le présent paragraphe spécifie des exigences générales de protection pour les parties **accessibles** aux **personnes ordinaires**, aux **personnes averties** et aux **personnes qualifiées**.

Le Tableau 41 présente un résumé des **protections** nécessaires.

Tableau 41 – Résumé des protections nécessaires

Personne	Nombre de protections nécessaires à interposer entre la source d'énergie et une personne		
	MS1	MS2	MS3
Personne ordinaire	0 ^a	1 ^b	2 ^c
Personne avertie	0	0	2 ^d
Personne qualifiée	0	0	0 ou 1 ^e
^a Voir 4.3.2.1 et 8.3.2. ^b Voir 4.3.2.2, 4.3.2.3 et 8.3.2. ^c Voir 4.3.2.4 et 8.3.2. ^d Voir 4.3.3.2, 4.3.3.3 et 8.3.3. ^e Voir 4.3.4.3 et 8.3.4.			

8.3.2 Protection des personnes ordinaires

Aucune **protection** n'est nécessaire entre MS1 et une **personne ordinaire**.

Au moins une **protection** doit être interposée entre MS2 et une **personne ordinaire**.

A l'exception de ce qui est spécifié en 8.4.2 et 8.5.2, au moins une **protection principale de l'équipement** et une **protection supplémentaire de l'équipement** doivent être interposées entre MS3 et une **personne ordinaire**.

8.3.3 Protection des personnes averties

Aucune **protection** n'est nécessaire entre MS1 ou MS2 et une **personne avertie**. Cependant, pour MS2 dont l'évidence n'est pas apparente, une **protection mise en place sous forme d'instructions** doit être prévue.

A l'exception de ce qui est spécifié en 8.4.2 et 8.5.2, au moins une **protection principale de l'équipement** et une **protection supplémentaire de l'équipement** doivent être interposées entre MS3 et une **personne avertie**.

8.3.4 Protection des personnes qualifiées

Aucune **protection** n'est nécessaire entre MS1, MS2 ou MS3 et une **personne qualifiée**. Cependant, pour MS3 dont l'évidence n'est pas apparente, une **protection mise en place sous forme d'instructions** doit être prévue.

De plus, d'autres parties MS3 ne faisant pas l'objet d'un entretien doivent être localisées ou protégées afin qu'un contact involontaire avec ces parties pendant des opérations d'entretien ne soit pas susceptible de forcer une **personne qualifiée** à reculer vers d'autres sources d'alimentation de classe 2 ou classe 3 faisant l'objet d'un entretien.

NOTE Un mouvement de recul peut se produire lorsque la **personne qualifiée** peut être amenée à pénétrer entièrement ou partiellement à l'intérieur d'un grand équipement pour entretien.

8.4 Protections contre les parties avec arêtes vives et angles vifs

8.4.1 Exigences

Le présent paragraphe spécifie les **protections** qui réduisent la probabilité de blessure par des parties présentant des arêtes et des angles vifs dans des zones **accessibles** de l'équipement.

Une réflexion technique doit être menée pour classer une source d'énergie mécanique en tant que source MS1, MS2 ou MS3 conformément à la ligne 1 du Tableau 40.

A l'exception de ce qui est mentionné en 8.4.2, une **protection** appropriée doit être prévue comme indiqué dans le Tableau 41.

8.4.2 Protection mise en place sous forme d'instructions

Lorsque la présence d'une arête ou d'un angle vif **accessible** est nécessaire pour le fonctionnement de l'équipement:

- toute exposition limitée éventuelle ne doit pas constituer une menace vitale, et
- l'arête ou l'angle vif doit être évident pour une **personne ordinaire** ou une **personne avertie** lorsqu'elle est exposée, et
- l'arête vive doit être protégée dans toute la mesure du possible, et
- une **protection mise en place sous forme d'instructions** doit être utilisée pour réduire tout contact involontaire.

La **protection mise en place sous forme d'instructions** destinée à l'arête ou l'angle vif **accessible** doit être conforme à l'Article F.5 et doit être fixée à l'équipement à proximité de l'arête ou de l'angle vif, et contenir un symbole graphique ou un texte correspondant avec le libellé approprié suivant ou similaire:

AVERTISSEMENT Présence d'arêtes vives. Ne pas toucher.

8.4.3 Conformité

*La conformité est vérifiée par examen et, si nécessaire, par essai de l'Annexe V. Pendant et après l'application de la force, l'arête ou l'angle vif ne doit pas être **accessible**.*

8.5 Protections contre les parties mobiles

8.5.1 Exigences

Le présent paragraphe spécifie les **protections** qui réduisent la probabilité de blessure par des parties mobiles dans des zones **accessibles** de l'équipement (par exemple, les points de pincement, les roues engrenées et les parties qui peuvent commencer à bouger du fait d'un ré-enclenchement non prévu d'un dispositif de commande).

Une réflexion technique doit être menée pour classer une source d'énergie mécanique en tant que source MS1, MS2 ou MS3 conformément à la ligne 2 du Tableau 40.

L'expression « parties mobiles » dans ce paragraphe inclut les pales mobiles d'un ventilateur. Les pales mobiles d'un ventilateur sont classées conformément à la ligne 3 du Tableau 40.

NOTE 1 La capacité d'une partie à provoquer une blessure ne dépend pas uniquement de l'énergie cinétique qu'elle a acquise. Par conséquent, la classification utilisée dans la présente norme peut être fondée uniquement sur l'expérience courante et sur la réflexion technique.

NOTE 2 Les exemples de paramètres qui ont un impact sur le transfert de l'énergie vers une partie du corps incluent la forme de la surface qui rentre en collision avec la partie du corps, l'élasticité, la vitesse et la masse de l'équipement et de la partie du corps.

Une **enveloppe mécanique** ou une barrière utilisée comme une **protection de l'équipement** doit être construite de façon à ce que les parties MS2 ou MS3 ne soient pas **accessibles** à une **personne ordinaire** et que les parties MS3 ne soient pas **accessibles** à une **personne avertie**.

Lorsqu'il existe une probabilité que des doigts, des bijoux, des vêtements, des cheveux, etc. soient pris dans des parties (par exemple, des engrenages), une **protection de l'équipement** doit être prévue pour éviter des blessures.

Si la **protection** est un **verrouillage de sécurité**, ce dernier doit être conforme aux exigences de l'Annexe K. Le mouvement de la partie doit être réduit à la classe MS1 avant que la pièce ne soit **accessible**.

Un ventilateur MS3 disposé, situé, enveloppé ou protégé de manière à ce qu'il soit peu probable qu'une **personne ordinaire** entre en contact avec les parties mobiles du ventilateur lors d'une opération d'entretien, ou qu'une **personne avertie** entre en contact avec ces parties lors d'une même opération, doit être muni d'une **protection mise en place sous forme d'instructions** comme spécifié en 8.5.2.

8.5.2 Partie MS2 ou MS3 devant être accessible pour le fonctionnement de l'équipement

Dans le cas où une partie mobile MS2 ou MS3 doit être **accessible** à une **personne ordinaire** ou à une **personne avertie** pour le fonctionnement de l'équipement:

- toute exposition ne doit pas constituer une menace vitale; et
- la partie mobile doit être évidente lorsque la personne y est exposée; et
- la partie mobile doit être protégée dans toute la mesure du possible; et
- une **protection mise en place sous forme d'instructions** doit être utilisée pour réduire tout contact involontaire; et
- pour une source MS3, un dispositif d'arrêt activé manuellement doit être facilement visible et mis en évidence à environ 750 mm de la partie MS3.

Si la position d'une partie mobile MS3 peut ne pas être évidente pour une **personne qualifiée**, du fait, par exemple, d'un mouvement intermittent, une **protection mise en place sous forme d'instructions** doit être prévue pour réduire tout contact involontaire. Un dispositif d'arrêt activé manuellement doit être facilement visible et mis en évidence à environ 750 mm de la partie MS3.

Les **protections mises en place sous forme d'instructions** pour une partie mobile doivent être conformes à l'Article F.5 et doivent être fixées à l'équipement à proximité de la partie

mobile et contenir un symbole graphique (tel que  pour des pales mobiles de ventilateur) ou du texte correspondant avec le libellé approprié suivant ou similaire:

AVERTISSEMENT
Parties mobiles dangereuses.
Se tenir à l'écart de la zone de mouvement des parties mobiles.

8.5.3 Conformité

L'accessibilité aux parties mobiles doit être vérifiée par examen, et si nécessaire, conformément à l'Annexe V. Le choix de la sonde dépend de l'application.

*La conformité est vérifiée par examen de la construction et des données disponibles, et lorsque nécessaire, par les essais appropriés de l'Annexe T pour les **enveloppes** et les **barrières**.*

La conformité de la stabilité thermoplastique est vérifiée par l'essai mentionné à l'Article T.8 suivi de l'essai de l'Annexe V. Une autre possibilité consiste à vérifier la conformité par examen de la construction et des données disponibles sur le matériau.

8.5.4 Catégories spéciales d'équipements comprenant des parties mobiles

8.5.4.1 Equipement de grande taille pour le stockage des données

Les exigences de la CEI 60950-23 viennent s'ajouter aux exigences correspondantes de la présente norme.

Les dimensions des équipements de grande taille sont telles qu'une personne peut y entrer entièrement. Des systèmes peuvent également comprendre des équipements similaires ayant des zones contenant des parties mobiles dans lesquelles seul un membre entier du corps ou une tête peut y entrer. Ces exigences s'appliquent à une enveloppe en trois dimensions de 0,75 m³ ou plus à proximité de la partie mobile.

Les références suivantes de la CEI 60950-23 doivent être traitées comme suit:

- l'Annexe K remplace 2.8 de la CEI 60950-1:2005;
- l'Article K.4 remplace 2.8.6 de la CEI 60950-1:2005;
- le terme «**personne qualifiée**» remplace le terme «PERSONNEL DE MAINTENANCE»;
- l'expression « zones **accessibles** à une **personne ordinaire** comme déterminé à l'Annexe V » remplace l'expression «ZONE D'ACCÈS DE L'OPÉRATEUR».

NOTE Un système de stockage de données autonome est un exemple de ce type d'équipement utilisé pour le stockage de données.

8.5.4.2 Equipements ayant un dispositif électromécanique pour la destruction de supports

8.5.4.2.1 Exigences générales

Le présent paragraphe concerne la protection des personnes, y compris les enfants, en spécifiant les **protections de l'équipement** sur les équipements conçus pour détruire mécaniquement différents supports au moyen de parties mobiles qui entraînent le support à l'intérieur de l'équipement. Le dispositif de destruction de supports dans cet équipement est classé MS3.

NOTE 1 Les exemples de ce type d'équipement incluent les déchiqueteuses de documents à usage de bureau personnel et à usage domestique et les dispositifs similaires de destruction de supports; ces dispositifs sont caractérisés suivant la nature de leur source de puissance.

Concernant les équipements destinés à être utilisés en des emplacements où des enfants ne sont pas susceptibles d'être présents, voir l'Article F.4.

NOTE 2 La conception de ces équipements s'applique d'ordinaire aux équipements commerciaux ou industriels prévus pour être installés dans des lieux n'accueillant normalement que des adultes.

Les équipements doivent comporter des **protections** de façon à ce que les parties mobiles MS3 ne soient pas **accessibles** à la sonde d'essai articulée correspondante de l'Annexe V et à la sonde en coin de la Figure V.4. Les exigences applicables aux **verrouillages de sécurité** sont conformes à l'Annexe K, à l'exception du fait que lorsque l'énergie d'une partie mobile ne peut pas être réduite à la classe d'énergie appropriée dans un délai de 2 s, le **verrouillage de sécurité** doit continuer à empêcher l'accès.

8.5.4.2.2 Protections mises en place sous forme d'instructions contre les parties mobiles

Une **protection mise en place sous forme d'instructions** doit être prévue conformément à l'Article F.5, et être adjacente à l'orifice d'alimentation du support, prévenant les **personnes ordinaires** sur les points suivants:

- l'équipement n'est pas destiné à être utilisé par des enfants (ce produit n'est pas un jouet);
- éviter que les mains, les vêtements et les cheveux ne touchent l'orifice d'alimentation du support.

Concernant les équipements installés en des emplacements où des enfants sont susceptibles d'être présents, les instructions doivent contenir un énoncé recommandant de débrancher l'équipement lorsque celui-ci n'est pas utilisé pendant une période prolongée.

8.5.4.2.3 Déconnexion de l'alimentation électrique

Un interrupteur d'isolement conforme à l'Annexe L doit être prévu pour couper l'alimentation électrique des parties mobiles MS3. Un interrupteur avec une position « OFF » (arrêt), qui coupe toute alimentation électrique en provenance de la partie mobile MS3 est acceptable. L'interrupteur doit être situé à un endroit facilement **accessible** pour l'utilisateur dont une partie du corps ou des vêtements peuvent être happés par les parties mobiles.

Les positions « ON » (marche) et « OFF » (arrêt) d'un interrupteur à deux positions doivent être marquées conformément à F.3.5.2.

Pour un interrupteur à plusieurs positions, la position « OFF » (arrêt) doit être marquée conformément à F.3.5.2, et les autres positions doivent être marquées avec les libellés ou les symboles appropriés.

8.5.4.2.4 Méthode d'essai

Concernant les dispositifs de destruction de supports du type coupe en bande et dispositifs similaires, la sonde en coin de la Figure V.4 est appliquée avec une force maximale de 45 N.

Concernant les dispositifs de destruction de supports du type coupe en travers et dispositifs similaires, la sonde en coin est appliquée avec une force maximale de 90 N. La force est appliquée dans une direction quelconque par rapport à l'orifice.

NOTE Les dispositifs de destruction de supports sont généralement de deux types, à savoir, à coupe en bande ou à coupe en travers. Un dispositif de destruction de supports à coupe en bande procède au déchetage du support en longues bandes utilisant un mécanisme de déchetage à moteur. Un dispositif de destruction de supports à coupe en travers procède au déchetage du support de deux manières ou plus en petits morceaux (confettis) utilisant généralement un moteur plus puissant et un mécanisme de déchetage plus complexe.

Toute enveloppe ou protection qui peut être déposée ou ouverte par une personne ordinaire ou une personne avertie doit être déposée ou ouverte avant l'application des sondes.

8.5.4.2.5 Conformité

La conformité est vérifiée conformément à V.1.2 et V.1.5. Selon que l'équipement est un dispositif de destruction de supports à coupe en bande ou un dispositif de destruction de supports à coupe en travers, la sonde en coin de la Figure V.4 est appliquée avec les forces spécifiées dans le présent paragraphe. La sonde en coin ne doit entrer en contact avec aucune partie mobile.

Lorsque l'équipement est muni d'un **verrouillage de sécurité**, la conformité est vérifiée selon l'Annexe K, à l'exception du fait que lorsque l'énergie d'une partie mobile ne peut pas être réduite à la classe d'énergie appropriée dans un délai de 2 s, le **verrouillage de sécurité** doit continuer à empêcher l'accès.

8.5.5 Protection des personnes contre le desserrage, l'explosion ou l'implosion de parties

8.5.5.1 Protection contre les parties MS3

Lorsque l'équipement contient des parties fonctionnant à vitesse élevée, des surfaces sous pression ou d'autres éléments similaires, des **protections** doivent être prévues pour empêcher les parties ou les fragments tels des morceaux de support ou de verre de blesser des personnes.

Les équipements ayant les conceptions suivantes sont des exemples considérés comme équipement du type MS3:

- les supports solides amovibles en plastique fonctionnant à des vitesses élevées tels que ceux utilisés dans les lecteurs CD ou DVD dont la vitesse de rotation peut atteindre plus de 8 000 r/min; et
- les tubes cathodiques (CRT) dont la face a une dimension maximale dépassant 160 mm; et
- les lampes dans lesquelles la pression dépasse 0,2 MPa lorsqu'elles sont froides ou 0,4 MPa en fonctionnement sont considérées comme des lampes haute pression et doivent être classées comme éléments du type MS3.

La conformité est vérifiée conformément à 8.5.5.2.1, 8.5.5.2.2 et à l'Annexe U, suivant le cas.

Pour contenir d'autres parties desserrées ou brisées éventuelles, une **double protection** ou une **protection renforcée** doit être suffisamment robuste pour:

- contenir les parties; ou
- réduire l'énergie des parties vers le niveau MS1.

La conformité est vérifiée par examen ou, si nécessaire, par essai. La force d'essai appliquée à l'intérieur de l'enveloppe, si nécessaire, doit être égale à 1,25 fois la force calculée exercée par une partie brisée ou desserrée.

8.5.5.2 Exigences et méthodes d'essai

8.5.5.2.1 Exigences sur les enveloppes mécaniques pour les supports solides en rotation

8.5.5.2.1.1 Généralités

Le présent paragraphe évalue le confinement des supports solides endommagés classés MS3 conformément à 8.5.5.1, qui peuvent voler en éclats dans les **conditions normales de fonctionnement**. L'ensemble amovible porte-enceinte du support est soumis à l'essai conformément à 8.5.5.2.1.2 pour évaluer la taille de l'espacement potentiel pendant l'essai de force statique par lequel des fragments de support peuvent être projetés.

8.5.5.2.1.2 Méthodes d'essai

La taille de l'espacement 'X' entre l'ensemble porte-enceinte et l'enveloppe est mesurée en appliquant la force suivante.

Une force de valeur $F \pm 10\%$ est appliquée sur l'intérieur du couvercle à l'endroit le plus défavorable. La formule de calcul de la force statique à appliquer est la suivante:

$$F = S \times mv^2 / R_o$$

où

- F* est la force à appliquer exprimée en Newtons;
- S* = 0,250 lorsque aucun déflecteur n'est utilisé (en considérant la taille fractionnaire de la masse fragmentaire dans le cas le plus défavorable);
- S* = 0,125 lorsqu'un déflecteur est utilisé (en considérant la taille fractionnaire de la masse fragmentaire dans le cas le plus défavorable);
- m* est la masse du support exprimée en kilogrammes;
- v* est la vitesse du diamètre extérieur du support exprimée en mètres par seconde;
- R_o* est le rayon extérieur du support exprimé en mètres.

