IEC 62368-1

Edition 2.0 2014-02

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

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

IEC 62368-1:2014-02(en-fr)

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Part 1: Safety requirements

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AUDIO/VIDEO, INFORMATION AND COMMUNICATION TECHNOLOGY EQUIPMENT –

Part 1: Safety requirements

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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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 second edition cancels and replaces the first edition published in 2010. It constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

– addition of requirements for LEDs;
– new requirements for wall and ceiling mounting means;
– addition of acoustic shock requirements for personal music players;
– revision of the battery requirements, including new requirements for coin / button cell batteries;
– revision of the burn requirements.

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

FDIS	Report on voting
108/521/FDIS	108/531/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.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 62368 series, published under the general title *Audio/video, information and communication technology equipment*, can be found on the IEC website.

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

0.2.1, 1, 4.1.15, 4.7.3, 5.2.2.2, 5.4.2.3.2.4, 5.4.2.5, 5.4.5.1, 5.5.2.1, 5.5.6, 5.6.4.2, 5.7.5, 5.7.6.1, 10.5.3, 10.6.2.1, F.3.3.6, Table 13, Table 14 and Table 39.

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**.

In figures and tables, if colour is available:

– green colour denotes a class 1 energy source;
– yellow colour denotes a class 2 energy source;
– red colour denotes a class 3 energy source.

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.

NOTE 1 The attention of National Committees 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 the committee 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, the committee recommends that this edition of the 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 is contained in IEC/TR 62368-2. It provides 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 part of IEC 62368 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 used in the equipment. **Skilled persons** are 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

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).

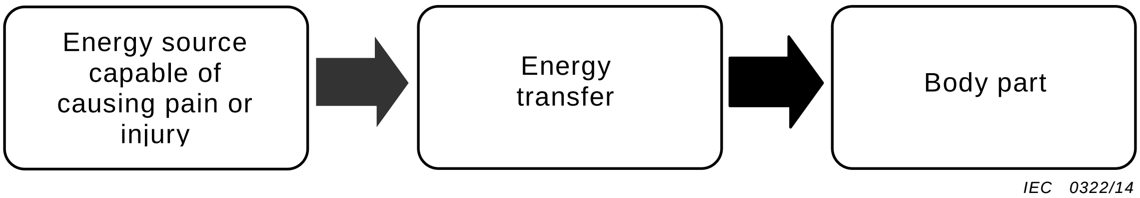


Figure 1 – Three block model for pain and injury

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 or physiological reaction may not be manifested for days, weeks, months, or years.

0.4 Energy sources

Energy sources are addressed by this standard, together with 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 use 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, 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

Many products necessarily use energy capable of causing pain or injury. Product design cannot eliminate such energy use. Consequently, such products should use 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.

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

– **equipment safeguards** are always useful, since they do not require any knowledge or actions by persons coming into contact with the equipment;
– **installation safeguards** are useful when a safety characteristic can only be provided after installation (for example, the equipment has to be bolted to the floor to provide stability);
– behavioural **safeguards** are useful when the equipment requires an energy source to be **accessible**.

In practice, **safeguard** selection accounts for 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 Personal safeguard

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

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

0.5.5 Behavioural safeguards

0.5.5.1 Introduction to behavioural safeguards

In the absence of an equipment, installation, or **personal safeguard**, a person may use a specific behaviour as a **safeguard** to avoid energy transfer and consequent injury. A behavioural **safeguard** is a voluntary or instructed behaviour intended to reduce the likelihood of transfer of energy to a body part.

Three kinds of behavioural **safeguards** are specified in this standard. Each kind of behavioural **safeguard** is associated with a specific kind of person. An **instructional safeguard** is usually addressed to an **ordinary person**, but may also be addressed to an **instructed person** or a **skilled person**. A **precautionary safeguard** is used by an **instructed person**. A **skill safeguard** is used by a **skilled person**.

0.5.5.2 Instructional safeguard

An **instructional safeguard** is a means of providing information, 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 visual indicator (symbols or words or both) or an audible message, as applicable to the expected use of the product.

When accessing locations where the equipment 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 or class 3 energy source.

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

If exposure to an energy source capable of causing pain or injury is essential to the correct functioning of equipment, an **instructional safeguard** may be used to ensure protection of persons instead of another **safeguard**. Consideration should be given as to whether the **instructional safeguard** should require the use of a **personal safeguard**.

Provision of an **instructional safeguard** does not result in an **ordinary person** becoming an **instructed person** (see 0.5.5.3).

0.5.5.3 Precautionary safeguard (used by an instructed person)

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** is expected to then apply precaution as a **safeguard** to avoid injury.

0.5.5.4 Skill safeguard (used by a skilled person)

A **skill safeguard** is the education, training, knowledge and experience of the **skilled person** that is used to protect the **skilled person** against class 2 or 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** is expected to then apply skill as a **safeguard** to avoid injury.

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**.

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** needs to partially or wholly enter between two or more class 3 energy source locations while servicing.

0.5.8 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: gloves	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 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.

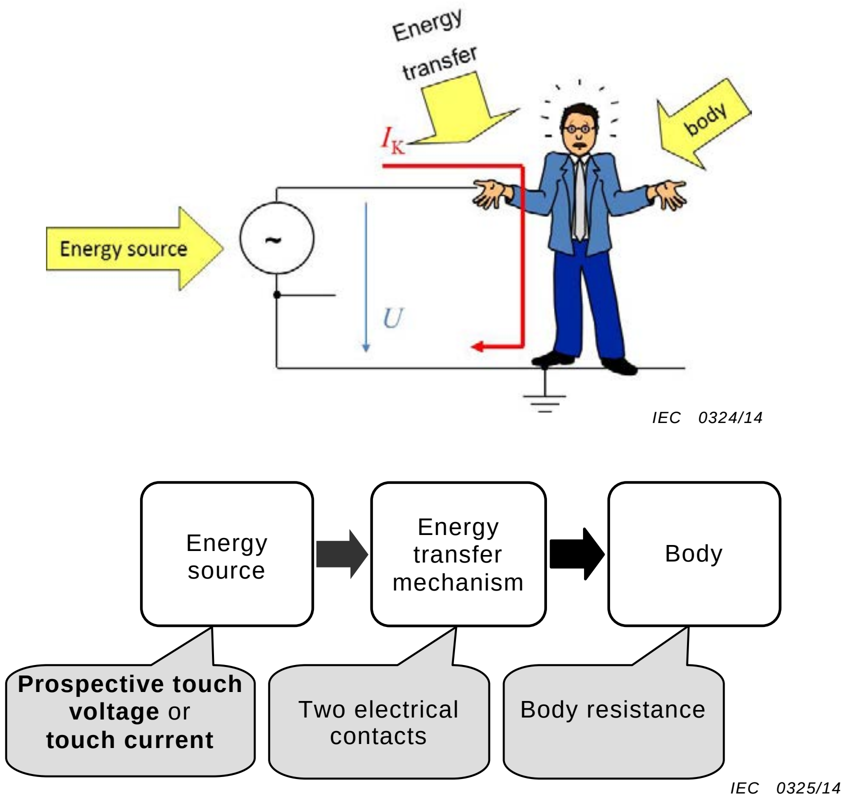


Figure 3 – Schematic and model for electrically-caused pain or injury

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.

0.6.2 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).

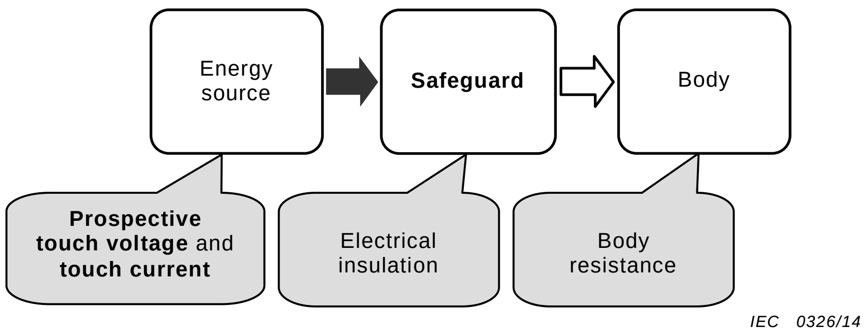


Figure 4 – Model for protection against electrically-caused pain or injury

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 placed 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**) placed between the energy source and a body part.