NOTE 1 La masse totale du support est celle spécifiée par le fabricant.

NOTE 2 Les supports CD et DVD typiques se situent dans cette plage.

- Pour un CD (conformément à la CEI 60908)
 - épaisseur: 1,20 mm $\begin{smallmatrix} +0,3 \\ -0,1 \end{smallmatrix}$ mm,
 - masse: 14 g à 33 g.
- Pour un DVD (conformément à la norme ECMA-267)
 - épaisseur: 1,20 mm $\begin{smallmatrix} +0,3 \\ -0,06 \end{smallmatrix}$ mm,
 - masse: 13 g à 20 g.

8.5.5.2.1.3 Conformité

La conformité est vérifiée par examen et, si nécessaire, par les essais suivants conformément à la Figure 48 ou 49, selon le cas.

Lorsqu'un déflecteur pour support n'est pas utilisé, le couvercle sur la porte ne doit ni se casser, ni se séparer du lecteur, ni se plier au point de créer une ouverture supérieure à « X » mm, valeur mesurée entre n'importe quelle partie de la porte du support et la surface extérieure de l'enveloppe la plus proche; c'est à travers cette ouverture que des fragments de support peuvent être projetés. Une sonde cylindrique ou une jauge d'épaisseur doit être utilisée pour mesurer l'ouverture (voir la Figure 48). « X » est l'épaisseur la plus faible du support en millimètres spécifiée par le fabricant.

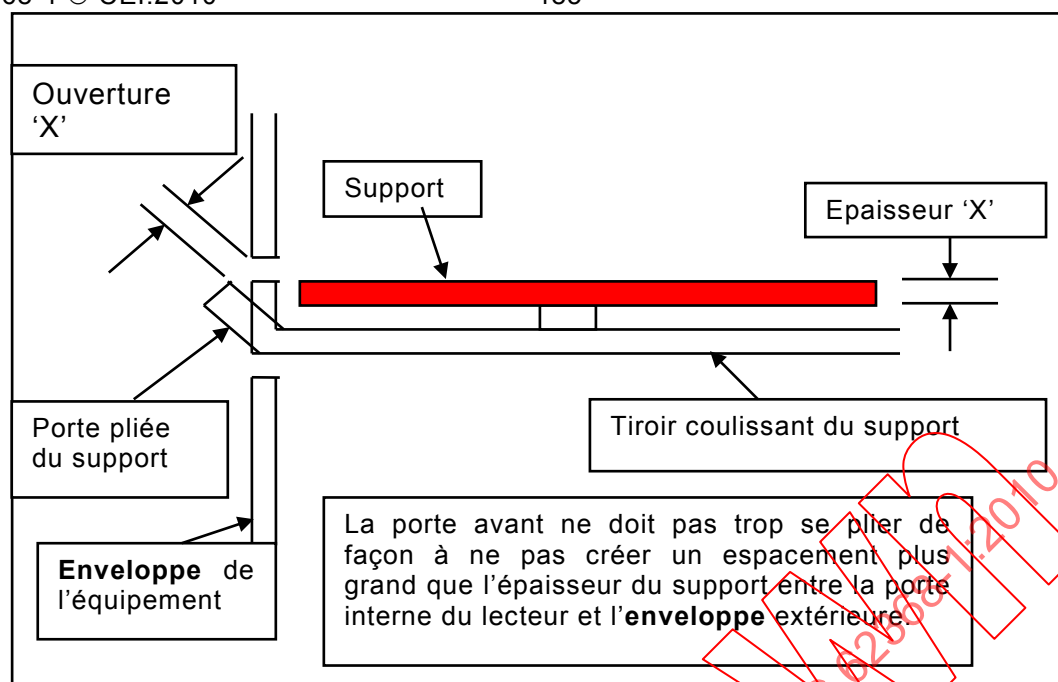


Figure 48 – Exemple de détermination de l'ouverture « X » sans déflecteur

Lorsqu'un déflecteur de support est utilisé, le couvercle sur l'ensemble porte-déflecteur ne doit ni se casser, ni se séparer du lecteur ni se plier au point de créer une ouverture par laquelle des fragments de support peuvent être projetés (voir la Figure 49).

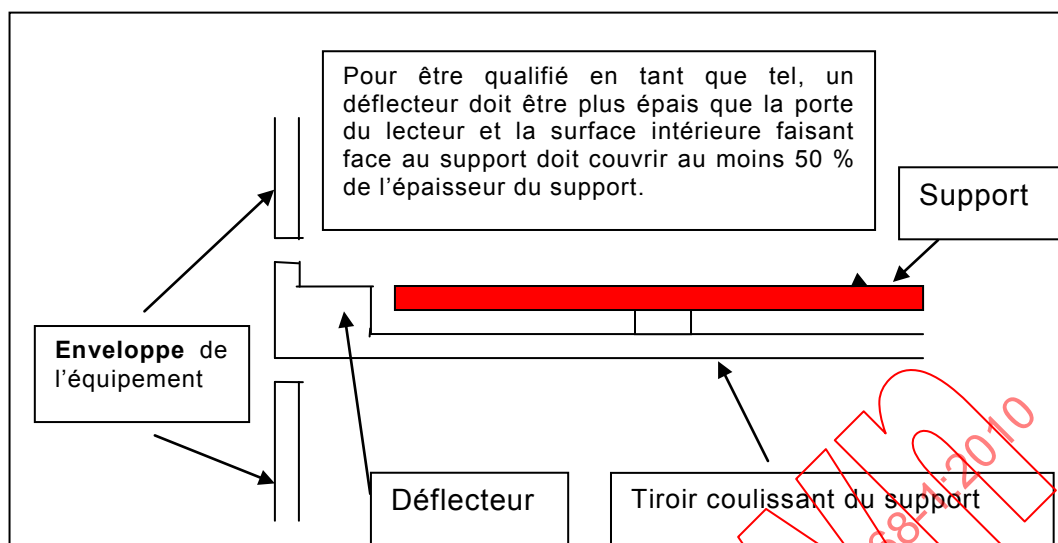


Figure 49 – Exemple de détermination de l'ouverture « X » avec déflecteur

8.5.5.2.2 Lampes haute pression

8.5.5.2.2.1 Généralités

Le mécanisme de confinement pour les lampes haute pression classées MS3 doit avoir une résistance appropriée pour contenir l'explosion d'une lampe afin de réduire la probabilité de blessure pour une **personne ordinaire** ou une **personne avertie** pendant une utilisation normale ou au cours du remplacement de la lampe équipée, selon le cas.

Les particules sont considérées comme des parties de classe MS1 si elles sont contenues dans la lampe équipée ou l'enveloppe de l'équipement d'après l'essai effectué conformément à 8.5.5.2.2.2.

Les particules sont considérées comme des parties de classe MS2 si la taille d'une particule est inférieure à 0,8 mm sur l'axe le plus long.

Les particules sont considérées comme des parties de classe MS3 si la taille d'une particule est supérieure ou égale à 0,8 mm sur l'axe le plus long.

8.5.5.2.2.2 Méthodes d'essai

Concernant la protection contre les effets dus à une défaillance d'une lampe à haute pression, l'essai suivant est effectué comme suit:

- les lampes considérées comme des parties de classe MS3 pendant un remplacement sur site sont soumises à l'essai dans le cadre de la lampe équipée séparée de l'équipement;
- les lampes considérées comme des parties de classe MS3 uniquement pendant leur fonctionnement peuvent être soumises à l'essai séparément dans leur lampe équipée, ou à leur emplacement normal dans l'équipement, ou les deux.

L'explosion d'une lampe est stimulée par impact mécanique, par un générateur d'impulsions électroniques ou par une méthode similaire. La lampe doit fonctionner pendant au moins 5 min afin qu'elle atteigne sa température et sa pression de fonctionnement. Pour évaluer les résultats de la rupture du point de vue de la zone de débris potentielle et de la taille des particules, un tapis source potentielle d'incendie foncé et collant de taille appropriée (ou toute autre méthode adéquate) est placé près de l'orifice de sortie de l'équipement. L'ouverture de l'équipement doit être orientée de façon à évaluer le mieux possible la quantité de particules

éjectées horizontalement en provenance du produit vers le tapis source potentielle d'incendie foncé et collant. Après la rupture, les particules de verre générées sont mesurées à l'aide d'une loupe ayant une résolution de 0,1 mm. L'essai doit être effectué pour simuler la position de fonctionnement la plus défavorable spécifiée dans les instructions.

NOTE Il est recommandé de disposer d'un tapis source potentielle d'incendie collant de couleur bleu foncé pour un examen plus aisé des débris de verre potentiels.

Un exemple illustrant la méthode utilisant un générateur d'impulsions électroniques est donné à la Figure D.3.

La charge est augmentée par pas de 5 J jusqu'à ce que les ruptures de lampe deviennent répétitives.

8.5.5.2.2.3 Conformité

La conformité est vérifiée par examen physique, ou, si nécessaire, par les essais de 8.5.5.2.2.2.

Une fois l'essai effectué, examiner les particules de verre se trouvant sur le tapis source potentielle d'incendie collant et foncé. Aucune particule MS3 ne doit être trouvée et aucune particule MS2 ne doit être trouvée au-delà de 1 m de l'ouverture de l'enveloppe.

8.6 Stabilité de l'équipement

8.6.1 Exigences

Le présent paragraphe stipule les exigences de performance qui réduisent la probabilité que l'équipement MS2 ou MS3 devienne physiquement instable au point de se renverser.

La classification des produits dans le but d'évaluer la stabilité de l'équipement doit être effectuée selon le Tableau 40, ligne 5.

Les équipements MS2 ou MS3 non fixés doivent être soumis à l'essai de stabilité de 8.6.2.2 à un angle de 10°.

NOTE Parmi les exemples de ce type d'équipement, on compte certains systèmes de haut-parleur et certains systèmes audio.

Les équipements MS2 ou MS3 non fixés, dont les commandes sont normalement accessibles ou ayant un affichage à images mobiles, doivent être soumis à l'essai conformément aux essais de pose au sol de 8.6.2 et aux essais de non pose au sol de 8.6.3 selon le cas.

Les équipements MS2 ou MS3 posés au sol et fixés à la structure du bâtiment doivent être soumis à l'essai de force horizontale de 8.7.2 uniquement.

Les unités individuelles qui sont conçues pour être fixées ensemble mécaniquement sur place et ne sont pas utilisées individuellement, ou l'**équipement stationnaire**, doivent être évalués par examen après installation, conformément aux instructions du fabricant et, si nécessaire, soumis à essai conformément à 8.6.2.2.

Lorsque des matériaux thermoplastiques sont impliqués dans la construction, les essais mécaniques adaptés doivent être réalisés après l'essai de relaxation des contraintes de l'Article T.8 lorsque l'équipement a refroidi et a atteint la température ambiante.

Les équipements MS3 qui ne sont pas posés au sol sont soumis à essai conformément à 8.6.3.1 et 8.6.3.2, et doivent avoir une **protection mise en place sous forme d'instructions** conformément à l'Article F.5, les éléments 3 et 4 situés dans les instructions d'installation ou d'utilisation comportant les informations suivantes ou équivalentes:

AVERTISSEMENT

Ne jamais placer l'équipement dans un endroit instable. L'équipement est susceptible de tomber et de causer des blessures corporelles graves ou la mort. De nombreuses blessures, en particulier sur les enfants, peuvent être évitées en prenant de simples précautions telles que:

- Utiliser les coffres ou supports recommandés par le fabricant de l'équipement.
- Utiliser uniquement les meubles qui peuvent soutenir les équipements de manière sécurisée.
- S'assurer que l'équipement ne dépasse pas du bord du meuble qui le soutient.
- Ne pas placer l'équipement sur des meubles hauts (par exemple, des armoires ou des bibliothèques) sans accrocher le meuble et l'équipement à un support adapté.
- Ne pas placer l'équipement sur un tissu ou d'autres matériaux se trouvant entre l'équipement et le meuble qui le soutient.
- Enseigner aux enfants les dangers de monter sur les meubles pour atteindre l'équipement ou ses commandes.

8.6.2 Stabilité statique pour les équipements posés au sol

8.6.2.1 Exigences

Le présent paragraphe traite de la stabilité de l'équipement qui peut être manipulé ou déplacé pendant l'utilisation normale ou l'installation.

Les équipements MS2 ou MS3 ne doivent pas se renverser s'ils sont installés conformément aux instructions d'installation ou lors d'un déplacement.

L'équipement doit être bloqué, si nécessaire, au moyen d'une cale de la plus petite dimension possible, pour l'empêcher de glisser ou de rouler pendant l'essai. Pendant les essais, les récipients, s'il y en a, doivent contenir la quantité de substance, d'après leur capacité assignée, qui correspond aux conditions les plus défavorables.

La conformité est vérifiée par examen ou, si nécessaire, par essai. L'équipement ne doit pas se renverser.

8.6.2.2 Essai de stabilité statique

*Toutes les portes, tiroirs, roulettes, pieds réglables et autres parties mobiles, s'ils sont utilisés par une **personne ordinaire**, sont disposés dans toute combinaison entraînant la plus faible stabilité. Les équipements dont les caractéristiques permettent des positions multiples doivent être soumis à essai dans la position la plus défavorable permise par la construction de l'équipement. Cependant, si les roulettes sont uniquement conçues pour transporter l'équipement et si les instructions d'installation nécessitent que les pieds réglables soient baissés après l'installation, alors les pieds réglables (et non les roulettes) sont utilisés dans cet essai.*

- a) *L'équipement MS3 ne doit pas se renverser lorsqu'une force correspondant à 20 % du poids de l'équipement mais inférieure à 250 N est appliquée dans une direction quelconque, sauf vers le haut, en tout point de l'équipement de manière à produire le moment de renversement maximal, et ce, à une hauteur ne dépassant pas 1,5 m du sol. La force d'essai doit être interrompue si l'équipement reste stable après avoir été incliné de 15° par rapport à la verticale. En variante, l'équipement doit être renversé à un angle inférieur ou égal à 15° par rapport à la verticale.*
- b) *L'équipement MS3 ne doit pas se renverser lorsqu'une force constante de 800 N vers le bas est appliquée au point de levier pour un moment maximal sur une surface horizontale*

d'au moins 125 mm sur au moins 200 mm, à une hauteur inférieure ou égale à 1 m du sol. La force de 800 N est appliquée par l'intermédiaire d'un appareil d'essai adapté ayant une surface plate d'environ 125 mm par 200 mm. La force dirigée vers le bas est appliquée sur la surface plate complète de l'**outil** d'essai en contact avec l'équipement; il n'est pas nécessaire que l'appareil d'essai soit en contact total avec des surfaces irrégulières (par exemple, des surfaces ondulées ou courbes). Les équipements dont la forme ou la souplesse de la surface n'est pas susceptible d'être utilisée comme marche ou comme échelle sont exclus de l'essai.

NOTE Des exemples de ce type d'équipement sont les produits associés à un chariot ou un support ou les produits avec saillie ou retrait qui ne doivent vraisemblablement pas être utilisés comme marche ou comme échelle.

Lorsque l'équipement MS3 est soumis à une maintenance périodique ou à un entretien régulier ou lorsqu'il est réparé à l'endroit de son utilisation normale, les portes, tiroirs, etc. ou tout autre moyen d'ajustement **accessible** à une **personne avertie** ou **qualifiée** doit être disposé selon la combinaison spécifiée par les instructions d'entretien entraînant la plus faible stabilité. L'essai de a), ci-dessus, est répété si nécessaire.

8.6.2.3 Essai de stabilité de déplacement

Les portes, tiroirs, roulettes, pieds réglables et autres parties mobiles des équipements posés au sol et censés être déplacés par des **personnes ordinaires**, et dont le diamètre minimal des roues est inférieur à 100 mm, doivent être disposés dans toute combinaison entraînant la plus faible stabilité. Un équipement dont les caractéristiques permettent des positions multiples doit être soumis à essai dans la position la plus défavorable permise par la construction de l'équipement.

Les portes, tiroirs, etc. des équipements posés au sol et censés être déplacés par une **personne avertie** ou une **personne qualifiée**, et dont le diamètre minimal des roues est inférieur à 100 mm, doivent être positionnés conformément aux instructions du fabricant. Un équipement dont les caractéristiques permettent des positions multiples doit être soumis à essai dans la position la plus défavorable permise par la construction de l'équipement.

Les équipements MS2 ou MS3 posés au sol ne doivent pas se renverser lorsqu'ils sont inclinés à un angle de 10° dans toute direction par rapport à leur position droite normale. Si l'équipement est tel que lorsqu'il est incliné à un angle de 10° en étant posé sur un plan horizontal, une de ses parties qui n'est pas normalement en contact avec la surface d'appui touche le plan horizontal, alors l'équipement est placé sur un support horizontal afin que le contact ne soit pas avec la surface horizontale et que la combinaison soit inclinée dans la direction la plus défavorable à un angle de 10°. En variante, l'équipement peut être placé sur un plan, puis est soumis à une rotation selon un angle de 360° par rapport à son axe vertical normal lorsqu'il est incliné à un angle de 10°.

NOTE L'essai sur le support horizontal peut être nécessaire (par exemple, pour les équipements pourvus de petits pieds, de roulettes ou d'accessoires similaires).

8.6.3 Équipements non posés au sol avec des commandes normalement accessibles en usage normal ou ayant des affichages à images mobiles

8.6.3.1 Essai de lame de verre

Les équipements MS2 ou MS3 (sauf les équipements posés au sol) susceptibles d'être utilisés dans les maisons individuelles ou environnements d'installation similaires où ils peuvent être **accessibles** aux enfants, sont placés sur une surface horizontale propre, sèche et couverte de verre afin que seuls les pieds de support soient en contact avec le verre. La surface couverte de verre est ensuite inclinée dans la direction la plus défavorable à un angle de 10°.

Pendant les essais, l'équipement ne doit pas glisser ou se renverser.

8.6.3.2 Essai de force horizontale

8.6.3.2.1 Généralités

Le présent paragraphe traite du risque que les enfants soient attirés par les équipements MS2 ou MS3 susceptibles d'être élevés au-dessus du sol avec des commandes normalement **accessibles** ou des affichages à images mobiles qui poussent les enfants à essayer de monter sur les dispositifs susceptibles de se renverser facilement. Cette exigence ne s'applique pas aux autres équipements.

NOTE On considère que les équipements ayant les commandes d'utilisateur montées à l'avant et comportant des images mobiles augmentent la fréquence d'enfants attirés par les écrans, augmentant ainsi la probabilité que les enfants essayent de monter sur l'équipement ou de le déplacer.

8.6.3.2.2 Méthode d'essai

Les équipements MS2 ou MS3 doivent être placés sur une surface horizontale antidérapante avec toutes les portes, tiroirs, roulettes, pieds réglables et toutes autres parties mobiles disposés selon la combinaison entraînant la plus faible stabilité. L'équipement doit être bloqué, si nécessaire, au moyen d'une cale de la plus petite dimension possible, pour l'empêcher de glisser ou de rouler lorsqu'il est soumis à l'un des essais suivants:

- a) une force horizontale extérieure égale à 13 % du poids de l'équipement ou 100 N, la valeur la plus faible étant retenue, est appliquée dans une direction horizontale en un point de l'équipement qui entraîne la plus faible stabilité. Cette force ne doit pas être appliquée à plus de 1,5 m au-dessus de la surface d'appui; ou*
- b) l'équipement doit être déplacé suivant tout angle d'inclinaison inférieur ou égal à 15° par rapport à la verticale.*

Pendant l'essai, l'équipement ne doit pas se renverser.

8.7 Equipement monté sur un mur ou au plafond

8.7.1 Généralités

Le présent paragraphe stipule comment réduire la probabilité de blessure causée par la chute d'un équipement due à un dysfonctionnement des moyens de montage.

Les moyens de montage des équipements MS2 ou MS3 conçus pour être montés sur un mur ou au plafond doivent être capables de supporter verticalement quatre fois le poids de l'équipement et aussi une contrainte latérale. Le matériel de montage doit être fourni avec l'équipement ou décrit en détail dans les instructions d'utilisation (par exemple, la longueur des vis et le type de surface de montage adaptée à l'installation, etc.). La classification des équipements dans le but d'évaluer les moyens de montage sur le mur doit être effectuée selon le Tableau 40, ligne 6.

8.7.2 Méthode d'essai

L'équipement est monté en conformité avec les instructions du fabricant et, si possible, les moyens de montage sont positionnés de manière à représenter la plus grande contrainte sur les supports.

Une force vers le bas, en plus du poids de l'équipement, est appliquée vers le bas au centre de gravité pendant 60 s. La force ajoutée doit être égale à trois fois le poids de l'équipement, mais à un minimum de 50 N au total. L'équipement et ses moyens de montage associés doivent rester fixés pendant l'essai.

En outre, pour les équipements montés sur le mur, une force horizontale de 50 N est appliquée latéralement pendant 60 s.

8.7.3 Conformité

La conformité est vérifiée par examen de la construction et des données disponibles, ou si nécessaire, par l'essai de 8.7.2.

8.8 Méthode d'essai de la force de la poignée

8.8.1 Généralités

Le présent paragraphe stipule comment réduire la probabilité de blessure due à un dysfonctionnement d'une poignée entraînant la chute de l'équipement, sauf pour les équipements MS1 n'ayant qu'une poignée.

Le présent paragraphe s'applique à une poignée dont la fonction déclarée par le fabricant est de soulever ou porter l'équipement.

Pour les besoins du présent paragraphe, l'équipement est classifié conformément au Tableau 40, ligne 5.

8.8.2 Conformité et méthode d'essai

L'équipement doit satisfaire à l'essai suivant:

Un poids doit être uniformément appliqué sur une largeur de 75 mm au centre de la poignée, sans serrage.

Le poids doit correspondre au poids de l'équipement plus un autre poids, tel que stipulé ci-dessous:

- pour l'équipement MS1, avec deux poignées ou plus, un poids qui exerce une force de trois fois le poids de l'équipement;*
- pour l'équipement MS2, un poids qui exerce une force de trois fois le poids de l'équipement;*
- pour l'équipement MS3 avec une masse inférieure ou égale à 50 kg, un poids qui exerce une force de deux fois le poids de l'équipement ou 75 kg, la valeur la plus grande étant retenue;*
- pour l'équipement MS3 avec une masse supérieure à 50 kg, un poids qui exerce une force d'une fois le poids de l'équipement ou 100 kg, la valeur la plus grande étant retenue.*

Le poids supplémentaire doit commencer à zéro et augmenter progressivement afin que la valeur d'essai soit atteinte en 5 s à 10 s et maintenue pendant 60 s. Lorsque l'équipement comporte deux poignées ou plus, la force doit être répartie entre les différentes poignées. La répartition des forces doit être déterminée en mesurant le pourcentage du poids de l'équipement soutenu par chaque poignée avec l'équipement dans la position de portage prévue. Lorsque l'équipement MS2 est équipé de plus d'une poignée et qu'il est considéré capable d'être porté par une seule poignée, chaque poignée doit être capable de soutenir la force totale.

A la suite de l'essai, la poignée, ses moyens de fixation ou la partie de l'enveloppe à laquelle elle est fixée, ne doivent pas se rompre, se fissurer ou se détacher de l'équipement.

8.9 Exigences relatives aux attaches des roues ou des roulettes

8.9.1 Généralités

Le présent paragraphe stipule comment réduire la probabilité que des équipements MS3 et certains MS2, y compris des chariots, des supports ou des éléments de support semblables de l'équipement ne se renversent lorsqu'ils sont en mouvement. Pour les besoins du présent paragraphe, l'équipement est classifié selon le Tableau 40, ligne 5.

8.9.2 Méthode d'essai

*Les roues ou roulettes des équipements MS3 ou leur chariot, support ou élément de support semblable, prévus pour être déplacés dans le cadre des **conditions normales de fonctionnement**, doivent être capables de supporter une traction de 20 N sans être endommagés ou séparés de leurs moyens de fixation. La force de traction doit être appliquée par un poids ou une traction régulière à la roue ou roulette pendant une période de 1 min dans toutes les directions rendues possibles par la construction.*

8.10 Chariots, supports et éléments de support semblables

8.10.1 Généralités

Le présent paragraphe stipule comment réduire le risque de renversement, de rupture de matériau ou de décalage des chariots, supports ou éléments de supports semblables adaptés à l'équipement monté.

L'équipement doit être stable par rapport au chariot, support ou élément de support semblable. Pour les besoins du présent paragraphe, les classifications MS du Tableau 40, ligne 5, sont appliquées en utilisant la masse combinée des équipements et des chariots ou supports spécifiés avec l'équipement.

Tous les chariots et supports spécifiés pour une utilisation avec l'équipement doivent être soumis aux essais applicables décrits dans les paragraphes suivants. Les chariots, supports ou éléments de support semblables doivent être soumis aux essais applicables, seuls puis avec les équipements spécifiés par le fabricant placés sur le chariot ou le support.

Les équipements MS3, y compris leurs chariots de support, supports et éléments de support semblables, qui ne sont pas déplacés dans le cadre des **conditions normales de fonctionnement**, doivent être conformes à l'essai de force horizontale de 8.6.3.2.

Les équipements MS2 ou MS3, qui ont une hauteur de plus de 1 m, y compris ceux montés sur leurs chariots, supports ou éléments de support spécifiés, doivent être conformes à l'essai de stabilité de déplacement en 8.6.2.3, à la différence que l'angle d'inclinaison devient 15°. Si l'équipement est pourvu de roues ou roulettes qui permettent à l'équipement de se déplacer uniquement dans des directions limitées, l'essai n'est réalisé que dans ces directions-là (par exemple, un tableau blanc électronique).

8.10.2 Marquage et instructions

Un chariot, support ou élément de support semblable spécifié par le fabricant pour une utilisation avec des équipements spécifiques, mais conditionné et vendu séparément de l'équipement, doit être fourni avec une **protection mise en place sous forme d'instructions**, conformément à l'Article F.5.

Les éléments 2, 3 et 4, selon le cas, doivent inclure le nom du fabricant, une dénomination de catalogue distinctive de l'équipement à supporter, le modèle ou la série, ainsi que le nom de l'équipement et l'énoncé ou texte équivalent suivant:

ATTENTION

Ce (chariot, support ou élément de support) est conçu pour être utilisé uniquement avec (nom du fabricant), (numéro de modèle ou de série), (nom de l'équipement).

Toute utilisation avec un autre équipement peut causer une instabilité entraînant des blessures.

Lorsqu'il est impossible d'inclure la dénomination du numéro ou de la série du modèle de l'équipement spécifique sur le chariot, le support ou l'élément de support semblable, cette information doit être donnée dans les instructions.

Les équipements conçus et vendus uniquement pour être utilisés avec un chariot, un support ou un élément de support semblable spécifique doivent être fournis avec une **protection mise en place sous forme d'instructions** conformément à l'Article F.5.

Les éléments 2, 3 ou 4, selon le cas, doivent inclure:

ATTENTION

Ce (nom de l'équipement) est conçu pour être utilisé uniquement avec (nom du fabricant), (numéro de modèle ou de série), (chariot, support ou élément de support). Toute utilisation avec d'autres (chariots, supports ou éléments de support) peut causer une instabilité entraînant des blessures.

8.10.3 Essai de chargement de chariot, de support ou élément de support et conformité

*Les chariots, supports ou éléments de support doivent être construits de telle manière que les déformations ou endommagements permanents pouvant entraîner des blessures chez une personne, ne se produisent pas lorsqu'ils sont soumis à une force de 220 N appliquée pendant 1 min à tout point de levier ou de prise **accessible** à un enfant.*

Pour déterminer la conformité, la force est appliquée à travers l'extrémité d'un cylindre circulaire de 30 mm de diamètre. La force doit être appliquée à un tiroir d'étagère ou à un support à cheville ou à une partie équivalente qui se situe à moins de 750 mm du sol et qui supporte tout ou partie du poids d'un enfant. La force doit être appliquée pendant 1 min avec le chariot ou support à la température ambiante. La partie ne doit pas s'effondrer ou se rompre et exposer ainsi des arêtes vives ou produire des points de pincement susceptibles d'entraîner des blessures.

De plus, les chariots, supports ou autres éléments de support doivent être construits de telle manière que les déformations ou endommagements permanents pouvant entraîner des blessures chez des personnes ne se produisent pas lorsque chaque surface d'appui est individuellement chargée avec:

- la charge prévue du fabricant plus 440 N pour la surface censée supporter un affichage à images mobiles; ou*
- quatre fois la charge prévue du fabricant ou 100 N, la valeur la plus grande étant retenue, mais ne dépassant pas 440 N, est appliquée à toutes les surfaces applicables.*

Une zone de stockage dédiée prévue pour contenir des accessoires spécifiques tels que les cassettes, les disques etc. doit être complètement remplie au niveau de la charge assignée.

Le poids doit être appliqué pendant 1 min sur chaque surface d'appui, avec les autres surfaces d'appui déchargées.

8.10.4 Essai de choc sur chariot, support ou élément de support

Lorsqu'ils sont soumis à essai conformément à la description ci-dessous, les chariots, supports ou éléments de support ne doivent pas représenter un risque de blessures pour les personnes.

Un choc unique de 7 J doit être appliqué à une partie du chariot ou du support et la méthode d'essai doit être telle que décrite à l'Article T.6. Cependant, un chariot, support ou élément de support en verre doit être soumis à essai conformément à T.9.1.

8.10.5 Stabilité mécanique

Les chariots, supports ou éléments de support, y compris ceux posés au sol, et, le cas échéant, en combinaison avec leurs équipements MS2 ou MS3 prévus, doivent être soumis aux essais applicables décrits en 8.6.2.3 et 8.6.3.2.

Pour les besoins de ces essais, le poids doit être considéré comme le poids total de l'équipement plus le poids du chariot, du support ou de l'élément de support. L'équipement doit être installé conformément aux instructions du fabricant et la force horizontale doit être appliquée au chariot, support ou élément de support ou à l'équipement prévu afin de produire un moment de renversement maximal sur l'équipement à un point situé à une hauteur maximale de 1,5 m au-dessus du niveau du sol.

Si lors des essais de 8.6.2.3 et 8.6.3.2, l'équipement commence à glisser ou à s'incliner par rapport au chariot, support ou élément de support, seul l'essai de force horizontale doit être répété en réduisant la force à 13 % du poids de l'équipement seul ou à 100 N, la valeur la plus basse étant retenue.

L'équipement et le chariot ou le support ne doivent pas se renverser.

8.10.6 Stabilité en température des matériaux thermoplastiques

Un équipement, chariot, support ou élément de support construit dans des matériaux thermoplastiques doit subir l'essai de l'Article T.8, sans contraction, gauchissement ou autre déformation des matériaux thermoplastiques qui empêchent que l'équipement soit conforme à 8.10.3, 8.10.4 et 8.10.5.

8.11 Moyens de montage des équipements montés sur casier

8.11.1 Exigences

Le présent paragraphe s'applique aux moyens de montage des équipements MS2 et MS3 installés dans un casier, qui peuvent être éloignés de ce dernier pour l'installation, l'entretien et autres opérations similaires. Cette exigence ne s'applique pas aux équipements fixés en place, sous-ensembles d'équipements ou casiers dont la position d'installation supérieure présente une hauteur inférieure à 1 m par rapport à la surface d'appui.

Pour les besoins du présent paragraphe, les moyens de montage mécaniques sont désignés comme constituant un rail de glissière. Ce paragraphe spécifie les exigences permettant au rail de glissière de réduire la probabilité de blessure en maintenant l'équipement dans une position sécurisée et en ne permettant pas aux rails de glissière de se gondoler, aux moyens d'attachement de se rompre ou à l'équipement de glisser au-delà de l'extrémité des rails de glissière.

NOTE 1 Les rails de glissière incluent les glissières de support, les glissières de friction ou d'autres moyens de montage équivalents.

NOTE 2 Les ensembles de rails de glissière de parties/unités intégrées du produit fini (par exemple, bacs d'alimentation à extraction des photocopieurs/imprimantes) ne sont pas considérés comme des équipements montés sur casier.

La classification des produits dans le but d'évaluer la stabilité de l'équipement doit être effectuée selon le Tableau 40, ligne 5.

De tels rails de glissière doivent être munis de butées d'extrémité qui empêchent l'équipement de glisser involontairement au-delà des moyens de montage.

8.11.2 Essai de résistance mécanique, à une force variable N

Le rail de glissière doit être installé sur un casier avec l'équipement, ou un dispositif équivalent, conformément aux instructions du fabricant. Avec les équipements montés dans leur position étendue, une force supplémentaire au poids de l'équipement doit être appliquée vers le bas au centre de gravité pendant 1 min au moyen d'un appareil d'essai adapté qui crée un contact sur une surface plane circulaire de 30 mm de diamètre. Si l'application de cette force est susceptible d'endommager l'équipement, un plateau en métal ou d'autres moyens de répartir la force peuvent être placés sous l'appareil d'essai. La force totale doit

être calculée sur la base de la masse de l'équipement plus une masse supplémentaire, comme déterminé ci-dessous.

NOTE Cette force supplémentaire est censée prendre en compte les autres objets ou dispositifs pouvant être empilés au sommet de l'équipement monté sur casier en position étendue lors de l'installation d'un autre équipement.

Pour les équipements montés sur rails de glissière où les rails de glissière sont montés horizontalement de chaque côté de l'équipement, la force totale appliquée aux rails de glissière doit être égale à la plus grande des deux valeurs suivantes:

- 150 % de la masse de l'équipement plus 330 N,
- 150 % de la masse de l'équipement, plus une masse supplémentaire, où cette dernière masse est égale à la masse de l'équipement ou 530 N, selon la plus petite valeur.

Pour les équipements montés sur rails de glissière où les rails de glissière sont montés verticalement sur le haut et dans le fond de l'équipement dans le casier, la force totale appliquée aux rails de glissière doit être égale à 150 % de la masse de l'équipement, avec une force minimale de 250 N et une force maximale de 530 N.

*Si la surface d'appui est conçue pour être une étagère, alors la répartition de la force sur un plateau de métal sous l'appareil d'essai ne s'applique pas. Le fabricant doit spécifier la charge maximale censée être placée sur l'étagère dans le but de déterminer la force qui doit être appliquée sur l'étagère. Une **protection mise en place sous forme d'instructions** doit être apportée à l'étagère pour indiquer le poids maximal pouvant être ajouté à l'étagère. L'essai de force doit être réalisé à 125 % du poids maximal spécifié par le fabricant. La force doit être appliquée directement au moyen de l'appareil d'essai assurant le contact avec une surface plane circulaire de 30 mm de diamètre.*

8.11.3 Essai de résistance mécanique, avec application d'une force de 250 N, y compris les butées d'extrémité

Les équipements montés sur rails de glissière sont installés dans un casier conformément aux instructions du fabricant. Une force statique de 250 N est appliquée sur les équipements montés sur rails de glissière, dans toutes les directions sauf vers le haut, afin d'inclure la position la plus défavorable des équipements montés sur rails de glissière, pendant 1 min. Cette force est appliquée aux équipements montés sur rails de glissière dans leur position entièrement étendue (entretien) et leur position normalement en retrait (fonctionnement) au moyen d'un instrument d'essai adapté assurant le contact sur une surface plane circulaire de 30 mm de diamètre. La force est appliquée avec la surface plane complète de l'instrument d'essai en contact avec l'équipement. Il n'est pas nécessaire que l'instrument d'essai soit en contact total avec des surfaces irrégulières (par exemple, des surfaces ondulées ou courbes).

NOTE Des exigences supplémentaires pour un essai de force dynamique sur les butées d'extrémité sont en cours de développement.