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

0.7 Electrically-caused fire

0.7.1 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.

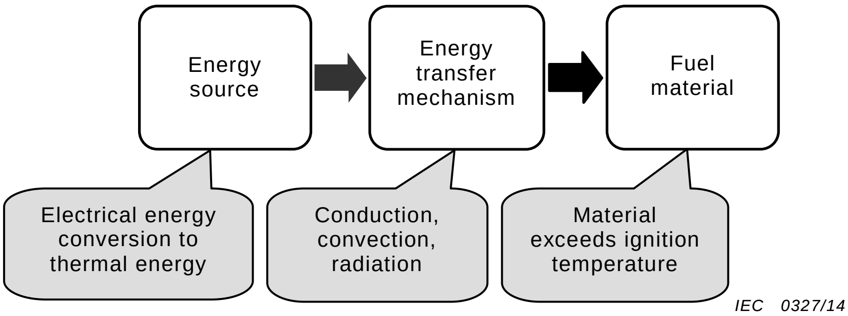


Figure 5 – Model for electrically-caused fire

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 ignites by itself. Both result in fire.

0.7.2 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.

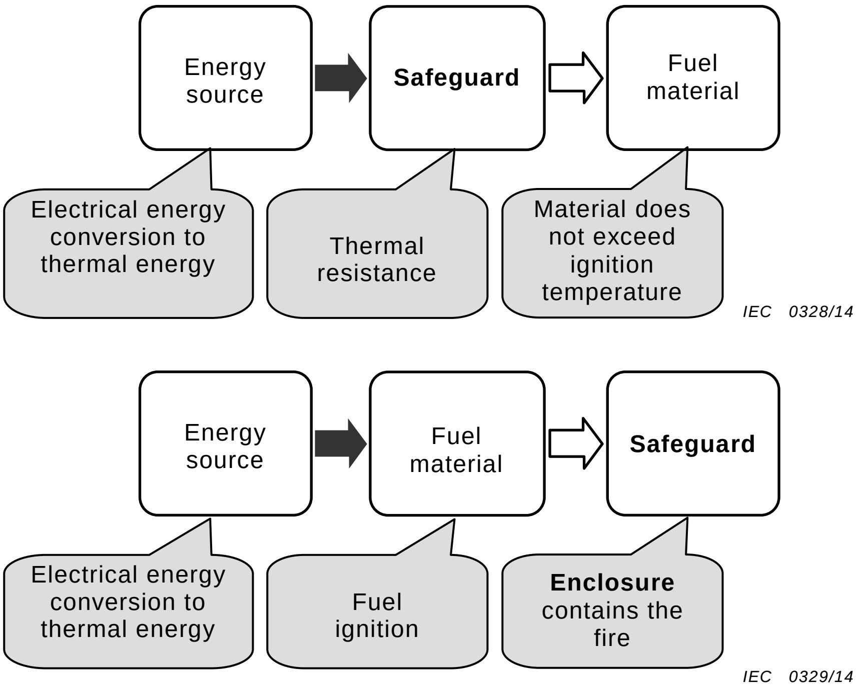


Figure 6 – Models for protection against fire

0.8 Injury caused by hazardous substances

Injury caused by **hazardous substances** is due to a chemical reaction with a body part. The extent of injury by a given substance depends on both the magnitude and duration of exposure and on the body part susceptibility to that substance.

The **basic safeguard** against injury caused by **hazardous substances** is containment of the material.

Supplementary safeguards against injury caused by **hazardous substances** 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 **hazardous substances** used in equipment. These regulations do not enable a practical classification of **hazardous substances** 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

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;

– robust handles;

– robust 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**.

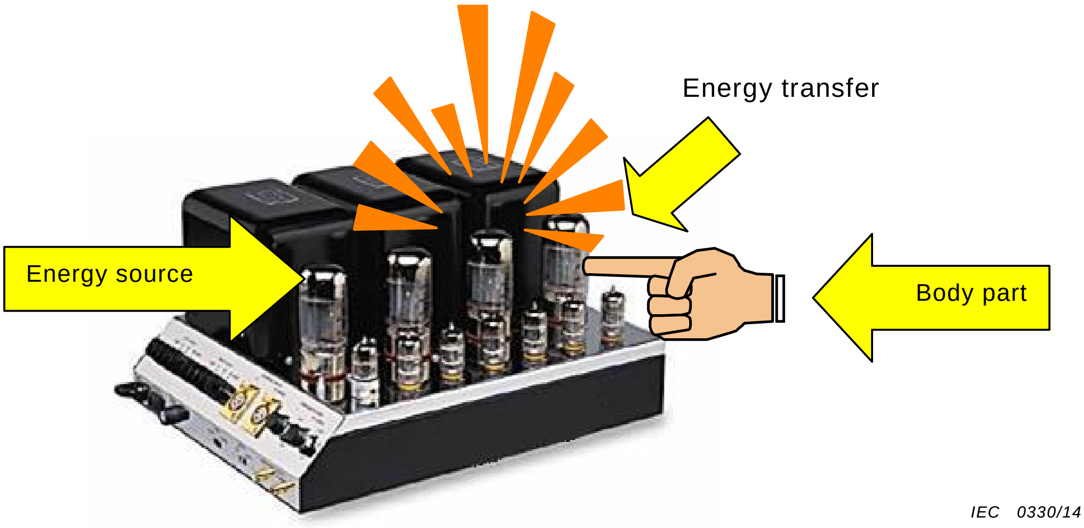
0.10 Thermally-caused injury (skin burn)

0.10.1 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.



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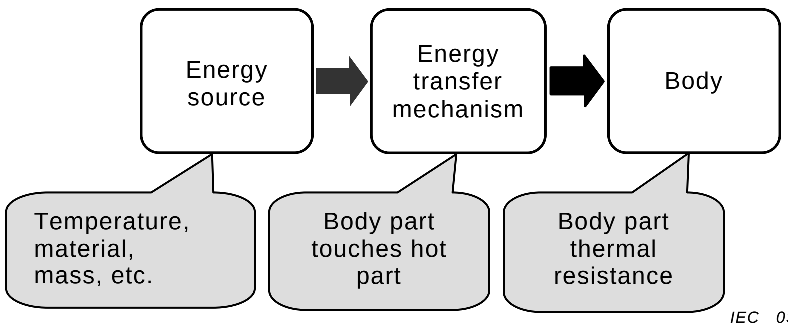

IEC 0331/14

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).

0.10.2 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).

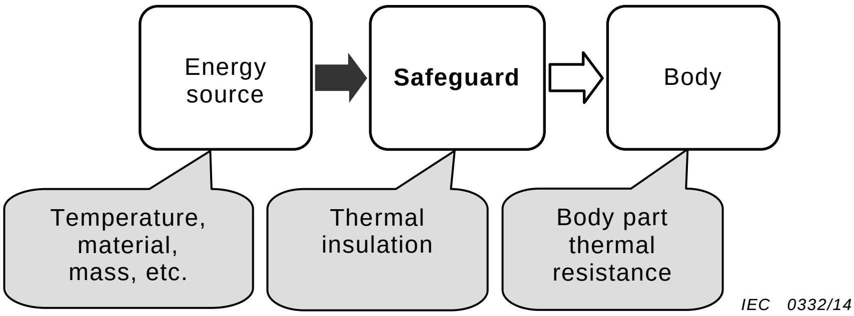

Figure 8 – Model for protection against thermally-caused injury

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 placed 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**); and

– heat sinking, etc.

The **supplementary safeguard** against a thermal energy source capable of causing injury is thermal insulation placed 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

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.

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.

The **basic safeguard** against auditory injury is to limit the acoustic output of personal music players and their associated headphones and earphones.

Examples of **supplementary safeguards** against auditory pain and injury are the provision of warnings and information advising the user how to use the equipment correctly.

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.