8.11.4 Conformité

La conformité est vérifiée par examen et par les données disponibles du fabricant. Si les données ne sont pas disponibles, les essais conformes à 8.11.2 et 8.11.3 sont alors effectués.

L'équipement et ses rails de glissière associés doivent rester fixés pendant les essais. Un cycle complet de déplacement sur les rails de glissière doit être effectué après chaque essai. Si les moyens de montage ne sont pas en mesure d'effectuer un cycle complet sans fixation, une force horizontale de 100 N doit être appliquée au centre de la partie avant de l'équipement, et ce, afin de rentrer entièrement l'équipement dans le casier. Si l'équipement ne parvient pas à rentrer entièrement dans le casier, les moyens de montage ne doivent pas présenter de flexion ou de gondolement à un degré susceptible d'entraîner des blessures. Les butées d'extrémité doivent maintenir l'équipement dans une position sécurisée et ne doivent pas permettre à l'équipement de glisser au-delà de l'extrémité des rails de glissière.

8.12 Antennes télescopiques ou fouets

Les antennes télescopiques ou les antennes fouets doivent être munies à leur extrémité d'un bouton ou d'une bille de diamètre minimal de 6,0 mm. Une extrémité d'antenne et les sections d'une antenne télescopique doivent être fixées de manière à ce qu'elles ne puissent pas être enlevées.

La conformité est vérifiée par examen et par l'essai de l'Article T.10.

9 Brûlure thermique

9.1 Généralités

Le présent article spécifie des protections permettant de réduire la probabilité de brûlure de la peau à la suite d'une conduction d'énergie thermique depuis des parties de l'équipement.

9.2 Classifications des sources d'énergie thermique

9.2.1 Généralités

Le présent paragraphe décrit les différentes sources d'énergie et définit leurs limites dans les **conditions normales de fonctionnement** et dans les **conditions anormales de fonctionnement** à une température ambiante normale de 25 °C. Les **conditions de premier défaut** ne sont pas prises en compte.

9.2.2 TS1

TS1 est une source d'énergie thermique avec des niveaux ne dépassant pas les limites de TS1 du Tableau 42 dans les **conditions normales de fonctionnement** et ne dépassant pas les limites de TS2 du Tableau 42 dans les **conditions anormales de fonctionnement**. Si, dans les **conditions anormales de fonctionnement**, l'équipement continue de fonctionner, TS1 ne dépasse pas les limites de TS2 spécifiées pour des durées de contact de moins de 1 s. Aucune limite ne s'applique lorsque la défaillance de l'équipement est évidente.

NOTE TS1 peut être **accessible** à une **personne ordinaire**.

9.2.3 TS2

TS2 est une source d'énergie thermique avec des niveaux dépassant les limites de TS1 dans les **conditions normales de fonctionnement** mais ne dépassant pas les limites de TS2 du Tableau 42 dans les **conditions normales** et **anormales de fonctionnement**. Si, dans les **conditions anormales de fonctionnement**, l'équipement continue de fonctionner, les limites de TS2 spécifiées pour des durées de contact de moins de 1 s s'appliquent. Aucune limite ne s'applique lorsque la défaillance de l'équipement est évidente.

NOTE TS2 peut être **accessible** à une **personne avertie**, et dans les **conditions de premier défaut**, à une **personne ordinaire**.

TS2 peut être **accessible** à des **personnes ordinaires** si une **protection mise en place sous forme d'instructions** est en place.

9.2.4 TS3

TS3 est une source d'énergie thermique avec des niveaux dépassant les limites de TS2 appropriées du Tableau 42 dans les **conditions normales de fonctionnement** et les **conditions anormales de fonctionnement**, ou toute source d'énergie thermique déclarée comme TS3.

NOTE Les parties et surfaces classées TS3 peuvent être **accessibles** à une **personne qualifiée**.

9.2.5 Niveaux de température de contact

Tableau 42 – Limites de température de contact

	Parties accessibles ^a	Température maximale (T_{max}) °C			
		Métal	Verre, porcelaine et matériau vitreux	Plastique et caoutchouc ^b	Bois
TS1	Poignées, boutons, prises, etc., et surfaces externes tenus en utilisation normale (> 1 min) ^c	48	48	48	48
TS1	Poignées, boutons, prises, etc. et surfaces externes tenus pendant de courtes périodes ou touchés occasionnellement (> 10 s et < 1 min) ^c	51	56	60	60
TS1	Poignées, boutons, prises, etc. et surfaces externes touchés occasionnellement pendant de très courtes périodes (> 1 s et < 10 s) ^c	60	71	77	107
TS1	Surfaces externes qui ne nécessitent pas d'être touchées pour le fonctionnement de l'équipement (< 1 s) ^c	70 ^d	80 ^d	94 ^d	140
Les limites de TS2 sont 10 K supérieures à celles de TS1.					
^a Sauf pour les poignées, boutons, prises etc., les parties suivantes, à l'intérieur de l'équipement, ne nécessitent pas d'être conformes à ce tableau à condition qu'une protection mise en place sous forme d'instructions conformément à l'Article F.5 soit prévue sur ou à proximité de la partie chaude (voir 9.4.2): – une partie qui ne nécessite pas d'être touchée pour que l'équipement fonctionne et si un contact involontaire avec la partie est peu probable; – des parties internes de l'équipement nécessitant de la chaleur pour sa fonction prévue (par exemple, une contre-colleuse, une tête d'impression thermique, un four de fixage etc.) à condition que les parties ne soient pas susceptibles d'être touchées par une personne ordinaire dans les conditions normales de fonctionnement. ^b Pour chaque matériau, les données de ce matériau doivent être prises en compte pour déterminer la température maximale appropriée. ^c La durée de contact doit être déterminée par le fabricant. Pour les surfaces extérieures métalliques qui sont recouvertes d'un matériau plastique, dont l'épaisseur est au moins de 0,3 mm, un échauffement correspondant à la limite de température admissible du plastique et du caoutchouc est autorisé. ^d Pour les zones et les surfaces externes suivantes, la limite de température est de 100 °C à moins qu'une limite supérieure ne soit spécifiée plus haut: – une zone sur la surface externe de l'équipement dont les dimensions ne dépassent pas 50 mm et qui n'est pas susceptible d'être touchée lors d'une utilisation normale; ou – les surfaces accessibles de l'équipement nécessitant de la chaleur pour la fonction prévue (par exemple, les équipements contenant une contre-colleuse, une tête d'impression thermique, un four de fixage, etc.) et qui ne sont pas susceptibles d'être touchées en utilisation normale; ou – les radiateurs et parties métalliques qui recouvrent directement ces derniers, à l'exception de ceux disposés sur des surfaces comportant des interrupteurs ou organes de commande manipulés en utilisation normale. Pour ces zones et parties, une protection mise en place sous forme d'instructions conforme à l'Article F.5 doit être prévue sur ou à proximité de la partie chaude.					

9.3 Protection contre les sources d'énergie thermique

9.3.1 Généralités

Le présent paragraphe spécifie des exigences de protection pour les parties **accessibles** aux **personnes ordinaires**, aux **personnes averties** et aux **personnes qualifiées**.

9.3.2 Protection d'une personne ordinaire

9.3.2.1 Protection d'une personne ordinaire contre TS1

Aucune **protection** n'est nécessaire entre TS1 et une **personne ordinaire**.

9.3.2.2 Protection d'une personne ordinaire contre TS2

Au moins une **protection** doit être interposée entre TS2 et une **personne ordinaire**. Cette **protection** peut être:

- une **protection de l'équipement** telle qu'une isolation thermique; ou
- une **protection mise en place sous forme d'instructions** conforme à l'Article F.5.

Pour l'utilisation des **protections mises en place sous forme d'instructions**, voir 9.4.2.

9.3.2.3 Protection d'une personne ordinaire contre TS3

Au moins une **protection principale** de l'équipement et une **protection supplémentaire** doivent être interposées entre TS3 et une **personne ordinaire**.

NOTE La **protection supplémentaire** peut être une **protection mise en place sous forme d'instructions**.

9.3.2.4 Conformité

La conformité est vérifiée par examen.

9.3.3 Protection d'une personne avertie

9.3.3.1 Protection d'une personne avertie contre TS2

Aucune **protection de l'équipement** n'est nécessaire entre TS2 et une **personne avertie**.

9.3.3.2 Protection d'une personne avertie contre TS3

Au moins une **protection principale** de l'équipement et une **protection supplémentaire** doivent être interposées entre TS3 et une **personne avertie**.

NOTE La **protection supplémentaire** peut être une **protection mise en place sous forme d'instructions**.

La conformité est vérifiée par examen.

9.3.4 Protection d'une personne qualifiée

Les parties et surfaces classées TS3 doivent être équipées d'une **protection de l'équipement** ou d'une **protection mise en place sous forme d'instructions** afin qu'un contact involontaire avec ces parties et surfaces lors de l'entretien ne soit pas susceptible de pousser une **personne qualifiée** à reculer vers d'autres sources d'alimentation de classe 3 (voir la Figure 19).

La conformité est vérifiée par examen.

9.4 Exigences pour les protections

9.4.1 Protection de l'équipement

9.4.1.1 Exigences

Une **protection de l'équipement** doit limiter le transfert d'énergie thermique (température source) dans les **conditions normales** et **anormales de fonctionnement** ou limiter

l'accessibilité à une source d'énergie thermique à une température de contact telle que spécifiée par la classification TS selon le Tableau 42.

Les limites de température sont appliquées uniquement pour ces **conditions anormales de fonctionnement** lors desquelles l'équipement continue de fonctionner et les **conditions anormales de fonctionnement** ne sont pas évidentes. Si l'équipement arrête de fonctionner, alors les limites ne sont pas applicables.

9.4.1.2 Méthode d'essai et conformité

Cet essai est réalisé dans des conditions de température ambiante tel que défini en B.1.7, sauf que la température ambiante doit être de 25 °C.

L'équipement doit fonctionner de la manière dont le fabricant détermine qu'elle est susceptible d'entraîner des conditions thermiques élevées des surfaces et parties accessibles.

NOTE Cela peut ne pas correspondre aux conditions de courant ou de puissance d'entrée maximal(e), mais aux conditions qui délivrent le plus haut niveau thermique à la partie concernée.

La conformité est vérifiée en mesurant la température stable des surfaces accessibles.

9.4.2 Protection mise en place sous forme d'instructions

Une **protection mise en place sous forme d'instructions** doit être prévue, conformément à l'Article F.5 et être composée

- du symbole , CEI 60417-5041 (2002); ou
- de l'énoncé ou du texte équivalent suivant:

ATTENTION Surface chaude. Ne pas toucher.

La conformité est vérifiée par examen.

10 Rayonnements

10.1 Généralités

Le présent article spécifie les moyens pour réduire la probabilité d'exposition des personnes à des niveaux de rayonnements électromagnétiques ionisants et non ionisants pouvant provoquer des blessures. Le présent article fournit également une protection contre une détérioration de l'audition due à des niveaux sonores excessifs qui peuvent être produits par des équipements électroniques.

10.2 Classifications des sources d'énergie de rayonnement

10.2.1 RS1

Une source RS1 possède des niveaux ne dépassant pas les limites de la classe RS1 dans les **conditions normales et anormales de fonctionnement** et ne dépassant pas les limites de la classe RS2 dans les **conditions de premier défaut**. Lorsqu'une personne est exposée à une source RS1, l'énergie peut aller d'indétectable à détectable mais n'est pas douloureuse.

NOTE Une **personne ordinaire** peut être exposée à une source RS1.

10.2.2 RS2

Une source RS2 possède des niveaux ne dépassant pas les limites de la classe RS2 dans les **conditions normales** et **anormales de fonctionnement** et dans les **conditions de premier défaut**, mais n'est pas classée en tant que source RS1. Lorsqu'une personne est exposée à une source RS2, l'énergie peut aller de détectable à douloureuse. Une exposition à une source RS2 est acceptable dans les limites d'exposition données et dans des périodes courtes associées (taux d'exposition).

NOTE Une **personne avertie** peut être exposée à une source RS2. Dans les **conditions de premier défaut**, une **personne ordinaire** peut également être exposée à une source RS2.

10.2.3 RS3

Une source RS3 possède des niveaux dépassant les limites de la classe RS2, ou toute source d'alimentation déclarée comme une source RS3. Lorsqu'une personne est exposée à une source RS3, l'énergie, même pendant une exposition courte (puissance instantanée ou éclairage énergétique) est considérée comme pouvant provoquer des blessures.

NOTE Une **personne qualifiée** peut avoir accès à une source RS3 avec les **protections mises en place sous forme d'instructions** appropriées et les **protections mises en place grâce à l'expérience acquise** en place. Les réglementations nationales limitent le niveau de rayonnement et le temps d'exposition lorsqu'une **personne qualifiée** travaille directement en contact avec des parties où une source RS3 peut être présente.

10.3 Exigences relatives aux rayonnements électromagnétiques

10.3.1 Protection des personnes contre les rayonnements non ionisants

10.3.1.1 Généralités

Le présent paragraphe spécifie les protections permettant de réduire le risque des effets nocifs des rayonnements non ionisants sur les personnes quelles qu'elles soient.

NOTE Il convient de traiter les diodes qui émettent une lumière cohérente (telles que les diodes super luminescentes) comme une source laser.

10.3.1.2 Rayonnements non ionisants en provenance d'un laser

10.3.1.2.1 Exigences

Les équipements contenant un ou plusieurs lasers (y compris les diodes laser) doivent être conformes à la CEI 60825-1, 60825-2 ou 60825-12 suivant le cas

Lorsqu'un laser de classe 3R, 3B ou 4 est présent, un **outil** doit être nécessaire pour accéder à la partie concernée.

10.3.1.2.2 Conformité

La classification des énergies de rayonnement est déterminée par:

- *les mesures effectuées conformément à la série de la CEI 60825, ou*
- *la vérification de la fiche technique disponible du fabricant.*

La conformité est vérifiée selon la ou les normes applicables de la série de la CEI 60825.

NOTE 1 Selon la date de la présente norme, les normes applicables sont la CEI 60825-1, la CEI 60825-2 et la CEI 60825-12.

Concernant les équipements qui ne dépassent pas la limite d'émission accessible (LEA) de la classe 1 dans toutes les conditions de fonctionnement, de maintenance et de défaillance, une protection mise en place sous forme d'instructions d'avertissement pour lasers ou une

étiquette explicative sur les lasers n'est pas obligatoire. De tels équipements sont déclarés « exempts » (voir Article 1 de la CEI 60825-1:2007).

NOTE 2 La limite d'émission accessible est définie dans la CEI 60825-1:2007, 3.3.

10.3.1.3 Rayonnements optiques non ionisants provenant des lampes et des appareils utilisant des lampes (y compris les LED)

10.3.1.3.1 Généralités

Les équipements contenant des lampes ou des appareils utilisant des lampes qui produisent des rayonnements optiques supérieurs aux limites spécifiées dans la CEI 62471 dans la gamme de longueurs d'onde allant de 200 nm à 3000 nm, tel que spécifié par le fabricant de lampes, doivent être équipés de **protections** pour éliminer le rayonnement optique inutile supérieur aux limites spécifiées dans la CEI 62471. Il n'est pas nécessaire que les applications à faible puissance utilisant des LED soient conformes à la CEI 62471.

NOTE 1 Les lampes fluorescentes et incandescentes universelles, avec des enveloppes en verre ordinaires, ne sont pas considérées comme émettrices de rayonnement UV important.

NOTE 2 Des exemples d'applications à faible puissance utilisant des LED qui sont exemptes des exigences ci-dessus concernent:

- les voyants de signalisation;
- les dispositifs à infrarouge tels que ceux utilisés dans les équipements de divertissement domestiques;
- les dispositifs à infrarouge pour la transmission de données tels que ceux utilisés entre les ordinateurs et leurs périphériques;
- les optocoupleurs, et
- les autres dispositifs similaires à faible puissance.

NOTE 3 Si le rayonnement optique est un rayonnement IR-A visible à large bande et si la luminance de la source ne dépasse pas 10^4 cd/m², il est probable 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).

NOTE 4 Pour les limites UV-C (longueurs d'onde comprises entre 180 nm et 200 nm), la valeur donnée dans la CEI 62471 pour 200 nm est utilisée.

Les exigences de marquage de l'Article F.5 ne sont pas obligatoires pour une porte ou un couvercle qui est équipé d'un interrupteur de **verrouillage de sécurité** qui coupe l'alimentation de la lampe UV lors de l'ouverture de la porte ou du couvercle, ou de tout autre mécanisme qui empêche l'**accès** au rayonnement UV.

Dans la CEI 62471,

- le groupe exempt est de la classe RS1,
- les groupes de risque 1 et 2 sont de la classe RS2,
- le groupe de risque 3 est de la classe RS3.

10.3.1.3.2 Exigences

A l'exception de la condition suivante en a) ou b), le rayonnement optique doit:

- soit être contenu dans l'**enveloppe** des lampes et des appareils utilisant des lampes ou dans l'**enveloppe** de l'équipement; soit
- ne pas dépasser les limites correspondant au groupe exempt données dans la CEI 62471 pour les **conditions normales de fonctionnement** (par exemple, 8 h d'exposition au rayonnement UV).

NOTE 1 Les appareils utilisant des lampes mentionnés en 6.1.1 de la CEI 62471:2006 sont exemptés des exigences ci-dessus.

NOTE 2 Le groupe exempt est décrit en 6.1.1 de la CEI 62471:2006.

a) Concernant le rayonnement UV:

Les équipements qui produisent une lumière visible qui est uniquement émise à travers une lentille de mise au point en verre ayant un affaiblissement de rayonnement ultraviolet de 90% jusqu'à 400 nm sont exempts s'il n'existe pas d'autres ouvertures à travers lesquelles un rayonnement visible est émis.

NOTE 3 Le verre d'une épaisseur de 2 mm satisfait généralement à cette exigence.

Des niveaux plus élevés d'exposition aux UV sont acceptables pendant des périodes plus courtes (jusqu'à 100 s pour la classe RS2) pendant des opérations de nettoyage et d'entretien, si la lampe à UV doit rester allumée pendant ces opérations. Cependant, le rayonnement optique ne doit pas dépasser les limites correspondant au groupe de risque 2 (risque modéré) données dans la CEI 62471. Les limites d'exposition correspondantes pour les intervalles de temps réduits pour ces opérations doivent être spécifiées dans les instructions.

Les portes et les couvercles qui, lorsqu'ils sont ouverts, permettent l'accès à une source de la classe RS2, doivent comporter une **protection mise en place sous forme d'instructions** fournie conformément à l'Article F.5 et se composant:

- du symbole , qui se compose de la CEI 60417-5751 (2002) combiné au sigle d'avertissement triangulaire de l'ISO 3864-2, ou
- de l'énoncé ou du texte équivalent suivant:

AVERTISSEMENT
Eteindre la lampe UV avant ouverture.

Si le symbole de rayonnement UV est utilisé sur l'équipement, tant le symbole que la **protection mise en place sous forme d'instructions** similaires au marquage ci-dessus doivent figurer ensemble dans les instructions. Lorsqu'un symbole est utilisé, sa signification doit être expliquée dans les instructions.

Si des **personnes qualifiées** sont susceptibles d'être exposées à des émissions plus élevées que celles spécifiées ci-dessus, dans une zone **accessible** uniquement aux **personnes qualifiées**, et s'il est nécessaire que l'équipement reste sous tension pendant l'opération d'entretien, alors une **protection mise en place sous forme d'instructions** doit être prévue conformément à l'Article F.5 et doit se composer:

- du symbole , qui se compose de la CEI 60417-5751 (2002) combiné au sigle d'avertissement triangulaire de l'ISO 3864-2, ou
- de l'énoncé ou du texte équivalent suivant:

AVERTISSEMENT
Utiliser des moyens de protection pour les yeux et la peau contre les rayonnements UV pendant les opérations d'entretien.

Le marquage doit être situé de façon à être facilement visible pendant les opérations d'entretien. La **protection mise en place sous forme d'instructions** doit être visible avant l'ouverture des moyens d'accès à la source de classe RS3.

Si le symbole de rayonnement UV est utilisé sur l'équipement, tant le symbole que la **protection mise en place sous forme d'instructions** similaires au marquage ci-dessus doivent figurer ensemble dans les instructions d'entretien.

b) Concernant le rayonnement visible:

Si l'émission de niveaux élevés de rayonnement visible est nécessaire pour la fonction prévue de l'équipement, une **protection mise en place sous forme d'instructions** doit être prévue conformément à l'Article F.5 et doit se composer:

- du symbole , qui se compose de la CEI 60417-5012 (2002) combiné au sigle d'avertissement triangulaire de l'ISO 3864-2, ou
- de l'énoncé ou du texte équivalent suivant:

AVERTISSEMENT
Ne pas regarder le faisceau.

Des niveaux plus élevés d'exposition sont acceptables pendant des périodes plus courtes pendant des opérations de nettoyage et d'entretien s'il est nécessaire que la lampe reste allumée pendant ces opérations; cependant, le rayonnement optique ne doit pas dépasser les limites correspondant au groupe de risque 2 (risque modéré) données dans la CEI 62471. Les limites correspondantes sont celles pour les intervalles de temps prévus pour ces opérations et doivent être spécifiées dans les instructions.

Concernant les portes et les couvercles, qui, lorsqu'ils sont ouverts, laissent passer des émissions plus élevées que celles spécifiées ci-dessus lors de l'accès à la source, une **protection mise en place sous forme d'instructions** doit être prévue conformément à l'Article F.5 et doit se composer:

- du symbole , qui se compose de la CEI 60417-5012 (2002) combiné au sigle d'avertissement triangulaire de l'ISO 3864-2, ou
- de l'énoncé ou du texte équivalent suivant:

AVERTISSEMENT
Eteindre la lampe avant ouverture.

La **protection mise en place sous forme d'instructions** doit être conforme à l'Article F.5. Le marquage ci-dessus n'est pas obligatoire pour une porte ou un couvercle qui est équipé d'un interrupteur de **verrouillage de sécurité** qui coupe l'alimentation de la lampe lors de l'ouverture de la porte ou du couvercle, ou de tout autre mécanisme qui empêche l'accès au rayonnement visible.

Si le symbole de rayonnement visible est utilisé sur l'équipement, tant le symbole que la **protection mise en place sous forme d'instructions** similaires au marquage ci-dessus doivent figurer ensemble dans les instructions. Lorsqu'un symbole est utilisé, sa signification doit être expliquée dans les instructions.

Si des **personnes qualifiées** sont susceptibles d'être exposées à des émissions plus élevées que celles spécifiées ci-dessus, et s'il est nécessaire que l'équipement reste sous tension pendant l'opération d'entretien, alors une **protection mise en place sous forme d'instructions** doit être prévue conformément à l'Article F.5 et doit se composer:

- du symbole , qui se compose de la CEI 60417-5012 (2002) combiné au sigle d'avertissement triangulaire de l'ISO 3864-2, ou
- de l'énoncé ou du texte équivalent suivant:

AVERTISSEMENT
Utiliser un moyen de protection pour les yeux
pendant les opérations d'entretien.

Le marquage doit être situé de façon à être facilement visible pendant les opérations d'entretien.

Si le symbole de rayonnement visible est utilisé sur l'équipement, tant le symbole que la **protection mise en place sous forme d'instructions** similaires au marquage ci-dessus doivent figurer ensemble dans les instructions d'entretien.

10.3.1.3.3 Conformité

La conformité est vérifiée par une évaluation des fiches techniques disponibles, par examen et, si nécessaire, par des mesures.

NOTE Concernant des indications sur les techniques de mesure, voir la CEI 62471.

10.3.2 Rayonnements non ionisants en provenance de fréquences radioélectriques dans la plage 0 Hz à 300 GHz

Ces types de rayonnements ne sont pas traités dans la présente norme.

NOTE 1 Les réglementations nationales s'appliquent.

NOTE 2 Dans les pays membres du CENELEC, le taux des rayonnements non ionisants est réglementé par la Recommandation 1999/519/CE du Conseil européen du 12 juillet 1999 relative à la limitation de l'exposition du public aux champs électromagnétiques (de 0 Hz à 300 GHz).

NOTE 3 Concernant les éléments rayonnants intentionnels, il convient de prendre en compte les recommandations de la Commission internationale de protection contre les rayonnements non ionisants (ICNIRP) relative à la limitation de l'exposition aux champs électriques, magnétiques et électromagnétiques (jusqu'à 300 GHz) variant dans le temps. Concernant les dispositifs portatifs et installés sur le corps, une attention toute particulière est portée aux CEI 62209-1 et CEI 62209-2.

10.3.3 Protection des personnes contre les rayonnements ionisants (rayons X)

10.3.3.1 Généralités

Le présent paragraphe définit le niveau de rayonnement ionisant afin de réduire le risque de blessures aux personnes, et décrit la méthode de mesure des rayonnements ionisants.

10.3.3.2 Exigences

Les équipements ne doivent pas générer de rayonnements ionisants à des niveaux dangereux pour les personnes. Pour une **personne ordinaire** et une **personne avertie**, les limites de RS1 ne doivent pas être dépassées. Pour les **personnes qualifiées**, les limites de RS2 ne doivent pas être dépassées.

Une **protection de l'équipement** doit être interposée entre toutes les personnes et une source RS2 ou RS3. De plus, si une **personne qualifiée** peut être exposée à une source RS2, alors une **protection mise en place sous forme d'instructions** est exigée.

10.3.3.3 Conformité

*Pour une source RS1, en tout point situé à 50 mm de la surface de la zone **accessible** aux **personnes ordinaires** et aux **personnes averties**, le taux d'exposition ne doit pas dépasser 36 pA/kg (5 µSv/h, or 0,5 mR/h).*

NOTE 1 Cette valeur est cohérente avec la publication 60 de la Commission Internationale de Radioprotection (ICRP).

*Pour une source RS2, et pour la protection d'une **personne qualifiée**, une mesure supplémentaire est effectuée, toute partie du coffret, du boîtier et du châssis étant retirée selon les instructions d'entretien (exposition à des tubes cathodiques), à la tension d'essai maximale applicable et dans les conditions conformes à 10.3.3.4. Le taux d'exposition ne doit*

pas dépasser 185 pA/kg (25 μ Sv/h, ou 2,5 mR/h) en tout point situé à 100 mm de la surface extérieure de tout composant de l'équipement.

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. Cette directive exige qu'en tout point situé à 100 mm de la surface du matériel, le taux d'exposition ne doit pas dépasser 1 μ Sv/h (0,1 mR/h) en prenant en compte le niveau de fond. Pour les exigences complètes, voir la directive ci-dessus.

NOTE 3 Aux Etats-Unis, les conditions de mesure données dans la partie 1020 du titre 21 du code des règlements fédéraux des Etats-Unis sont les suivantes (pour les exigences complètes, voir les règlements ci-dessus).

Les mesures sont effectuées avec l'équipement soumis à l'essai connecté à la source d'alimentation suivante:

- 130 V si la **tension assignée** est comprise entre 110 V et 120 V;
- 110 % de la **tension assignée**, si la **tension assignée** n'est pas comprise entre 110 V et 120 V.

Pendant les mesures:

- toutes les commandes utilisateur et de service **accessibles** sont réglées en fonction des combinaisons qui produisent des émissions à rayonnement X maximales; et
- les **conditions anormales de fonctionnement** de toute anomalie d'un composant ou d'un circuit provoquant une augmentation des émissions à rayonnement X doivent être simulées.

NOTE 4 Au Canada, les conditions de mesure données dans la partie C.1370 des règlements consolidés du Canada sont les suivantes (pour les exigences complètes, voir les règlements ci-dessus).

Les mesures sont effectuées avec l'équipement soumis à l'essai connecté à la source d'alimentation suivante:

- 127 V si la **tension assignée** est comprise entre 110 V et 120 V;
- 110 % de la **tension assignée**, si la **tension assignée** n'est pas comprise entre 110 V et 120 V.

Pendant les mesures, toutes les commandes utilisateur et de service **accessibles** sont réglées en fonction des combinaisons qui produisent des émissions à rayonnement X maximales.

10.3.3.4 Méthode d'essai

Les équipements qui sont susceptibles de produire des rayonnements ionisants sont vérifiés en mesurant le taux de rayonnement. Le niveau de fond est pris en compte.

Le taux de rayonnement est déterminé au moyen d'un moniteur de rayonnement du type de la chambre d'ionisation ayant une surface effective de 1 000 mm² ou au moyen d'équipements de mesure d'autres types donnant des résultats équivalents.

*Des mesures sont effectuées sur l'équipement soumis à l'essai fonctionnant à la tension d'alimentation la plus défavorable (voir B.2.3) et avec des commandes pour une **personne ordinaire** et une **personne avertie** et des commandes pour une **personne qualifiée** qui ne sont pas bloquées de manière sûre et réglées de façon à produire un rayonnement maximal tout en maintenant l'équipement opérationnel pour une utilisation normale.*

NOTE 1 Les joints soudés et la fixation par application de peinture, d'époxyde ou de matériaux similaires sont considérés comme des moyens de blocage sûrs.

*De plus, la mesure doit être effectuée dans les **conditions anormales de fonctionnement** et dans les **conditions de premier défaut** qui peuvent provoquer une augmentation de la haute tension, à condition que l'image reste intelligible pendant 5 min, période à l'issue de laquelle la mesure est effectuée et moyennée sur 5 min.*

Pendant les mesures, l'image doit rester intelligible.

Une image est considérée comme intelligible si elle satisfait aux conditions suivantes:

- *une amplitude de balayage d'au moins 70 % de la largeur et de la hauteur utiles de l'écran;*
- *une luminance minimale de 50 cd/m², avec un champ blanc stable fourni par un générateur d'essai;*
- *pas plus de 12 claquages sur une période d'1 h;*
- *une résolution horizontale correspondant au moins à 1,5 MHz au centre, avec une dégradation verticale similaire.*

NOTE 2 Aux Etats-Unis et au Canada, une image intelligible est en synchronisation tout en couvrant 60 % de la surface de vision de l'écran.

10.3.4 Protection des matériaux contre les lampes produisant des rayonnements UV

Les matériaux qui sont exposés aux rayonnements UV produits par une lampe dans l'équipement doivent être suffisamment résistants à la dégradation de manière à ce que la sécurité n'en soit pas affectée.

NOTE Il n'est pas nécessaire d'évaluer les métaux et les matériaux en verre et en céramique

La conformité est vérifiée par les essais de l'Annexe C.

10.4 Protection contre les sources d'énergie acoustique

10.4.1 Généralités

Le présent paragraphe spécifie les exigences de **protection** contre les sources d'énergie acoustique étroitement accolées à l'oreille, pour toutes les personnes.

NOTE En Australie, les limites de l'AS/ACIF S004 s'appliquent aux équipements reliés à un réseau de télécommunications.

10.4.2 Exigences

Les éléments suivants doivent être conformes aux exigences de 10.4.3:

petit équipement de reproduction audio alimenté par batterie dont le but est d'écouter des sons enregistrés ou diffusés et utilisant des écouteurs ou des oreillettes avec fils qui peuvent être utilisés dans, sur ou autour des oreilles et qui permettent à l'utilisateur de se déplacer.

NOTE 1 Les lecteurs de CD ou de mini-disques portables, les lecteurs audio MP3 ou des équipements similaires sont des exemples correspondant à l'équipement décrit ci-dessus.

NOTE 2 D'autres équipements sont en cours d'étude.

10.4.3 Protection des personnes ordinaires

Une **protection mise en place sous forme d'instructions** doit être prévue conformément à l'Article F.5, ayant le libellé suivant ou équivalent:

Pour éviter une détérioration éventuelle de l'audition, ne pas écouter à des niveaux de volume élevés sur des périodes prolongées. Pour savoir si le niveau de réglage du son n'est pas trop élevé, s'assurer que l'on peut entendre sa propre voix en parlant normalement tout en écoutant un son avec les écouteurs.

NOTE La **protection mise en place sous forme d'instructions** indique qu'une exposition prolongée à une source d'alimentation acoustique peut provoquer des lésions. La **protection mise en place sous forme d'instructions** fournit suffisamment d'informations pour permettre à l'utilisateur de comprendre les effets d'une écoute à des niveaux de son trop élevés.

Annexe A (informative)

Exemples d'équipements relevant du domaine d'application de la présente norme

Certains exemples d'équipements relevant du domaine d'application de la présente norme sont:

Type de produit générique	Exemple spécifique de type générique
Équipement bancaire	Machines de traitement monétaire comprenant des distributeurs automatiques de billets (DAB)
Équipement électronique grand public (notamment équipement professionnel audio, vidéo et appareils de musique électroniques)	Équipement de réception et amplificateurs audio et/ou vidéo, équipement destiné à l'alimentation d'autres équipements relevant du domaine d'application de la présente norme, instruments de musique électroniques et accessoires électroniques tels que générateurs de rythme, générateurs de tons, syntoniseurs et appareils similaires utilisés avec des instruments de musique électroniques ou non électroniques, équipement audio et/ou vidéo pour l'enseignement, vidéo-projecteurs, caméras et moniteurs vidéo, jeux vidéo, juke box, platines tourne-disque et lecteurs de disques optiques, enregistreurs de bande et de disques optiques, convertisseurs et amplificateurs de signal d'antenne, positionneurs d'antennes, équipement CB, équipement pour l'imagerie, équipement pour jeux de lumière électroniques, équipement de communication utilisant comme moyen de transmission le réseau d'alimentation basse tension, récepteurs de tête de réseau câblé, équipement multimédia, équipement électronique à mémoire flash
Machines de traitement des données et de texte et machines d'équipement associées	Équipement de préparation des données, équipement de traitement des données, équipement de stockage des données, ordinateurs personnels, traceurs, imprimantes, scanners, équipement de traitement de texte, écrans d'affichage
Équipement de réseau de données	Ponts, équipement de terminaison de circuit de données, équipement terminal de données, routeurs
Équipement électrique et électronique pour le commerce de détail	Caisses enregistreuses, bornes de point de vente, y compris les balances électroniques associées
Machines de bureau électriques et électroniques	Calculatrices, photocopieurs, dictaphones, déchiqueteuses, duplicateurs, effaceurs, équipement micrographique de bureau, classeurs électriques, rogneuses (poinçonneuses, séparateurs, massicots), taqueuses, taille-crayons, agrafeuses, machines à écrire
Autre équipement de traitement de l'information	Équipement de photo-impression, bornes d'information publique, équipement multimédia
Équipement d'envoi du courrier	Machines de traitement du courrier, affranchisseuses
Équipement d'infrastructure de réseau de télécommunication	Équipement pour facturation, multiplexeurs, équipement d'alimentation et de terminaison de réseau, stations fixes radio, répéteurs, équipement de transmission, équipement de commutation en télécommunication
Équipement de terminal de télécommunication	Équipement de télécopie, systèmes d'intercommunication téléphonique, modems, PABX, radiomessagers, répondeurs téléphoniques, postes téléphoniques (avec et sans fil)

Cette liste ne doit pas être considérée comme exhaustive et les équipements qui n'y sont pas inclus peuvent néanmoins faire partie du domaine d'application.

Annexe B

(normative)

Essais en conditions normales de fonctionnement, essais en conditions anormales de fonctionnement et essais en condition de premier défaut

B.1 Généralités

B.1.1 Introduction

La présente annexe spécifie différents essais et différentes conditions d'essai applicables à l'équipement.

B.1.2 Applicabilité de l'essai

Si un essai en particulier n'est de toute évidence pas applicable, ou non nécessaire après vérification des données disponibles, l'essai ne doit pas être effectué. Les essais inclus dans la présente norme doivent être effectués uniquement s'ils sont en relation avec la sécurité.

Afin de savoir si un essai est applicable ou non, les circuits et la construction doivent être soigneusement inspectés pour tenir compte des conséquences de défauts éventuels. Les conséquences d'un défaut peuvent nécessiter ou non l'utilisation d'une **protection** pour réduire la probabilité de blessures ou de départ de feu.