NOTE 2 A **rated voltage** of 600 V is considered to include equipment rated 400/690 V.

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;
– external power supply units intended to supply other equipment within the scope of this part of IEC 62368;
– accessories intended to be used with equipment within the scope of this part of IEC 62368.

This part of IEC 62368 does not apply to power supply systems which are not an integral part of the equipment, such as motor-generator sets, **battery** backup systems and distribution transformers.

This part of IEC 62328 specifies **safeguards** for **ordinary persons**, **instructed persons**, and **skilled persons**. Additional requirements may apply for equipment that is clearly designed or intended for use by children or specifically attractive to children.

NOTE 3 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 part of IEC 62368 does not apply to equipment to be used in wet areas. Additional requirements may apply.

Additional requirements for equipment intended for outdoor installation are given in IEC 60950-22.

This part of IEC 62368 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 as specified in Clause 7;
– electrostatic discharge events;
– environmental aspects;
– 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.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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/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 60086-5, *Primary batteries – Part 5: Safety of batteries with aqueous electrolyte*

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

IEC 60227-2:2003, *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V – Part 2: Test methods*

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

IEC 60309 (all parts), *Plugs, socket-outlets and couplers for industrial purposes*

IEC 60317 (all parts), *Specifications for particular types of winding wires*

IEC 60317-43, *Specifications for particular types of winding wires – Part 43: Aromatic polyimide tape wrapped round copper wire, class 240*

IEC 60320 (all parts), *Appliance couplers for household and similar general purposes*

IEC 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 60332-2-2, *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*, available from: <http://www.graphical-symbols.info/equipment>

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

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 60730-1:2010, *Automatic electrical controls for household and similar use – Part 1: General requirements*

IEC 60738-1:2009, *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 60825-1:2007, *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, *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 60950-22:2005, *Information technology equipment – Safety – Part 22: Equipment to be installed outdoors*

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 mm^2 up to 35 mm^2 (included)*

IEC 60999-2, *Connecting devices – Electrical copper conductors – Safety requirements for screw-type and screwless-type clamping units – Part 2: Particular requirements for clamping units for conductors above 35 mm^2 up to 300 mm^2 (included)*

IEC 61051-1, Varistors for use in electronic equipment – Part 1: Generic specification

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

Amendment 1:2009

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 61058-1:2008, *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 61558-2-16, *Safety of transformers, reactors, power supply units and similar products for voltages up to 1 100 V – Part 2-16: Particular requirements and tests for switch mode power supply units and transformers for switch mode power supply units*[1]

IEC 61643-11, *Low-voltage surge protective devices – Part 11: Surge protective devices connected to low-voltage power systems – Requirements and test methods*

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 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 62281, *Safety of primary and secondary lithium cells and batteries during transport*

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

IEC/TR 62471-2, *Photobiological safety of lamps and lamp systems – Part 2: Guidance on manufacturing requirements relating to non-laser optical radiation safety*

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

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

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1 To be published.

2 To be published.

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*

ISO 7000, *Graphical symbols for use on equipment – Index and synopsis,* available from: <http://www.graphical-symbols.info/equipment>

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*

EN 50332-1, *Sound system equipment: Headphones and earphones associated with portable audio equipment – Maximum sound pressure level measurement methodology and limit considerations – Part 1: General method for "one package equipment"*

EN 50332-2, *Sound system equipment: Headphones and earphones associated with portable audio equipment – Maximum sound pressure level measurement methodology and limit considerations – Part 2: Matching of sets with headphones if either or both are offered separately*

3 Terms, definitions and abbreviations

3.1 Energy source abbreviations

Abbreviation	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 Other abbreviations

Abbreviation	Description
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
GDT	gas discharge tube
IC	integrated circuit
ICX	integrated circuit with X-capacitor function
LED	light emitting diode
LEL	lower explosion limit
LFC	liquid filled component
LPS	limited power source
MOV	metal oxide varistor
NiCd	nickel cadmium

Abbreviation	Description
PIS	potential ingnition source
PPE	personal protective equipment
PTC	positive temperature coefficient
RC	resistor-capacitor
RG	risk group
Sb	antimony
SPD	surge protective device
SRME	slide rail mounted equipment
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 indicating the number of the defined term.

Where the words "voltage" and "current" or their abbreviations are used, they are r.m.s. values unless otherwise specified.

3.3.1 Circuit terms

3.3.1.1
external circuit
electrical circuit that is external to the equipment and is not **mains**

Note 1 to entry: 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 1 to entry: **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

[SOURCE: IEC 60050-195:1998, 195-06-13, modified – the term **safeguard** has been used]

3.3.2.2
enclosure
housing affording the type and degree of protection suitable for the intended application

[SOURCE: IEC 60050-195:1998, 195-02-35]

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 pain and 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 or disconnected from 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 or via a non-industrial appliance coupler, or both

Note 1 to entry: Examples are plugs and socket-outlets covered by standards such as IEC/TR 60083 and IEC 60320-1.

3.3.3.6
pluggable equipment type B
equipment that is intended for connection to the **mains** via an industrial plug and socket-outlet or via an industrial appliance coupler, or both

Note 1 to entry: Examples are plugs and socket-outlets covered by standards such as IEC 60309-1.

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 1 to entry: **Stationary equipment** is neither **movable equipment** nor **transportable equipment**.

3.3.3.8
transportable equipment
equipment that is intended to be routinely carried

Note 1 to entry: 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 to entry: 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

Note 1 to entry: Materials are classified 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

Note 1 to entry: 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**

[SOURCE: IEC 60050-195, Amendment 1:2001, 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 placed between two conductive parts or between a conductive part and a body part

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

3.3.6 Miscellaneous

3.3.6.1
accessible
touchable by a body part

Note 1 to entry: A body part is represented by one or more of the probes specified in Annex V, as applicable.

3.3.6.2
cheesecloth
bleached cotton cloth of approximately 40 g/m^2

Note 1 to entry: **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 isolation

3.3.6.4
functional earth
earthing a point or points in a system or in an installation or in equipment, for purposes other than electrical safety

[SOURCE: IEC 60050-195, Amendment 1:2001, 195-01-13]

3.3.6.5
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**

3.3.6.6
pollution degree
numeral characterising the expected pollution of the micro-environment

[SOURCE: IEC 60050-581:2008, 581-21-07]

3.3.6.7
restricted access area
area **accessible** only to **skilled persons** and **instructed persons** with the proper authorization

3.3.6.8
routine test
test to which each individual device is subjected during or after manufacture to ascertain whether it complies with certain criteria

[SOURCE: IEC 60664-1:2007, 3.19.2]

3.3.6.9
sampling test
test on a number of devices taken at random from a batch

[SOURCE: IEC 60664-1:2007, 3.19.3]

3.3.6.10
tool
object that can be used to operate a screw, latch or similar fixing means

Note 1 to entry: Examples of **tools** include coins, tableware, screwdrivers, pliers, etc.

3.3.6.11
touch current
electric current through a human body when body parts touch two or more **accessible** parts or one **accessible** part and earth

3.3.6.12
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

3.3.6.13
wrapping tissue
tissue between 12 g/m^2 and 30 g/m^2

Note 1 to entry: The **wrapping tissue** is soft, thin, usually translucent paper used for wrapping delicate articles.

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 to entry: **Abnormal operating conditions** are specified in Clause B.3.

Note 2 to entry: An **abnormal operating condition** may be introduced by the equipment or by a person.

Note 3 to entry: 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 range of normal use that can reasonably be expected

Note 1 to entry: Unless otherwise stated, the most severe conditions of normal use are the most unfavourable default values as specified in Clause B.2.

Note 2 to entry: Misuse is not covered by **normal operating conditions**. Instead, it is covered by **abnormal operating conditions**.

3.3.7.5
overload condition
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 1 to entry: The frequency applied should be within the amplifier/transducer's intended operating range.

3.3.7.7
rated load impedance
impedance or resistance as declared by the manufacturer, 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

Note 1 to entry: **Reasonably foreseeable misuse** is considered to be a form of **abnormal operating conditions**.

[SOURCE: ISO/IEC Guide 51:1999, 3.14, modified – Note 1 to entry has been added.]

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

Note 1 to entry: **Single fault conditions** are specified in Clause B.4.

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 use **equipment safeguards** and **precautionary safeguards** with respect to those energy sources

Note 1 to entry: 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**

[SOURCE: IEC 60050-826:2004, 826-18-03]

3.3.8.3
skilled person
person with relevant education or experience to enable him or her to identify hazards and to take appropriate actions to reduce the risks of injury to themselves and others

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

Note 2 to entry: 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

Note 1 to entry: Equipment may have more than one **rated voltage** value or may have a **rated voltage range**.

[SOURCE: IEC 60664-1:2007, 3.9]

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
current 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

3.3.11.6
personal safeguard
personal protective equipment that is worn on the body and that reduces exposure to an energy source

Note 1 to entry: Personal protective equipment (PPE) is a form of a **personal safeguard**. Examples are shields, goggles, gloves, aprons, face masks or breathing apparatus.

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, provided for protective equipotential-bonding of parts required to be earthed for safety purposes

Note 1 to entry: A **protective bonding conductor** is internal in the equipment.

3.3.11.9
protective conductor
conductor provided for the purposes of safety (for example, protection against electric shock)

Note 1 to entry: A **protective conductor** is either a **protective earthing conductor** or a **protective bonding conductor**.

[SOURCE: IEC 60050, Amendment 1:2001, 195-02-09]

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

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 1 to entry: 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

Note 1 to entry: A **safety interlock** encompasses the system of components and circuits that are directly involved in the **safeguard** function, including electro-mechanical devices, conductors on printed boards, wiring and their terminations, etc., as applicable.

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

[SOURCE: IEC 60664-1:2007, 3.2]

3.3.12.2
creepage distance
shortest distance along the surface of an insulating material between two conductive parts

[SOURCE: IEC 60664-1:2007, 3.3, modified — "solid" has been deleted.]

3.3.13 Temperature controls

3.3.13.1
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 1 to entry: A **temperature limiter** may be of the automatic reset or of the manual reset type.

3.3.13.2
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

3.3.13.3
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
voltage having a peak-to-peak ripple not exceeding 10 % of the average value

Note 1 to entry: 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 **mains** input to the equipment arising from external transients

3.3.14.3
peak working voltage
peak value of the **working voltage**, including any d.c. component and any repetitive peak impulses generated in the equipment

3.3.14.4
prospective touch voltage
voltage between simultaneously **accessible** conductive parts when those conductive parts are not being touched

3.3.14.5
protective conductor current
current flowing through the **protective earthing conductor** under **normal operating conditions**

Note 1 to entry: **Protective conductor current** was previously included in the term "leakage current".

3.3.14.6
required withstand voltage
peak voltage that the insulation under consideration is required to withstand

3.3.14.7
r.m.s. working voltage
true r.m.s. value of the **working voltage**

Note 1 to entry: True r.m.s. measurement includes any d.c. component of the waveform.

Note 2 to entry: 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:

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

3.3.14.8
temporary overvoltage
overvoltage at **mains** power frequency of relatively long duration

3.3.14.9
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**

Note 1 to entry: 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

Note 1 to entry: 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.

Note 2 to entry: **Class I equipment** may be provided with **class II construction**.

3.3.15.2
class II construction
part of an equipment for which protection against electric shock relies upon **double insulation** or **reinforced insulation**

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

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 1 to entry: **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 substance
substance that has the potential for adversely impacting human health

Note 1 to entry: The criteria for determining whether a substance is classified as hazardous are usually defined by law or regulation.

3.3.17 Batteries

3.3.17.1
battery
assembly of **cell**(s) ready for use as a source of electrical energy characterized by its voltage, size, terminal arrangement, capacity and rate capability

Note 1 to entry: The term **battery** pack is considered to be a **battery**.

3.3.17.2
cell
basic manufactured unit providing a source of electrical energy by direct conversion of chemical energy, that consists of electrodes, separators, electrolyte, container and terminals

3.3.17.3
coin / button cell battery
small, single **cell battery** having a diameter greater than its height

3.3.17.4
highest specified charging temperature
highest temperature specified by the manufacturer at a site on each individual **cell** comprising the **battery** during charging of a secondary **battery**

Note 1 to entry: It is usually assumed that the end-product manufacturer is responsible to specify the safety-sensitive temperature, voltage or current of the **battery**, based on the specifications provided by **battery** supplier.

3.3.17.5
lowest specified charging temperature
lowest temperature as declared by the manufacturer at a site on each individual **cell** comprising the **battery** during charging of a secondary **battery**

3.3.17.6
maximum specified charging current
highest charging current as declared by the manufacturer during charging of a secondary **battery**

3.3.17.7
maximum specified charging voltage
highest charging voltage as declared by the manufacturer during charging of a secondary **battery**

3.3.17.8
secondary lithium battery
battery that incorporates:

– one or more secondary lithium **cells**; and
– a housing and a terminal arrangement; and
– may have electronic control devices; and
– that is ready for use.

Note 1 to entry: Examples of a **secondary lithium battery** include a rechargeable lithium-ion **battery**, a rechargeable lithium-polymer **battery** and a rechargeable lithium manganese **battery**.

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 edition 3 of this standard. It is added here to provide a smooth transition from the latest editions of IEC 60950-1 and IEC 60065 to this standard.

4.1.2 Use of components

Where the component, or a characteristic of a component, is a **safeguard** or a part of a **safeguard**, components shall comply with the requirements of this standard or, where specified in a requirements clause, with the safety aspects of the relevant IEC component standards.

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

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

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

– a component shall be checked for correct application and use in accordance with its rating;
– a component that has been demonstrated to comply with a standard harmonized with the relevant IEC component standard shall be 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; and
– where components are used in circuits not in accordance with their specified ratings, the components shall be tested under the conditions occurring in the equipment. The number of samples required for test is, in general, the same as required by an equivalent standard.

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

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.

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 manufacturer's instructions with regard to installation, relocation, servicing and operation, as applicable.

4.1.5 Constructions and components not specifically covered

Where the equipment involves technologies, components 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.

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 a negligible 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.1.6).

4.1.11 Steady state conditions

Steady state conditions are conditions when temperature stability is considered to exist (see B.1.6).

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 38).

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.

Compliance is checked by inspection.

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
– **single fault conditions** that do not result in class 2 limits being exceeded.

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;
– a class 2 energy source to be a class 3 energy source.

A neutral conductor is considered to be a class 3 electrical energy source.

A **protective conductor** is considered to be a class 1 electrical energy source.

4.3 Protection against energy sources

4.3.1 General

The terms "persons", "body", and "body parts" are represented by the 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** are required 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**.

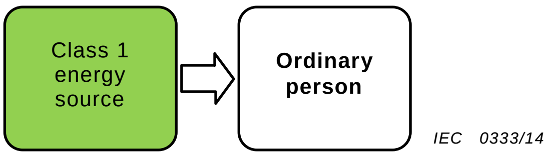


Figure 9 – Model for protection of an ordinary person against a class 1 energy source

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

At least one **basic safeguard** is required between a class 2 energy source and an **ordinary person** (see Figure 10).

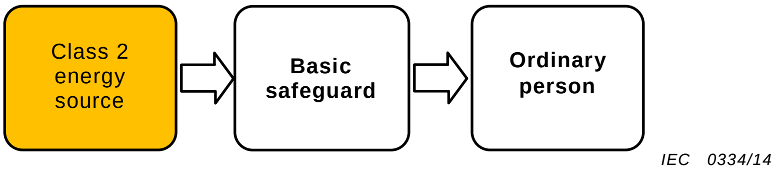


Figure 10 – Model for protection of an ordinary person against a class 2 energy source

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 **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.