B.1.3 Type d'essai

Sauf spécification contraire, les essais spécifiés sont des **essais de type**.

B.1.4 Échantillons d'essai

Sauf spécification contraire, l'échantillon soumis à essai doit être représentatif de l'équipement réel ou doit être l'équipement réel.

Comme variante à l'exécution des essais sur l'équipement complet, des essais peuvent être effectués séparément sur des circuits, des composants ou des sous-ensembles en dehors de l'équipement, à condition qu'un examen de l'équipement et de la disposition des circuits assure que de tels essais montrent que l'équipement assemblé est conforme aux exigences de la norme. Si l'un de ces essais indique la probabilité de non-conformité dans l'équipement complet, l'essai doit être répété dans l'équipement.

Si un essai risque d'être destructif, un modèle peut être utilisé pour reproduire la condition à évaluer.

NOTE Compte tenu de l'importance des ressources engagées dans les essais et afin de réduire au minimum le gaspillage, il est recommandé que toutes les parties concernées étudient conjointement le programme d'essai, les échantillons et la séquence d'essais. Il est recommandé d'effectuer en dernier lieu les essais susceptibles de mener à la destruction de l'échantillon d'essai.

B.1.5 Mesure des tensions à la terre

Lorsque la norme spécifie une tension entre une partie conductrice et la terre, toutes les parties reliées à la terre suivantes sont étudiées:

- la borne de terre de protection (le cas échéant); et
- toute autre partie conductrice devant être connectée à la borne de terre de protection (par exemple, voir 5.6); et

- toute partie conductrice de l'équipement qui est mise à la terre pour des raisons fonctionnelles.

Les parties qui, dans l'application, sont mises à la terre par l'intermédiaire d'un branchement à un autre équipement, mais qui ne sont pas reliées à la terre au sein de l'équipement tel que soumis à l'essai, doivent être reliées à la terre à l'endroit où la tension est la plus élevée.

Lors de la mesure d'une tension entre la terre et un conducteur dans un circuit qui n'est pas mis à la terre dans l'application de l'équipement prévue, une résistance non inductive de $5\,000\ \Omega \pm 10\%$ doit être branchée sur l'instrument de mesure de la tension.

La baisse de tension dans le **conducteur de mise à la terre de protection** du câble d'alimentation, ou dans un conducteur d'un autre câble externe mis à la terre, n'est pas incluse dans les mesures.

B.1.6 Conformité par vérification des données pertinentes

Dans la présente norme, lorsque la conformité des matériels, composants ou sous-ensembles est vérifiée par examen ou par mise à l'essai des propriétés, la conformité peut être confirmée par une revue des données pertinentes ou des résultats d'essais précédents disponibles, à la place des **essais de type** spécifiés.

B.1.7 Conditions de mesure de la température

Le montage de mesure de l'essai doit reproduire les conditions d'installation de l'équipement les plus strictes. Lorsqu'une température maximale ($T_{\max}$) est spécifiée pour assurer la conformité aux essais, cette dernière est basée sur l'hypothèse selon laquelle la température ambiante du local d'essai est de 25 °C avec l'équipement en service. Le fabricant peut cependant spécifier une température ambiante maximale différente.

Sauf spécification contraire, il n'est pas nécessaire de maintenir la température ambiante (T_{amb}) à une valeur spécifique pendant les essais, mais cette dernière doit toutefois être surveillée et enregistrée.

Par référence aux essais qui doivent être poursuivis jusqu'à l'obtention de températures en régime constant, l'équilibre thermique est considéré exister si l'échauffement ne dépasse pas 3 K sur une période de 30 min. Si la température mesurée est au moins 10 % inférieure à la limite de température spécifiée, l'équilibre thermique est considéré exister si l'échauffement ne dépasse pas 1 K sur une période de 5 min.

Sauf spécification d'une méthode particulière, les températures des enroulements doivent être déterminées soit par la méthode par thermocouple, soit par toute autre méthode donnant la température moyenne des fils de bobinage telle que la méthode de résistance.

B.2 Conditions normales de fonctionnement

B.2.1 Généralités

Sauf si des conditions d'essai sont spécifiées par ailleurs et lorsqu'un impact significatif sur les résultats de l'essai est manifeste, les essais doivent être effectués dans les **conditions normales de fonctionnement** les plus défavorables, en prenant en compte les paramètres suivants:

- la tension d'alimentation;
- la fréquence d'alimentation;
- les conditions environnementales (par exemple la température ambiante maximale assignée spécifiée par le fabricant);

- l'emplacement physique de l'équipement et la position des parties mobiles, tels que spécifiés par le fabricant;
- le mode de fonctionnement, y compris les chargements externes dus à l'équipement interconnecté;
- l'ajustement d'une commande.

Pour les amplificateurs audio et les équipements comprenant un amplificateur audio, des conditions d'essai supplémentaires s'appliquent, voir l'Annexe E.

B.2.2 Fréquence d'alimentation

Pour déterminer la fréquence d'alimentation la plus défavorable pour un essai, plusieurs fréquences dans la plage des **fréquences assignées** doivent être prises en compte (par exemple, 50 Hz et 60 Hz) mais il n'est pas nécessaire de prendre en compte la tolérance sur une **fréquence assignée** (par exemple, 50 Hz $\pm$ 0,5 Hz).

B.2.3 Tension d'alimentation

Pour déterminer la tension d'alimentation la plus défavorable pour un essai, les variables suivantes doivent être prises en compte:

- les multiples **tensions assignées**,
- les extrêmes des **plages de tensions assignées**,
- la tolérance sur la **tension assignée** telle que déclarée par le fabricant.

Si le fabricant n'a pas déclaré de tolérance, elle doit être comprise entre +10 % et -10 % pour le **réseau d'alimentation** c.a. et entre +20 % et -15 % pour le **réseau d'alimentation** c.c. uniquement.

Lorsqu'un paragraphe relatif à un essai n'exige pas la tension d'alimentation la plus défavorable (en ne se référant pas spécifiquement à B.2.3), la tension d'alimentation est la valeur de la **tension assignée** ou toute autre valeur comprise dans la **plage de tensions assignées**.

B.2.4 Tensions normales de fonctionnement

Les tensions suivantes doivent être prises en considération:

- les tensions normales de fonctionnement générées dans l'équipement, y compris les tensions de crête répétitives telles que les tensions associées à des alimentations à découpage,
- les tensions normales de fonctionnement générées à l'extérieur de l'équipement, y compris les signaux de sonnerie reçus à partir de **circuits externes** tels qu'indiqués dans le Tableau 16, sous les numéros d'identification 11, 12, 13 et 14.

Les **tensions transitoires du réseau d'alimentation** générées en externe et les tensions transitoires du **circuit externe** ne doivent pas être prises en compte:

- lors de la détermination des **tensions de service**, parce que ces tensions transitoires ont été prises en compte dans les procédures de détermination des **distances d'isolement dans l'air** minimales (voir 5.4.2);
- lors de la classification des circuits dans l'équipement comme ES1, ES2 et ES3 (voir 5.2).

B.2.5 Essai à l'entrée du circuit

Afin de déterminer le courant absorbé ou la puissance absorbée, les variables suivantes doivent être prises en considération:

- les charges dues aux caractéristiques facultatives, offertes ou fournies par le fabricant, à intégrer dans ou avec l'équipement soumis à essai;
- les charges dues à d'autres unités d'équipement prévues par le fabricant afin d'extraire du courant de l'équipement soumis à essai;
- les charges susceptibles d'être connectées à toute prise de courant standard sur l'équipement **accessible** à une **personne ordinaire**, jusqu'à la valeur spécifiée par le fabricant;
- pour les équipements contenant un amplificateur audio, voir l'Annexe E;
- pour les affichages à images mobiles, les réglages suivants doivent s'appliquer:
 - le « signal à trois barres verticales » doit être utilisé tel que défini en 3.2.1.3 de la CEI 60107-1:1997; et
 - les commandes d'image **accessibles** à l'utilisateur doivent être ajustées de manière à obtenir la consommation de courant maximale; et
 - les réglages audio doivent être définis tels qu'à l'Article E.1 de la présente norme.

Les charges artificielles peuvent être utilisées pour simuler de telles charges lors de l'essai.

Dans chacun des cas, les valeurs sont relevées lorsque le courant absorbé ou la puissance absorbée s'est stabilisé(e). Si le courant ou la puissance varie pendant le cycle de fonctionnement normal, le courant ou la puissance en régime constant est considéré(e) comme l'indication moyenne de la valeur, relevée sur un ampèremètre ou wattmètre de valeur efficace, pendant une période représentative.

La conformité est vérifiée en mesurant le courant ou la puissance absorbé(e) de l'équipement dans les conditions suivantes:

- *lorsque l'équipement contient plus d'une **tension assignée**, le courant ou la puissance absorbé(e) est relevé(e) pour chaque **tension assignée** et à chaque tolérance de la **tension assignée**;*
- *lorsque l'équipement contient une ou plusieurs **plages de tensions assignées**, le courant ou la puissance absorbé(e) est relevé(e) à chaque extrémité de chaque **plage de tensions assignées** et à la tolérance de chaque extrémité de chaque **plage de tensions assignées***
 - *lorsque chaque valeur du **courant assigné** ou de la **puissance assignée** est marquée, elle est comparée à la valeur la plus élevée du courant ou de la puissance absorbé(e) relevé(e) dans la **plage de tensions assignées** correspondante, mais ne comprend pas les tolérances sur les tensions,*
 - *lorsque deux valeurs de **courant assigné** ou de **puissance assignée** sont marquées, séparées par un trait d'union, elles sont comparées aux deux valeurs relevées dans la **plage de tensions assignées** correspondante mais ne comprennent pas les tolérances sur les tensions.*

Le courant ou la puissance absorbé(e) mesuré(e) dans les **conditions normales de fonctionnement**, mais à la **tension assignée** ou à toute tension comprise dans la **plage de tensions assignées**, ne doit pas dépasser le **courant assigné** ou la **puissance assignée** de plus de 10 %.

B.2.6 Conditions de mesure de la température de fonctionnement

B.2.6.1 Généralités

Les températures relevées sur l'équipement doivent être conformes à B.2.6.2 ou B.2.6.3, le cas échéant, toutes les températures étant indiquées en degrés Celsius (°C); où

T est la température relevée sur la partie en question dans les conditions d'essai prescrites;

$T_{\max}$ est la température maximale spécifiée pour la conformité avec l'essai;

T_{amb} est la température ambiante pendant l'essai;

T_{ma} est la température ambiante maximale spécifiée par le fabricant, ou 25 °C, la valeur la plus grande étant retenue.

B.2.6.2 Échauffement/refroidissement dépendant de la température de fonctionnement

En ce qui concerne les équipements dont il est prévu que la valeur d'échauffement ou de refroidissement dépende de la température (par exemple, l'équipement contient un ventilateur qui s'accélère à mesure que la température augmente), 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 chacun des composants, il peut se révéler nécessaire d'effectuer plusieurs essais à différentes valeurs de T_{amb} .

NOTE 2 La valeur la plus défavorable de T_{amb} peut être différente selon les composants.

D'une autre façon, la mesure de la température peut être effectuée dans des conditions de température ambiante en mettant le dispositif d'échauffement/refroidissement sur son réglage le plus inefficace ou en le mettant hors service.

B.2.6.3 Échauffement/refroidissement indépendant de la température de fonctionnement

En ce qui concerne les équipements dont il est prévu que la valeur d'échauffement ou de refroidissement ne dépende pas de la température ambiante, la méthode spécifiée en B.2.6.2 peut être utilisée. D'une autre façon, l'essai est réalisé à toute valeur de T_{amb} dans la plage de fonctionnement spécifiée par le fabricant. Dans ce cas:

T ne doit pas dépasser $(T_{\max} + T_{\text{amb}} - T_{\text{ma}})$.

Pendant l'essai, il convient que T_{amb} ne dépasse pas T_{ma} sauf en cas d'accord entre toutes les parties impliquées.

B.2.7 Charge de la batterie dans les conditions normales de fonctionnement

Dans les **conditions normales de fonctionnement**, le **courant de charge maximal**, la **tension de charge de limite supérieure**, la **température de charge la plus faible** et la **température de charge la plus élevée** doivent satisfaire aux exigences de l'Annexe M le cas échéant.

B.3 Simulation de conditions anormales de fonctionnement

B.3.1 Généralités

Lors de la simulation de **conditions anormales de fonctionnement**, les parties, alimentations et supports doivent être en place s'ils sont susceptibles d'influencer les résultats de l'essai.

Chaque **condition anormale de fonctionnement** doit être appliquée à tour de rôle.

Les défauts, qui sont la conséquence directe d'une **condition anormale de fonctionnement**, sont réputés être une **condition de premier défaut**.

L'équipement, l'installation, les instructions et les spécifications doivent être étudiés afin de déterminer les **conditions anormales de fonctionnement** qui peuvent être raisonnablement escomptées.

Les exemples de **conditions anormales de fonctionnement** suivants doivent au moins être envisagés, le cas échéant, en plus des exemples mentionnés de B.3.2 à B.3.7:

- pour les équipements fonctionnant avec du papier, un bourrage papier;
- pour les équipements comprenant des commandes **accessibles** à une **personne ordinaire**, les réglages, individuels et collectifs, de ces commandes pour des conditions de fonctionnement correspondant au cas le plus défavorable;
- pour les amplificateurs audio équipés de commandes **accessibles** à une **personne ordinaire**, les réglages, individuels et collectifs, de ces commandes pour des conditions de fonctionnement correspondant au cas le plus défavorable, sans appliquer les conditions spécifiées dans l'Annexe E;
- pour les équipements comprenant des parties mobiles **accessibles** à une **personne ordinaire**, un enrayement des parties mobiles;
- pour les équipements avec supports, des supports, une taille de support ou une quantité de supports incorrects;
- pour les équipements comprenant des liquides ou des cartouches de liquide rechargeables, ou des matériaux rechargeables, des liquides ou des matériaux répandus dans l'équipement.

Avant d'appliquer l'une des **conditions anormales de fonctionnement** susmentionnées, l'équipement doit être soumis à des **conditions normales de fonctionnement**.

B.3.2 Couverture des ouvertures de ventilation

Le dessus, les côtés et l'arrière d'un équipement, si de telles surfaces comportent des ouvertures de ventilation, doivent être recouverts un par un avec un morceau de carton (papier rigide épais ou carton mince) d'une densité de 200 g/m², dont les dimensions ne sont pas inférieures à chaque surface soumise à essai, recouvrant toutes les ouvertures.

Les ouvertures sur différentes surfaces sur le dessus de l'équipement (le cas échéant) sont recouvertes simultanément par différents morceaux de carton.

Les ouvertures sur le dessus de l'équipement, sur une surface inclinée à un angle supérieur à 30° et inférieur à 60° par rapport à l'horizontale, depuis laquelle un obstacle peut glisser, sont exclues.

Sur l'arrière et les côtés de l'équipement, le carton est fixé au bord supérieur et peut pendre librement.

NOTE Il n'existe pas d'exigences concernant le blocage des ouvertures placées au fond de l'équipement.

B.3.3 Essai de polarité sur les réseaux d'alimentation en courant continu

Si la connexion au **réseau d'alimentation** en courant continu n'est pas polarisée et si la connexion est **accessible** à une **personne ordinaire**, l'influence éventuelle de la polarité doit alors être prise en compte au moment de soumettre à l'essai l'équipement conçu pour le courant continu.

B.3.4 Réglage du sélecteur de tension

L'équipement destiné à être alimenté par le **réseau d'alimentation** muni d'un dispositif de réglage de tension destiné à être réglé par une **personne ordinaire** ou une **personne**

avertie, est soumis à l'essai avec le dispositif de réglage de la tension du **réseau d'alimentation** dans la position la plus défavorable.

B.3.5 Charge maximale aux bornes de sortie

Les bornes de sortie de l'équipement qui alimente en électricité d'autres équipements, à l'exception des socles de raccordement directement connectés au **réseau d'alimentation**, sont connectées aux impédances de charge les plus défavorables, y compris le court-circuit.

B.3.6 Polarité de batterie inversée

S'il est possible pour une **personne ordinaire** d'insérer les batteries remplaçables avec polarité inversée, l'équipement est soumis à l'essai dans toutes les configurations possibles avec une ou plusieurs batteries inversées (voir également l'Annexe M).

B.3.7 Conditions anormales de fonctionnement des amplificateurs audio

Les **conditions anormales de fonctionnement** des amplificateurs audio sont spécifiées à l'Article E.2.

B.3.8 Conformité pendant et après des conditions anormales de fonctionnement

*Pendant une **condition anormale de fonctionnement** qui ne conduit pas à une **condition de premier défaut**, toutes les **protections** doivent rester effectives. Après restauration des **conditions normales de fonctionnement**, toutes les **protections** doivent être conformes aux exigences applicables.*

*Si une **condition anormale de fonctionnement** entraîne une **condition de premier défaut**, l'Article B.4 s'applique.*

B.4 Simulation des conditions de premier défaut

B.4.1 Généralités

Lors d'une simulation de **conditions de premier défaut**, les parties, alimentations et supports doivent être en place s'ils sont susceptibles d'influencer les résultats de l'essai.

L'application de **conditions de premier défaut** doit se faire l'une après l'autre. Les défauts, qui sont les conséquences directes d'une **condition de premier défaut**, sont réputés faire partie de la **condition de premier défaut**.

L'équipement, les diagrammes de circuit et les spécifications de composant sont étudiés afin de déterminer les **conditions de premier défaut** qui peuvent être raisonnablement escomptées.

Les **conditions de premier défaut** suivantes doivent être prises en considération:

- une **condition de fonctionnement anormal** qui conduit à une **condition de premier défaut**. Par exemple, une **personne ordinaire** surchargeant les bornes de sortie externes, ou une **personne ordinaire** installant de manière incorrecte un interrupteur sélecteur;
- une défaillance de la **protection principale** ou une défaillance de la **protection supplémentaire**;
- à l'exception des composants de **protection** (c'est-à-dire, les composants conformes à l'Article G.13), une défaillance de composant simulée par le court-circuitage de deux fils et l'ouverture au circuit de l'un des fils du composant;
- lorsque requis en B.4.4, une défaillance de l'**isolation fonctionnelle**.