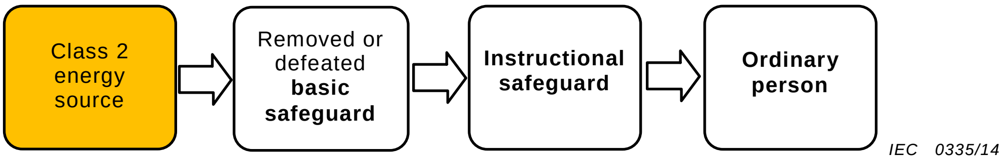


Figure 11 – Model for protection of an ordinary person against a class 2 energy source during ordinary person servicing conditions

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

Unless otherwise specified,

– an **equipment basic safeguard** and an **equipment supplementary safeguard** (together forming a **double safeguard**); or

– a **reinforced safeguard**

is required between a class 3 energy source and an **ordinary person** (see Figure 12).

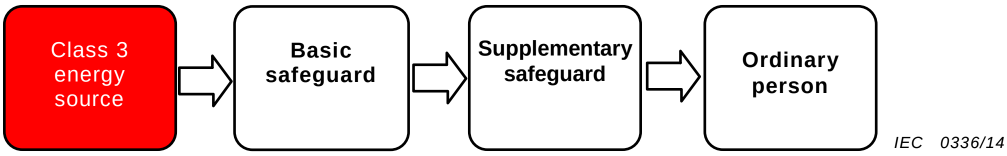


Figure 12 – Model for protection of an ordinary person against a class 3 energy source

4.3.3 Safeguards for protection of an instructed person

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

No **safeguards** are required between a class 1 energy source and an **instructed person** (see Figure 13).

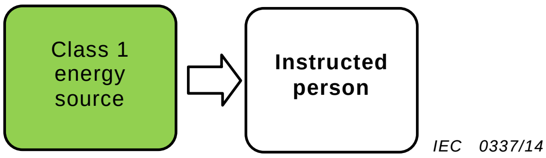


Figure 13 – Model for protection of an instructed person against a class 1 energy source

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

An **instructed person** uses a **precautionary safeguard** (see Figure 14). No additional **safeguards** are required between a class 2 energy source and an **instructed person**. Consequently, a class 2 energy source may be **accessible** to an **instructed person**.

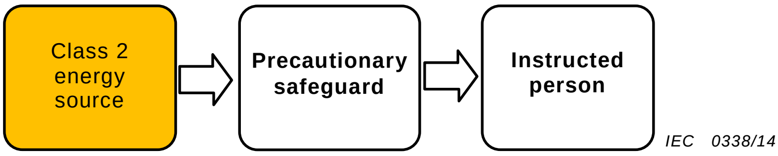


Figure 14 – Model for protection of an instructed person against a class 2 energy source

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

Unless otherwise specified,

– an **equipment basic safeguard** and an **equipment supplementary safeguard** (together forming a **double safeguard**); or

– a **reinforced safeguard**

is required between a class 3 energy source and an **instructed person** (see Figure 15).

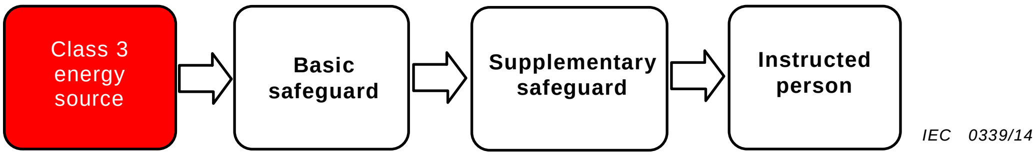


Figure 15 – Model for protection of an instructed person against a class 3 energy source

4.3.4 Safeguards for protection of a skilled person

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

No **safeguard** is required between a class 1 energy source and a **skilled person**. Consequently, a class 1 energy source may be **accessible** to a **skilled person** (see Figure 16).

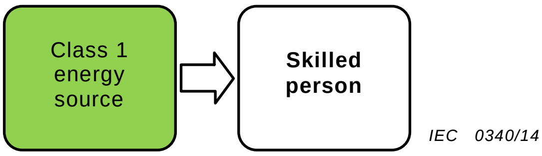


Figure 16 – Model for protection of a skilled person against a class 1 energy source

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

A **skilled person** uses a **skill safeguard** (see Figure 17). No additional **safeguards** are required between a class 2 energy source and a **skilled person**. Consequently, a class 2 energy source may be **accessible** to a **skilled person**.

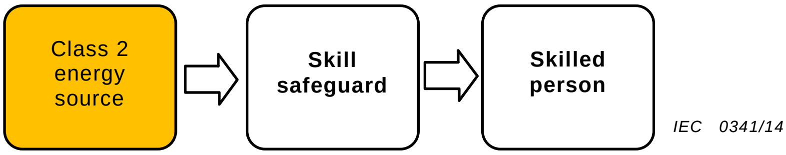


Figure 17 – Model for protection of a skilled person against a class 2 energy source

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

A **skilled person** uses a **skill safeguard** (see Figure 18). Unless otherwise specified, no additional **safeguards** are required between a class 3 energy source and a **skilled person**. Consequently, a class 3 energy source may be **accessible** to a **skilled person**.

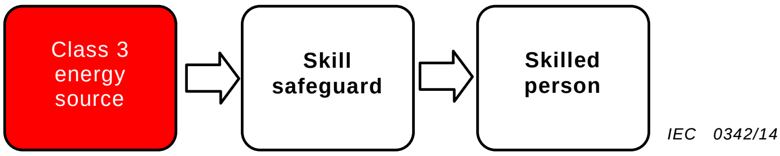


Figure 18 – Model for protection of a skilled person against a class 3 energy source

During equipment servicing conditions on a class 3 energy source, a **safeguard** intended to reduce the likelihood of injury due to an involuntary reaction is required 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).

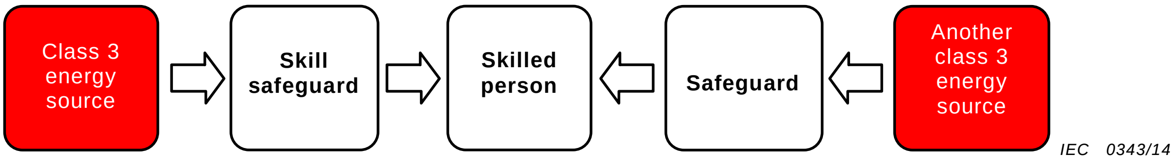


Figure 19 – Model for protection of a skilled person against class 3 energy sources during equipment servicing conditions

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 Equivalent materials or components

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

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

4.4.2 Composition of a safeguard

A **safeguard** may be comprised of one or more elements.

4.4.3 Accessible parts of a safeguard

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**.

4.4.4 Safeguard robustness

4.4.4.1 General

Where a solid **safeguard** (for example, an **enclosure**, barrier, **solid insulation**, earthed metal, glass, etc.) is **accessible** to an **ordinary person** or to an **instructed person**, the **safeguard** shall comply with the relevant robustness tests as specified in 4.4.4.2 to 4.4.4.9.

A solid **safeguard** that is not **accessible** shall comply with the stress relief test of Clause T.8.

For a **safeguard** that is **accessible** after opening an external **enclosure**, see 4.4.4.5.

Requirements for:

– adhesion of metalized coatings; and

– adhesives securing parts serving as **safeguards**; and

– parts that may defeat a **safeguard** if an adhesive fails

are specified in Clause P.4.

4.4.4.2 Steady force tests

An **enclosure** or barrier that is **accessible** and that is used as a **safeguard** of:

– **transportable equipment**; and

– **hand-held equipment**; and

– **direct plug-in equipment**;

shall be subjected to the steady force test of Clause T.4.

For all other equipment, an **enclosure** or barrier that is **accessible** and that is used as a **safeguard** shall be subjected to the steady force test of Clause T.5. There are no requirements for the bottom of equipment having a mass of more than 18 kg unless the user instructions permit an orientation in which the bottom of the **enclosure** becomes the top or a side of the equipment.

A **safeguard** that is **accessible** and that only acts as a **fire enclosure** or barrier shall be subjected to the steady force test of Clause T.3.

This subclause does not apply to glass. Requirements for glass are given in 4.4.4.6.

4.4.4.3 Drop tests

The following equipment shall be subjected to the drop test of Clause T.7:

– **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, including routine relocation;

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 or table-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.

4.4.4.4 Impact tests

All equipment, other than that specified in 4.4.4.3, shall be subjected to the impact test of Clause T.6.

The impact test of Clause T.6 is not applied to the following:

– the bottom of an **enclosure**, except if the user instructions permit an orientation in which the bottom of the **enclosure** becomes the top or a side of the equipment;
– glass;

NOTE Impact tests for glass are in 4.4.4.6.

– the surface of the **enclosure** of **stationary equipment**, including equipment for building-in, that is not **accessible** and is protected after installation.

4.4.4.5 Internal accessible safeguard tests

An internal solid **safeguard** that is **accessible** to an **ordinary person** after opening an external **enclosure** and whose failure would allow class 2 or class 3 energy sources to be **accessible** shall be subjected to the steady force test of Clause T.3.

4.4.4.6 Glass impact tests

The requirements below are applicable to all parts made of glass, with the exception of:

– platen glass used on copiers, scanners and the like, provided that the glass complies with 4.4.4.5 and is covered during normal use; and
– CRTs: Requirements for CRTs are given in Annex U; and
– glass that is laminated or has a construction such that glass particles do not separate from each other if the glass is broken; and

NOTE Laminated glass includes constructions such as plastic film affixed to single side of a glass.

– a **safeguard** that is **accessible** and that acts as a **fire enclosure** only.

Glass that is **accessible** to an **ordinary person** or to an **instructed person**:

– having a surface area exceeding 0,1 m^2; or
– having a major dimension exceeding 450 mm; or

– that prevents access to class 3 energy sources other than PS3,

shall be subjected to the glass impact test of Clause T.9.

4.4.4.7 Thermoplastic material tests

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. The thermoplastic material shall be subjected to the stress relief test of Clause T.8.

4.4.4.8 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.

4.4.4.9 Compliance criteria

During and after the tests:

– *except for PS3, class 3 energy sources shall not become* ***accessible*** *to an* ***ordinary person*** *or to an* ***instructed person****; and*
– *glass shall:*
  - *not break or crack; or*
  - *not expel pieces of glass greater than 30 g in mass or greater than 50 mm in any dimension; or*
  - *pass the fragmentation test of Clause T.10 on a separate test sample; and*
– *all other* ***safeguards*** *shall remain effective.*

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, or
– 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.

If an **explosion** occurs during **single fault conditions**, it shall not cause harm and the equipment shall comply with the relevant parts of this standard.

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

4.6 Fixing of conductors

4.6.1 Requirements

Conductors shall be such that displacement cannot defeat a **safeguard**, such as reducing **clearances** or **creepage distances** below the values specified in 5.4.2 and 5.4.3.

The fixing of the conductors shall be such that, if a conductor becomes loose or detached, the conductor cannot defeat a **safeguard**, such as reducing **clearances** or **creepage distances** below the values specified in 5.4.2 and 5.4.3.

For the purpose of these requirements, it is assumed that:

– two independent fixings will not become loose or detached at the same time; and

– parts fixed by means of screws or nuts provided with self-locking washers or other means of locking are not liable to become loose or detached.

NOTE Spring washers and the like can provide satisfactory locking.

4.6.2 Compliance criteria

Compliance is checked by inspection, by measurement or in case of doubt by applying a force of 10 N in the most unfavourable direction.

EXAMPLE Constructions regarded as meeting the requirements include:

– close-fitting tubing (for example, a heat shrink or rubber sleeve), applied over the wire and its termination;

– conductors connected by soldering and held in place near to the termination, independently of the soldered connection;

– conductors connected by soldering and securely hooked in before soldering, provided that the hole through which the conductor is passed is not unduly large;

– conductors connected to screw terminals, with an additional fixing near to the terminal that clamps, in the case of stranded conductors, the insulation and not only the conductors;

– conductors connected to screw terminals and provided with terminators that are unlikely to become free (for example, ring lugs crimped onto the conductors),however, the pivoting of such terminators is considered; or

– short rigid conductors that remain in position when the terminal screw is loosened.

4.7 Equipment for direct insertion into mains socket-outlets

4.7.1 General

Equipment incorporating integral pins for insertion into **mains** socket-outlets shall not impose undue torque on the socket-outlet. The means for retaining the pins shall withstand the forces to which the pins are likely to be subjected in normal use.

4.7.2 Requirements

The **mains** plug part shall comply with the relevant standard for the **mains** plug.

The equipment is inserted, as in normal use, into a fixed socket-outlet of a configuration as intended by the manufacturer, which is pivoted about a horizontal axis intersecting the centre lines of the contacts at a distance of 8 mm behind the engagement face of the socket outlet parallel to the engagement face.

4.7.3 Compliance criteria

Compliance is checked by inspection and, the additional torque that has to be applied to the socket-outlet to maintain the engagement face in the vertical plane shall not exceed 0,25 Nm. The torque to keep the socket-outlet itself in the vertical plane is not included in this value.

NOTE 1 In Australia and New Zealand, compliance is checked in accordance with AS/NZS 3112.

NOTE 2 In the United Kingdom, the torque test is performed using a socket-outlet complying with BS 1363, and the plug part shall be assessed to the relevant clauses of BS 1363.

4.8 Products containing lithium coin / button cell batteries

4.8.1 General

These requirements apply to equipment, including remote controls, that:

– are likely to be **accessible** to children, taking into account information given by the manufacturer; and

– include lithium **coin / button cell batteries** with a diameter of 32 mm or less.

These requirements do not apply to:

– professional equipment;

NOTE Professional equipment is equipment sold through special sales channels. All equipment sold through normal electronics stores are considered not to be professional equipment.

– equipment for locations where it is unlikely that children will be present; or

– equipment containing lithium **coin / button cell batteries** that are soldered in place.

4.8.2 Instructional safeguard

Equipment containing one or more lithium **coin / button cell batteries** shall have an **instructional safeguard** in accordance with Clause F.5.

The **instructional safeguard** is not required where these **batteries** are not intended to be replaced or are only **accessible** after damaging the equipment.

The elements of the **instructional safeguard** shall be as follows:

– element 1a: not available

– element 2: "Do not ingest battery, Chemical Burn Hazard" or equivalent wording

– element 3: the following or equivalent text

[The remote control supplied with] This product contains a coin / button cell battery. If the coin / button cell battery is swallowed, it can cause severe internal burns in just 2 hours and can lead to death.

– element 4: the following or equivalent text

Keep new and used batteries away from children.

If the battery compartment does not close securely, stop using the product and keep it away from children.

If you think batteries might have been swallowed or placed inside any part of the body, seek immediate medical attention.

4.8.3 Construction

Equipment having a **battery** compartment door / cover shall be designed to reduce the possibility of children removing the **battery** by one of the following methods:

– a **tool**, such as a screwdriver or coin, is required to open the **battery** compartment; or

– the **battery** compartment door / cover requires the application of a minimum of two independent and simultaneous movements to open by hand.

4.8.4 Tests

4.8.4.1 Test sequence

One sample shall be subjected to the applicable tests of 4.8.4.2 to 4.8.4.6. If applicable, the test in 4.8.4.2 shall be conducted first.

4.8.4.2 Stress relief test

*If the **battery** compartment utilizes moulded or formed thermoplastic materials, the sample consisting of the complete equipment, or of the complete **enclosure** together with any supporting framework, is tested according to the stress relief test of Clause T.8.*

*During the test, the **battery** may be removed.*

4.8.4.3 Battery replacement test

*For equipment with a **battery** compartment door / cover, the **battery** compartment shall be opened and closed and the **battery** removed and replaced ten times to simulate normal replacement according to the manufacturer's instructions.*

*If the **battery** compartment door / cover is secured by one or more screws, the screws are loosened and then tightened applying a continuous linear torque according to Table 37, using a suitable screwdriver, spanner or key. The screws are to be completely removed and reinserted each time*

4.8.4.4 Drop test

*Portable equipment having a mass of 7 kg or less are subjected to three drops from a height of 1 m onto a horizontal surface in positions likely to produce the maximum force on the **battery** compartment in accordance with Clause T.7.*

If the equipment is a remote control, it shall be subjected to ten drops.