B.4.2 Dispositif de contrôle de la température

À l'exception des **protections** de contrôle de la température, selon les Articles G.2 à G.5, tout dispositif ou composant unique d'un circuit contrôlant la température durant la mesure de température doit être mis en circuit ouvert ou court-circuité, selon ce qui se révèle être le plus défavorable.

Les températures doivent être mesurées selon les indications de l'Article B.17.

B.4.3 Essais moteur

B.4.3.1 Essai de moteur bloqué

Les moteurs sont bloqués ou le rotor est verrouillé dans le produit fini s'il est évident qu'une telle action provoque une augmentation de la température ambiante interne de l'équipement (par exemple, verrouillage du rotor sur le moteur du ventilateur afin d'arrêter le débit d'air).

B.4.3.2 Conformité

La conformité est vérifiée soit en inspectant et en examinant les données disponibles, soit en procédant à l'essai conformément à l'Article G.8.

B.4.4 Court-circuit de l'isolation fonctionnelle

B.4.4.1 Court-circuit des distances dans l'air pour l'isolation fonctionnelle

Les **distances d'isolement** pour l'**isolation fonctionnelle** doivent être court-circuitées à moins que la **distance d'isolement dans l'air pour l'isolation fonctionnelle** ne soit conforme à la **distance d'isolement dans l'air pour l'isolation principale** ou à l'essai de rigidité diélectrique du Tableau 31 pour l'**isolation principale**.

B.4.4.2 Court-circuit des lignes de fuite pour l'isolation fonctionnelle

Les **lignes de fuite** pour l'**isolation fonctionnelle** doivent être court-circuitées à moins que la **ligne de fuite pour l'isolation fonctionnelle** ne soit conforme à la **ligne de fuite pour l'isolation principale** ou à l'essai de rigidité diélectrique indiqué en 5.4.11.1 pour l'**isolation principale**.

B.4.4.3 Court-circuit de l'isolation fonctionnelle sur les cartes imprimées revêtues

L'**isolation fonctionnelle** sur une carte imprimée revêtue doit être court-circuitée à moins que l'**isolation fonctionnelle** ne soit conforme à la distance de séparation indiquée dans le Tableau G.12 ou à l'essai de rigidité diélectrique indiqué en 5.4.11.1 pour l'**isolation principale**.

B.4.5 Court-circuit et interruption des électrodes dans les tubes et les semi-conducteurs

Les électrodes dans les tubes électroniques et les fils des dispositifs semi-conducteurs doivent être court-circuités ou, le cas échéant, interrompus. Interrompre un fil à la fois ou deux fils connectés ensemble l'un après l'autre. Voir B.4.1 pour les exceptions à cet essai.

B.4.6 Court-circuit ou déconnexion des composants passifs

Les résistances, condensateurs, bobinages, haut-parleurs, appareils VDR et autres composants passifs doivent être court-circuités ou déconnectés, selon la situation la plus défavorable.

Ces **conditions de premier défaut** ne s'appliquent pas aux:

- thermistances CTP conformes à la CEI 60730-1:1999, Articles 15, 17, J.15 et J.17;
- thermistances CTP fournissant l'action de type 2.AL spécifiée dans la CEI 60730-1;
- courts-circuits entre les bornes d'entrée et de sortie des optocoupleurs qui sont conformes aux **distances d'isolement dans l'air** et aux **lignes de fuite** correspondantes, ainsi qu'aux exigences de distance dans l'isolation selon la présente norme;
- courts-circuits entre l'entrée et la sortie des transformateurs qui sont conformes aux exigences en termes de **distances d'isolement dans l'air** et de **lignes de fuite** correspondantes de la présente norme;
- résistances conformes aux essais cités en 5.5.3.6 et 5.5.4;
- condensateurs conformes à la CEI 60384-14 et évalués selon les termes de 5.5.3.2 de la présente norme;
- composants conformes aux exigences de sécurité des normes CEI relatives aux composants ou conformes à l'Annexe G.

B.4.7 Fonctionnement en continu des composants

*Les moteurs, les bobines relais ou dispositifs semblables, conçus pour un **fonctionnement de courte durée** ou un **fonctionnement intermittent**, sont mis en service en continu si cette condition peut se produire pendant le fonctionnement de l'équipement.*

*En ce qui concerne les équipements conçus pour un **fonctionnement de courte durée** ou un **fonctionnement intermittent**, l'essai est répété jusqu'à l'obtention de conditions de régime constant, quelle que soit la durée de fonctionnement. Dans le cadre de cet essai, les **thermostats**, les **limiteurs de température** et les **disjoncteurs thermiques** ne sont pas court-circuités.*

*Dans les circuits non connectés directement au **réseau d'alimentation**, ainsi que dans les circuits alimentés par un système d'alimentation électrique en courant continu et les composants électromécaniques normalement alimentés de manière intermittente, à l'exception des moteurs, un défaut doit être simulé dans le circuit conducteur pour provoquer une alimentation en continu du composant.*

La durée de l'essai doit être comme suit:

- *en ce qui concerne les équipements ou composants dont la défaillance de fonctionnement n'est pas évidente pour une **personne ordinaire**, la durée doit être aussi longue que nécessaire pour établir des conditions stables ou une interruption du circuit suite à d'autres conséquences de la condition de défaut simulée, la durée la plus courte étant retenue; et*
- *pour les autres équipements et composants: 5 min ou jusqu'à interruption du circuit suite à une défaillance du composant (par exemple, un claquage) ou suite à d'autres conséquences de la condition de défaut simulée, la durée la plus courte étant retenue.*

B.4.8 Conformité pendant et après des conditions de premier défaut

*Pendant et après une **condition de premier défaut**, une source d'énergie de classe 1 ou de classe 2 ne doit pas devenir une source d'énergie de classe 3.*

*Pour une source d'énergie de classe 3, pendant et après une **condition de premier défaut**, au moins une **protection** doit rester conforme aux exigences de ladite **protection**.*

B.4.9 Charge de la batterie dans les conditions de premier défaut

Dans les **conditions de premier défaut**, le **courant de charge maximal**, la **tension de charge de limite supérieure**, la **température de charge la plus faible** et la **température de charge la plus élevée** doivent satisfaire aux exigences de l'Annexe M le cas échéant.

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Annexe C (normative)

Rayonnement ultraviolet (UV)

C.1 Protection des matériaux des équipements contre le rayonnement ultraviolet

C.1.1 Généralités

La présente annexe définit les exigences et procédures d'essai applicables aux matériaux ayant des propriétés de sécurité et qui sont sujets à une exposition au rayonnement ultraviolet.

C.1.2 Exigences

Les exigences suivantes s'appliquent uniquement aux équipements comprenant des lampes qui produisent un rayonnement UV significatif dans le spectre compris entre 180 nm et 400 nm, tel que spécifié par le fabricant des lampes.

NOTE 1 Les lampes fluorescentes et incandescentes universelles, avec des enveloppes de verre ordinaires, ne sont pas considérées comme des lampes émettant une quantité significative de rayonnement UV.

NOTE 2 Les filtres et/ou les lentilles peuvent fournir une **protection** et peuvent être utilisés comme une partie de l'enveloppe.

Tableau C.1 – Limites minimales de rétention des propriétés après exposition au rayonnement 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	Série ISO 527	70 %
	ou résistance à la flexion ^{ab}	ISO 178	70 %
Pièces fournissant une résistance aux chocs	Choc Charpy ^c ou	ISO 179-1	70 %
	Choc Izod ^c ou	ISO 180	70 %
	Choc de traction ^c	ISO 8256	70 %
Toutes les pièces	Classification d'inflammabilité du matériau	Voir l'Article S.4 de la présente norme	^d

^a Les essais de résistance à la traction et à la flexion doivent être effectués sur des éprouvettes dont l'épaisseur n'est pas supérieure aux épaisseurs réelles.

^b La face de l'échantillon exposée au rayonnement UV doit être en contact avec les deux points de charge lorsque l'on utilise la méthode aux trois points de charge.

^c Les essais effectués sur des éprouvettes de 3,0 mm d'épaisseur pour le choc Izod et les essais de résistance à la traction et sur des éprouvettes de 4,0 mm d'épaisseur pour les essais de choc Charpy sont considérés comme représentatifs d'autres épaisseurs, jusqu'à 0,75 mm.

^d La **classification d'inflammabilité du matériau** peut varier tant qu'elle ne tombe pas au-dessous de ce qui est spécifié à l'Article 6 de la présente norme.

C.1.3 Méthode d'essai

La conformité est vérifiée par examen de la construction et des données disponibles concernant les caractéristiques de résistance aux UV des pièces exposées au rayonnement UV dans l'équipement. Si de telles données ne sont pas disponibles, les essais indiqués dans le Tableau C.1 sont effectués sur les pièces exposées.

Les échantillons prélevés sur les pièces, ou constitués de matériau identique, sont préparés selon la norme en vue de l'essai à effectuer. Ils sont ensuite exposés au rayonnement UV (échantillons conditionnés) selon l'Article C.2. Après le conditionnement, les échantillons ne doivent montrer aucun signe de détérioration significative, tels qu'un fendillement ou une fissure. Ils sont ensuite conservés à température ambiante pendant au moins 16 h et sans dépasser 96 h, après quoi ils sont soumis à essai selon la norme correspondant à l'essai en question.

Afin d'évaluer le pourcentage de rétention des propriétés après l'essai, les échantillons n'ayant pas été conditionnés selon l'Article C.2 sont soumis à essai en même temps que les échantillons conditionnés.

La rétention doit être telle que spécifiée dans le Tableau C.1.

C.2 Essai de conditionnement à la lumière ultraviolette

C.2.1 Appareillage d'essai

Les échantillons sont exposés à la lumière ultraviolette en utilisant l'un des appareils suivants:

- une lampe à double arc au carbone (voir C.2.3) avec une exposition en continu. L'appareillage d'essai doit fonctionner avec une température du panneau noir de $63\text{ °C} \pm 3\text{ °C}$; ou*
- une lampe à arc au xénon (voir C.2.4) avec une exposition continue. L'appareillage 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 $0,35\text{ W/m}^2$ à 340 nm et une température du panneau noir de $63\text{ °C} \pm 3\text{ °C}$.*

C.2.2 Montage des échantillons d'essai

Les échantillons sont montés verticalement à l'intérieur du cylindre de l'appareillage d'exposition à la lumière, avec leur plus large partie faisant face aux arcs. Ils sont montés de manière à ce qu'ils ne soient pas en contact les uns avec les autres.

C.2.3 Essai d'exposition à la lumière sous une lampe à arc au carbone

L'appareillage décrit dans l'ISO 4892-4, ou son équivalent, est utilisé conformément aux procédures données dans l'ISO 4892-1 et l'ISO 4892-4 en utilisant un filtre de type 1, sans arrosage à l'eau.

NOTE L'expression « sans arrosage à l'eau » indique que les échantillons ne sont pas aspergés d'eau pendant l'essai. Il convient de ne pas confondre cette expression avec le refroidissement par eau qui est nécessaire pour le fonctionnement de l'appareillage.

Les matériaux sont exposés à la lumière en continu pendant au moins 720 h.

Les matériaux soumis à l'essai avec arrosage à l'eau sont également considérés comme acceptables.

C.2.4 Essai d'exposition à la lumière sous une lampe à arc au xénon

L'appareillage décrit dans l'ISO 4892-2, ou son équivalent, est utilisé conformément aux procédures données dans l'ISO 4892-1 et l'ISO 4892-2:2006 en utilisant le cycle 2 de la méthode A décrite dans le Tableau 3, sans arrosage à l'eau.

NOTE L'expression « sans arrosage à l'eau » indique que les échantillons ne sont pas aspergés d'eau pendant l'essai. Il convient de ne pas confondre cette expression avec le refroidissement par eau qui est nécessaire pour le fonctionnement de l'appareillage.

Les matériaux sont exposés à la lumière en continu pendant au moins 1 000 h.

Les matériaux soumis à l'essai avec arrosage à l'eau sont également considérés comme acceptables.

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Annexe D (normative)

Générateurs d'essai

D.1 Générateurs d'impulsions d'essai

Ces circuits produisent des impulsions d'essai telles que référencées dans le Tableau D.1. Dans ce tableau:

- la surtension du circuit référence 1 est typique des tensions induites dans les lignes téléphoniques et les câbles coaxiaux dans les longues suites de câbles, provoquées par la foudre au niveau de leur blindage de mise à la terre;
- la surtension du circuit référence 2 est typique des élévations du potentiel de terre dues soit aux décharges de foudre sur les lignes d'alimentation, soit aux défauts dans les lignes d'alimentation;
- la surtension du circuit référence 3 est typique des tensions induites dans les fils d'antenne, provoquées par les décharges de foudre à proximité de la terre.

NOTE Des mesures de précaution extrêmes sont nécessaires pendant l'utilisation de ces générateurs d'essai en raison de la charge électrique élevée stockée dans le condensateur C_1 .

Le circuit de la Figure D.1, utilisant les valeurs de composants dans les circuits références 1 et 2 du Tableau D.1, est utilisé pour produire des impulsions, le condensateur C_1 étant chargé initialement à la tension U_c .

Le circuit référence 1 du Tableau D.1 produit des impulsions 10/700 μs (10 μs de temps virtuel de montée, 700 μs de temps virtuel de descente à la moitié de la valeur) destinées à simuler les transitoires dans les **circuits externes** comme indiqué dans le Tableau 16, sous les numéros d'identification 11, 12, 13, 14, 15, 16 et 17.

Le circuit référence 2 du Tableau D.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 moitié de la valeur) destinées à simuler les transitoires dans les systèmes de distribution d'alimentation.

Les formes des ondes d'impulsion sont dans les conditions de circuit ouvert et peuvent être différentes dans les conditions de charge.

*Pendant l'essai, la tension de crête de l'impulsion appliquée ne doit pas être inférieure à la tension d'essai de l'impulsion de crête (par exemple, voir le Tableau 21) et la forme d'impulsion (par exemple, 1,2 μs de temps virtuel de montée, 50 μs de temps virtuel de descente à la moitié de la valeur pour l'impulsion 1,2/50 μs) doit rester substantiellement la même que dans des conditions de circuit ouvert. Les composants en parallèle avec la **distance d'isolement dans l'air** peuvent être déconnectés pendant cet essai.*



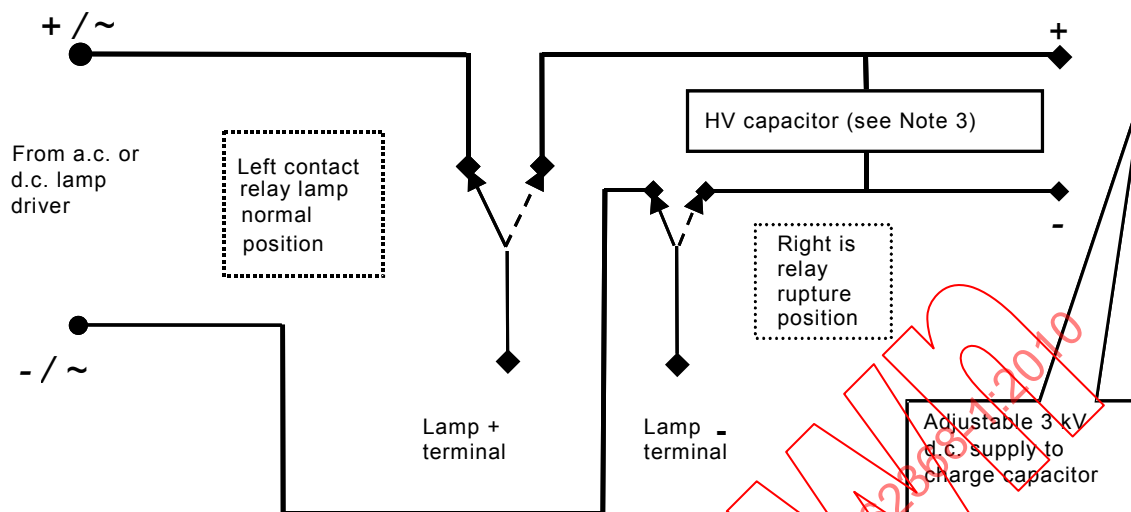
Le circuit de la Figure D.1, utilisant les valeurs de composants dans le circuit référence 3 du Tableau D.1, est utilisé pour produire des impulsions, le condensateur C_1 étant chargé initialement à la tension U_C . L'interrupteur utilisé dans le Tableau D.1 est un élément critique du circuit.



Référence	Impulsion d'essai	Figure	R_s	C_1	C_2	R_1	R_2	R_3
Circuit 1	10/700 μ s	D.1	-	20 μ F	0,2 μ F	50 Ω	15 Ω	25 Ω
Circuit 2	1,2/50 μ s	D.1	-	1 μ F	30 nF	76 Ω	13 Ω	25 Ω
Circuit 3	-	D.2	15 M Ω	1 nF	-	1 k Ω	-	-

NOTE Les circuits 1 et 2 sont basés sur la recommandation K.44 de l'UIT-T.

D.3 Générateur électronique d'impulsions



Légende

Anglais	Français
From a.c. or d.c. lamp driver	Du circuit de sortie de lampe c.a. ou c.c.
Left contact relay lamp normal position	Position normale relais de contact lampe à gauche
Right is relay rupture position	Position rupture de relais à droite
HV capacitor (see Note 3)	Condensateur HT (voir Note 3)
Lamp + terminal	Borne lampe +
Lamp – terminal	Borne lampe -
Adjustable 3 kV d.c. supply to charge capacitor	Alimentation réglable 3 kV c.c. pour la charge du condensateur

NOTE 1 La pression de fonctionnement de la lampe peut être convertie en énergie (Joules). Le niveau d'énergie de fonctionnement est le point de départ recommandé pour la charge d'essai.

NOTE 2 Le relais est de type défibrillateur double pôle 5 kV, rempli d'azote. Un relais qualifié de défibrillateur est suffisant. Voir la CEI 60601-2-4.

NOTE 3 Le condensateur HT a des valeurs assignées de 0,42 μ F 5 kV.

Figure D.3 – Exemple de générateur électronique d'impulsions

Annexe E (normative)

Conditions d'essai pour les équipements comprenant des amplificateurs audio

E.1 Conditions normales de fonctionnement des amplificateurs audio

Les amplificateurs audio doivent fonctionner à une fréquence de 1 000 Hz. Lorsqu'un amplificateur n'est pas conçu pour fonctionner à 1 000 Hz, la **fréquence de réponse crête** doit être utilisée.

Toutes les conditions suivantes doivent être considérées comme des **conditions normales de fonctionnement**:

- a) L'équipement doit fonctionner de manière à fournir $1/8^e$ de **puissance de sortie non écrêtée** à l'**impédance de charge assignée**. En variante, un signal de bruit rose de largeur de bande limitée peut être utilisé pour le fonctionnement, après que la **puissance de sortie non écrêtée** a été établie à l'aide d'un signal sinusoïdal. La largeur de bande du bruit provenant du signal d'essai doit être limitée par un filtre dont la caractéristique est décrite dans la Figure E.1.

Si l'écrêtage ne peut pas être atteint, la puissance maximale qu'il est possible d'atteindre doit être considérée comme la **puissance de sortie non écrêtée**.

Les commandes de tonalité doivent être réglées à mi-plage.

- b) L'**impédance de charge assignée** ou le circuit ouvert le/la plus défavorable de toute sortie, la solution la plus défavorable étant retenue.
- c) Les orgues ou instruments similaires qui possèdent un ensemble générateur de timbres doivent être mis en fonctionnement avec toute combinaison de deux clés de pédale basse, s'il y en a, et avec dix clés manuelles en jeu. Tous les registres et touches qui peuvent augmenter la puissance de sortie doivent être en action et l'équipement doit être réglé pour fournir $1/8$ de la puissance de sortie maximale qu'il est possible d'atteindre.
- d) Pour les amplificateurs audio utilisés dans un instrument de musique électronique qui ne délivre pas une tonalité continue, le signal décrit en a) doit être appliqué aux bornes d'entrée de signal ou à l'étage d'entrée approprié de l'amplificateur audio.
- e) Lorsque la fonction prévue de l'amplificateur dépend de la différence de phase entre deux voies, on doit avoir une différence de phase de 90° entre les signaux appliqués aux deux voies. Pour les amplificateurs multi-voies, contenant des voies ne pouvant pas être mises en fonctionnement de manière indépendante, ces voies en question doivent être chargées à $1/16$ de la **puissance de sortie non écrêtée**.
- f) Au moment de déterminer si une pièce ou un contact de borne est au-dessus de ES1 ou ES2 (voir le Tableau E.1), l'équipement doit être mis en fonctionnement afin de restituer une **puissance de sortie non écrêtée** maximale dans son **impédance de charge assignée**. La charge est retirée et la classe de la source d'alimentation électrique est déterminée à partir de la tension de sortie résultant du circuit ouvert.
- g) La température doit être mesurée avec l'équipement positionné conformément au manuel d'instruction fourni par le fabricant, ou, en l'absence d'instructions, l'équipement doit être positionné 5 cm en arrière de la partie avant d'une boîte d'essai en bois semi-ouverte, en laissant un espace libre de 1 cm le long des côtés et de la partie supérieure et une profondeur de 5 cm à l'arrière de l'équipement.

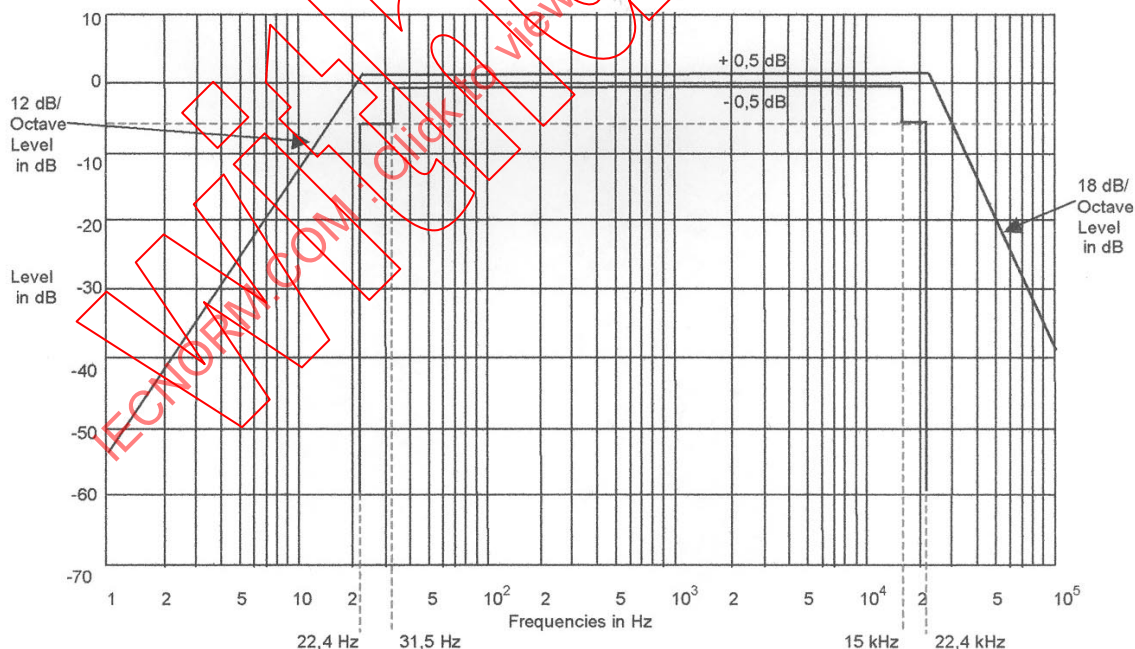
Tableau E.1 – Classes et protections de la source d'énergie électrique des signaux audio

Tension du signal audio V efficace	Classe	Exemples de protections entre la source d'énergie et une personne ordinaire	Exemple de protections entre la source d'énergie et une personne avertie
Entre 0 et 71	ES1	Aucune protection nécessaire	Aucune protection nécessaire
Supérieure à 71 et inférieure à 120	ES2	Bornes isolées ^a Marquage ISO 7000:2004, symbole  0434a ou symbole  0434b Protection mise en place sous forme d'instructions pour les pièces de borne non isolées et les fils dénudés ^b	Aucune protection nécessaire
Supérieure à 120	ES3	Connecteurs conformes aux exigences de la CEI 61984 avec marquage  , CEI 60417-5036 (2002)	

NOTE Lors de l'utilisation d'une fiche unipolaire ou d'un fil nu pour établir une liaison électrique avec un contact d'un dispositif de connexion extérieure pour la terre, l'antenne, ou le son, la vidéo ou les signaux associés, l'accessibilité est déterminée par l'utilisation d'une sonde d'essai illustrée à la Figure V.5. L'essai n'est pas appliqué aux bornes marquées du symbole CEI 60417-5036 (2002).

^a Les bornes qui n'ont pas de parties conductrices **accessibles** après avoir installé les fils en conformité avec les instructions.

^b Une **protection mise en place sous forme d'instructions** indiquant que les bornes ou les fils non isolés en contact peuvent provoquer une sensation déplaisante.



Légende

Anglais	Français
Octave level in dB	Niveau d'octave en dB
Level in dB	Niveau en dB
Frequencies in Hz	Fréquences en Hz

Figure E.1 – Filtre passe-bande pour la mesure du bruit en bande large

Si le fonctionnement continu d'un équipement comprenant un amplificateur audio n'est pas possible, l'amplificateur doit être mis en fonctionnement avec le niveau maximal de signal permettant un fonctionnement continu.

E.2 Conditions anormales de fonctionnement des amplificateurs audio

Les **conditions anormales de fonctionnement** doivent être simulées en réglant les commandes à la puissance de sortie la plus défavorable entre zéro et la puissance de sortie maximale qu'il est possible d'atteindre dans l'**impédance de charge assignée** la plus défavorable connectée aux bornes de sortie. Un court-circuit des bornes de sortie est également considéré comme une **condition anormale de fonctionnement**.

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Annexe F (normative)

Marquages des équipements, instructions et protections mises en place sous forme d'instructions

F.1 Généralités

La présente annexe spécifie les marquages des équipements, les instructions et les **protections mises en place sous forme d'instructions** nécessaires à l'installation des équipements, à leur fonctionnement, leur maintenance et leur entretien conformément aux exigences de la présente norme.

À moins que des symboles ne soient utilisés, le marquage des équipements, instructions et **protections mises en place sous forme d'instructions** liés à la sécurité doivent être rédigés dans la langue en vigueur dans le pays considéré.

La présente annexe ne s'applique pas au marquage des composants. Les marquages des composants sont spécifiés dans la norme sur le composant concerné.

La présente annexe peut s'appliquer aux sous-ensembles, tels que les alimentations électriques.

NOTE 1 Lorsque le terme marquage est utilisé dans la norme, il s'applique également aux instructions et aux éléments requis d'une **protection mise en place sous forme d'instructions**.

NOTE 2 Pour des exemples de marquage, voir le Tableau F.1. Les marquages d'équipement et les instructions ne sont pas limités à ceux spécifiés dans la présente annexe. L'équipement peut comprendre des marquages supplémentaires et peut être accompagné d'instructions supplémentaires non requises dans la présente annexe. D'autres normes et réglementations applicables peuvent nécessiter des marquages ou des instructions supplémentaires. Cependant, on doit veiller à ce que les marquages et instructions supplémentaires ne contredisent pas les marquages et instructions requis dans la présente annexe.

F.2 Symboles littéraux et symboles graphiques

F.2.1 Symboles littéraux

Les symboles littéraux pour les grandeurs et les unités doivent être conformes à la CEI 60027-1.

F.2.2 Symboles graphiques

Les symboles graphiques doivent être conformes à la CEI 60417, l'ISO 3864-2 ou l'ISO 7000. En l'absence de symboles adéquats dans la CEI 60417 ou l'ISO 3864-2 ou l'ISO 7000, le fabricant peut créer des symboles graphiques spécifiques.

NOTE Il convient de développer un nouveau symbole en accord avec les principes d'ergonomie et en conformité avec l'ISO 3864-2.

F.2.3 Conformité

La conformité est vérifiée par examen.

F.3 Marquages des équipements

F.3.1 Emplacements du marquage d'équipement

En général, les marquages d'équipement doivent se trouver à proximité ou à côté de la pièce ou de la région sujette au marquage.

Les marquages d'équipement spécifiés en F.3.2, F.3.3, F.3.6.2 et F.3.7 doivent se trouver à l'extérieur de l'équipement, à l'exception du fond. Toutefois, ces marquages peuvent se trouver à un endroit aisément **accessible** à la main, par exemple

- sous un couvercle, ou
- à l'extérieur de la base
 - d'un **équipement à enficher directement**, d'un **équipement portatif**, d'un **équipement transportable**, ou
 - d'un **équipement mobile** d'une masse ne dépassant pas 18 kg, à condition que l'emplacement du marquage soit fourni dans les instructions.

Les marquages ne doivent pas être placés sur des pièces retirables sans **outil**, sauf s'ils s'appliquent à cette pièce.

Pour les **équipements reliés en permanence**, les instructions d'installation doivent être fournies soit sous forme de marquages sur l'équipement, soit dans les instructions, soit dans un document d'instructions d'installation à part.

Pour les équipements montés sur casier ou panneau qui pèsent plus de 18 kg, les marquages peuvent être placés sur toute surface devenant visible après avoir retiré l'équipement du casier ou du panneau.

À moins que la signification du marquage ne soit évidente, le marquage doit être expliqué dans les instructions.

La conformité est vérifiée par examen.

F.3.2 Marquages d'identification des équipements

F.3.2.1 Identification du fabricant

Le fabricant ou le fournisseur responsable doit être identifié au moyen d'un marquage placé sur l'équipement. L'identification peut comporter le nom du fabricant, le nom du fournisseur responsable, la marque de fabrique ou toute autre forme d'identification équivalente.

F.3.2.2 Identification du modèle

Le numéro du modèle, le nom du modèle ou un équivalent doivent être identifiés au moyen d'un marquage placé sur l'équipement.

F.3.2.3 Conformité

La conformité est vérifiée par examen.

F.3.3 Marquages de caractéristiques assignées des équipements

F.3.3.1 Équipement sans connexion directe au réseau d'alimentation

Si un appareil n'est pas fourni avec un moyen de connexion directe au **réseau d'alimentation**, il n'est pas nécessaire de le marquer avec une classification électrique, telle

que sa **tension assignée**, son **courant assigné**, sa **puissance assignée** ou sa **fréquence assignée**.

F.3.3.2 Nature de la tension d'alimentation

La nature de la tension d'alimentation, en courant continu, alternatif ou triphasé alternatif, doit figurer sur l'équipement et doit être placée directement à la suite de la classification de la tension de l'équipement. Si un symbole est utilisé pour identifier les équipements à courant continu ou à courant alternatif, le symbole $\sim$, CEI 60417-5032 (2002) doit être utilisé pour le courant alternatif et le symbole $---$, CEI 60417-5031 (2002) doit être utilisé pour le courant continu.

L'équipement triphasé peut être identifié par « 3 phases » ou "3Ø" ou tout autre signe qui indique clairement la phase de la tension d'alimentation de l'équipement.

F.3.3.3 Tension assignée

La **tension assignée** de l'équipement doit être marquée sur l'équipement. Le marquage de la valeur assignée de la tension doit être immédiatement suivi de la nature du marquage de l'alimentation.

La **tension assignée** peut être:

- une seule valeur nominale, ou
- une seule valeur nominale et un pourcentage de tolérance de la valeur nominale, ou
- deux ou plusieurs valeurs nominales séparées par une barre oblique (/), ou
- une plage indiquée par des valeurs minimale et maximale séparées par un trait d'union, ou

toute autre type d'information indiquant clairement la tension de l'équipement.

Si l'équipement comprend plus d'une tension nominale, toutes ces tensions peuvent être marquées sur l'équipement. Cependant, la tension sur laquelle l'équipement est réglé doit être clairement indiquée (voir F.3.4).

Les équipements triphasés doivent porter les marquages relatifs à la tension entre phases, un symbole indiquant le système d'alimentation en conformité avec la CEI 61293, une barre oblique (/), la tension phase-neutre, le symbole pour la tension (V) et le nombre de phases, dans cet ordre. Tout autre type d'information indiquant clairement la **tension assignée** triphasée de l'équipement est également acceptable.

NOTE La barre oblique (/) représente le mot « ou » et le trait d'union (-) représente le mot « à ».

F.3.3.4 Fréquence assignée

La **fréquence assignée** de l'équipement doit être marquée sur l'équipement.

La **fréquence assignée** peut être:

- une seule valeur nominale, ou
- une seule valeur nominale et un pourcentage de tolérance de la valeur nominale, ou
- deux ou plusieurs valeurs nominales séparées par une barre oblique (/), ou
- une plage indiquée par des valeurs minimale et maximale séparées par un trait d'union, ou
- tout autre type d'information indiquant clairement la **fréquence assignée** de l'équipement.

F.3.3.5 Courant assigné ou puissance assignée

Le **courant assigné** ou la **puissance assignée** de l'équipement doivent être marqués sur l'équipement, conformément à B.2.5.

Pour les équipements triphasés, le **courant assigné** ou la **puissance assignée** est le courant ou la puissance d'une phase.

NOTE 1 Il n'est pas nécessaire de mentionner plus d'un chiffre significatif pour le **courant assigné** ou la **puissance assignée**.

NOTE 2 Dans certains pays, pour les marquages sur les équipements, l'indicateur de décimales requis est la virgule.

Si l'équipement dispose d'un socle de raccordement pour fournir l'énergie électrique du **réseau d'alimentation** aux autres équipements, le **courant assigné** et la **puissance assignée** de l'équipement doivent comprendre le courant ou la puissance assigné(e) de la prise de courant.

Pour les exigences de marquage relatives aux socles de prises de courant du **réseau d'alimentation**, voir F.3.5.1.

Si l'équipement comporte plus d'une **tension assignée**, le **courant assigné** ou la **puissance assignée** pour chaque **tension assignée** doit être marqué(e) sur l'équipement. La disposition des marquages doit clairement indiquer le **courant assigné** ou la **puissance assignée** associé(e) à chaque **tension assignée** de l'équipement.

F.3.3.6 Équipement avec connexions d'alimentation multiples

Si l'équipement comporte plusieurs connexions d'alimentation, chaque connexion doit être marquée avec son **courant assigné** ou sa **puissance assignée**.

Si l'équipement comprend plusieurs connexions d'alimentation et si chaque connexion a une **tension assignée** différente de celle des autres connexions d'alimentation, chaque connexion doit être marquée avec sa **tension assignée**.

Il n'est pas nécessaire de marquer les caractéristiques assignées de l'intégralité du système électrique.

F.3.3.7 Conformité

La conformité est vérifiée par examen.

F.3.4 Dispositif de réglage de la tension

Si l'équipement emploie un dispositif de réglage de la tension qui peut être manié par une **personne ordinaire** ou une **personne avertie**, le fait de modifier le réglage de la tension doit également modifier l'indication de la tension pour laquelle l'équipement est réglé. Le réglage doit être facilement identifiable dès que l'équipement est prêt à être utilisé.

Si l'équipement emploie un dispositif de réglage de la tension qui ne peut être manié que par une **personne qualifiée** et si le fait de modifier le réglage de la tension ne modifie pas également l'indication des valeurs assignées de la tension, une **protection mise en place sous forme d'instructions** doit stipuler que, lors de la modification du réglage de la tension, l'indication du réglage de la tension doit également être modifiée.

La conformité est vérifiée par examen.