4.8.4.5 Impact test

*The **battery** compartment door / cover shall be subjected to three impacts in a direction perpendicular to the **battery** compartment door / cover according to the test method of Clause T.6 with a force of:*

– *0,5 J (102 mm ± 10 mm height) for glasses for watching, for example, 3 dimensional television; or*

– *2 J (408 mm ± 10 mm height) for all other doors / covers.*

4.8.4.6 Crush test

Hand held remote control devices are to be supported by a fixed rigid supporting surface in a position likely to produce the most adverse results as long as the position can be self-supported. A crushing force of 330 N ± 5 N is applied to the exposed top and back surfaces of remote control devices placed in a stable condition by a flat surface measuring approximately 100 mm by 250 mm for a period of 10 s.

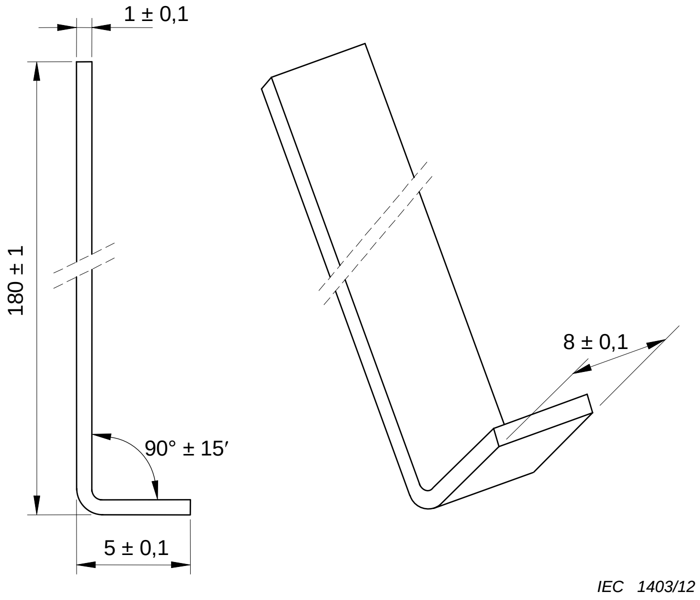
4.8.5 Compliance criteria

*Compliance is checked by applying a force of 30 N ± 1 N for 10 s to the **battery** compartment door / cover by a rigid test finger according to the test probe of Figure V.2 at the most* *unfavourable place and in the most unfavourable direction. The force shall be applied in one direction at a time.*

*The **battery** compartment door / cover shall remain functional, and:*

– *the **battery** shall not become **accessible**; or*

– *it shall not be possible remove the **battery** from the product with the test hook of Figure 20 using a force of approximately 20 N.*



Material: steel

Dimensions in millimetres

Figure 20 – Test hook

4.9 Likelihood of fire or shock due to entry of conductive objects

Where the entry of a conductive object from outside the equipment or from another part of the equipment can result in:

– bridging within PS2, PS3 and ES3 circuits; or

– bridging an ES3 circuit to **accessible**, unearthed conductive parts,

top and side openings above PS2, PS3 and ES3 circuits shall:

– be located more than 1,8 m above the floor; or

– comply with Annex P.

Compliance is checked by inspection or according to Annex P.

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 Clause 5.

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 current or voltage levels

– not exceeding ES1 limits under
  - **normal operating conditions**, and
  - **abnormal operating conditions**, and
  - **single fault conditions** of a component, device or insulation not serving as a **safeguard**; and

– not exceeding ES2 limits under **single faultconditions** of a **basic safeguard**.

5.2.1.2 ES2

ES2 is a class 2 electrical energy source where

– both the **prospective touch voltage** and the **touch current** exceed the limits for ES1; and

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

either the **prospective touch voltage** or the **touch current** does not exceed the limit for ES2.

5.2.1.3 ES3

ES3 is a class 3 electrical energy source where both the **prospective touch voltage** and **touch current** exceed the limit for ES2.

5.2.2 Electrical energy source ES1 and ES2 limits

5.2.2.1 General

The limits specified in 5.2.2 are with respect to earth or with respect to an **accessible** part.

NOTE Throughout 5.2.2, the term “voltage” is taken to mean “**prospective touch voltage**.” Likewise, the term “current” is taken to mean “**touch current**.”

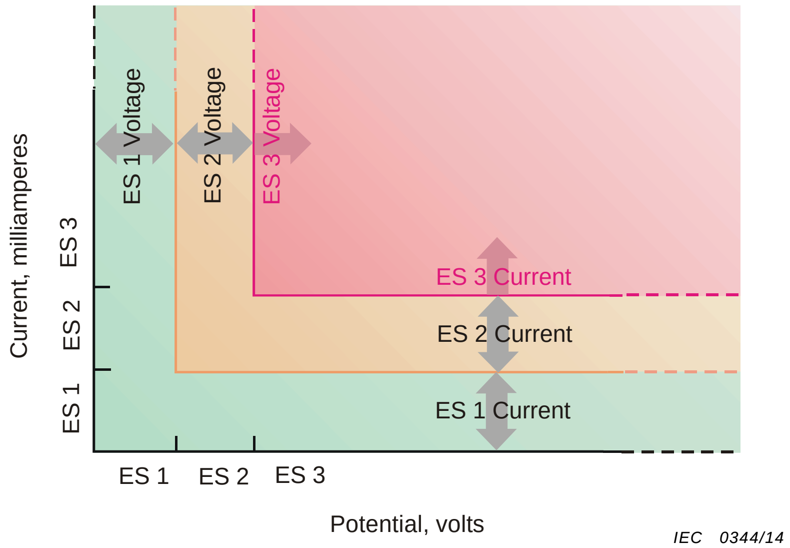


Figure 21 – Illustration showing ES limits for voltage and current

For any voltage up to the voltage limit, there is no limit for the current. Likewise for any current up to the current limit, there is no limit for the voltage, see Figure 21.

5.2.2.2 Steady-state voltage and current limits

An electrical energy source class is determined from both the voltage and the current under **normal operating conditions**, **abnormal operating conditions**, and **single fault conditions** (see Table 4).

The values are the maximum that can be delivered by the source. Steady state is considered established when the voltage or current values persist for 2 s or longer, otherwise the limits of 5.2.2.3, 5.2.2.4 or 5.2.2.5 apply, as appropriate.

NOTE In Denmark a warning (marking **safeguard**) for high **touch current** is required if the **touch current** exceeds the limits of 3,5 mA a.c. or 10 mA d.c.

Table 4 – Electrical energy source limits for steady-state ES1 and ES2

<table>
<tr><th rowspan="2">Energy source</th><th colspan="2">ES1 limits</th><th colspan="2">ES2 limits</th><th rowspan="2">ES3</th></tr>
<tr><th>Voltage</th><th>Current [a, c]</th><th>Voltage</th><th>Current [b, c]</th></tr>
<tr><td>d.c.</td><td>60 V</td><td>2 mA</td><td>120 V</td><td>25 mA</td><td rowspan="5">> ES2</td></tr>
<tr><td>a.c up to 1 kHz</td><td>30 V r.m.s.
42,4 V peak</td><td rowspan="3">0,5 mA r.m.s
0,707 mA peak</td><td>50 V r.m.s.
70,7 V peak</td><td rowspan="3">5 mA r.m.s.
7,07 mA peak</td></tr>
<tr><td>a.c. > 1 kHz up to 100 kHz</td><td>30 V r.m.s. + 0,4 f</td><td>50 V r.m.s. + 0,9 f</td></tr>
<tr><td>a.c above 100 kHz</td><td>70 V r.m.s.</td><td>140 V r.m.s.</td></tr>
<tr><td>Combined a.c. and d.c.</td><td>$\frac{U_{dc}\ \text{V}}{60} + \frac{U_{ac}\ \text{V r.m.s.}}{30} \le 1$
$\frac{U_{dc}\ \text{V}}{60} + \frac{U_{ac}\ \text{V peak}}{42,4} \le 1$</td><td>$\frac{I_{dc}\ \text{mA}}{2} + \frac{I_{ac}\ \text{mA r.m.s.}}{0,5} \le 1$
$\frac{I_{dc}\ \text{mA}}{2} + \frac{I_{ac}\ \text{mA peak}}{0,707} \le 1$</td><td>See Figure 23</td><td>See Figure 22</td></tr>
<tr><td colspan="6">The formulation below as a function of frequency may be of interest to designers for sinusoidal waveforms</td></tr>
<tr><th rowspan="2">Energy source</th><th colspan="2">ES1 limits</th><th colspan="2">ES2 limits</th><th rowspan="2">ES3</th></tr>
<tr><th colspan="2">Current [c]
r.m.s.</th><th colspan="2">Current [c]
r.m.s.</th></tr>
<tr><td>a.c up to 1 kHz</td><td colspan="2">0,5 mA</td><td colspan="2">5 mA</td><td rowspan="3">> ES2</td></tr>
<tr><td>a.c. > 1 kHz up to 100 kHz</td><td colspan="2">0,5 mA × f [d]</td><td colspan="2">5 mA + 0,95 f [e]</td></tr>
<tr><td>a.c above 100 kHz</td><td colspan="2">50 mA [d]</td><td colspan="2">100 mA [e]</td></tr>
<tr><td colspan="6">f is in kHz.

Peak values shall be used for non-sinusoidal voltage and current. RMS values may be used only for sinusoidal voltage and current.

See 5.7 for measurement of prospective touch voltage and touch current.</td></tr>
<tr><td colspan="6">[a] Current is measured using the measuring network specified in Figure 4, IEC 60990:1999.

[b] Current is measured using the measuring network specified in Figure 5, IEC 60990:1999.

[c] For sinusoidal waveforms and d.c., the current may be measured using a 2 000 Ω resistor.

[d] Above 22 kHz the accessible area is limited to 1 cm^2.

[e] Above 36 kHz the accessible area is limited to 1 cm^2.</td></tr>
</table>

Under **normal operating conditions**, **abnormal operating conditions** and **single fault conditions** (except for a **safeguard** fault), touch voltage or **touch current** shall be measured from all unearthed **accessible** conductive parts. **Touch current** (current [a] and current [b] of Table 4) shall be measured in accordance with 5.1.1 and 6.2.1 of IEC 60990:1999.

Under **single fault conditions** of a relevant **basic safeguard** or a **supplementary safeguard**, including 6.2.2.1 of IEC 60990:1999, touch voltage or **touch current** shall be measured from all unearthed **accessible** conductive parts. **Touch current** (current [b] of Table 4) shall be measured with the network specified in Figure 5 of IEC 60990:1999.

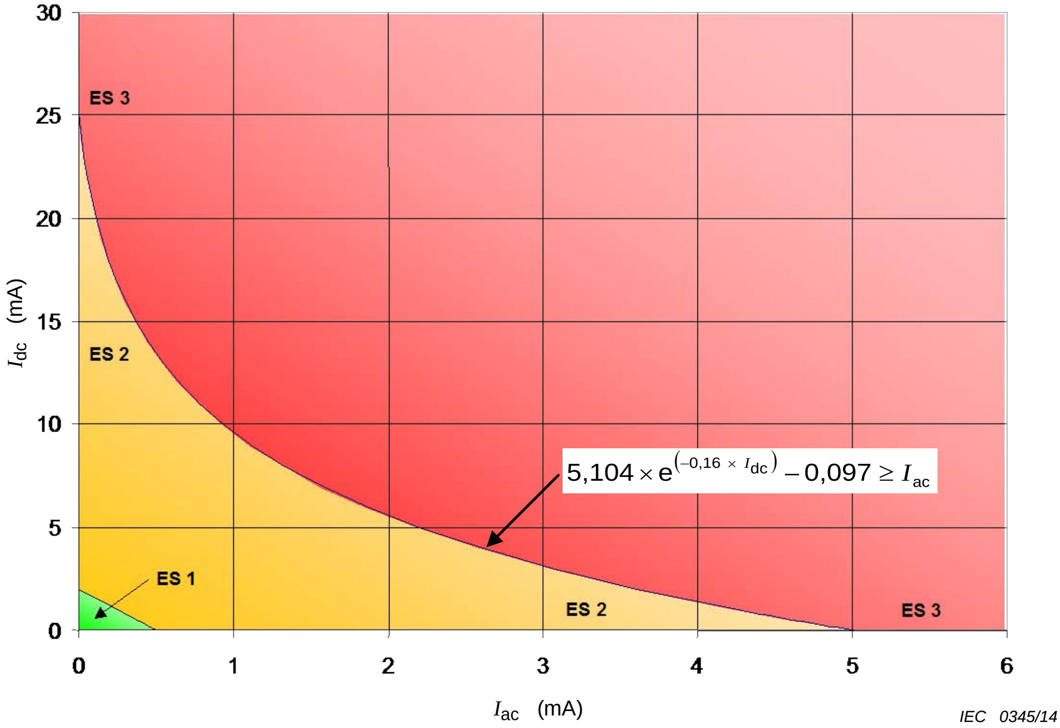


Figure 22 – Maximum values for combined a.c. current and d.c. current

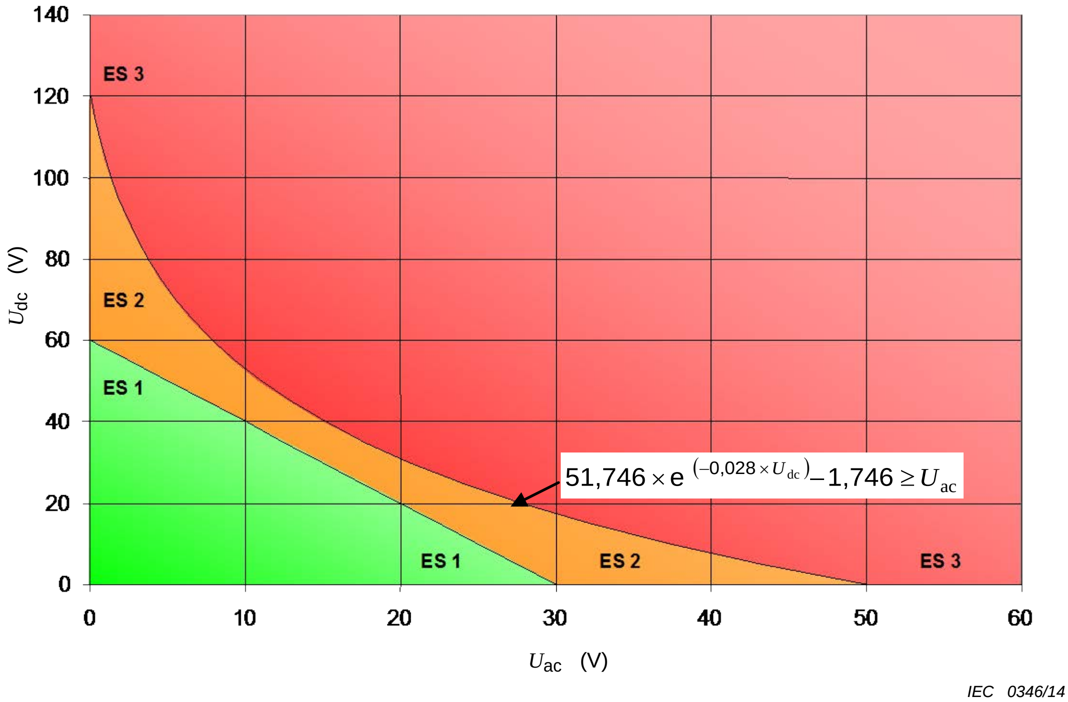


Figure 23 – Maximum values for combined a.c. voltage and d.c. voltage

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 5 .

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

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

Table 5 – Electrical energy source limits for a charged capacitor

C nF	**ES1** $U_{\mathbf{peak}}$ V	**ES2** $U_{\mathbf{peak}}$ V	**ES3** $U_{\mathbf{peak}}$ 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	> ES2
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 6 and Table 7. 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.

If more than one pulse is detected within a period of 3 s, then the electrical energy source is treated as a repetitive pulse and the limits of 5.2.2.5 apply.

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 6 – Voltage limits for single pulses

Pulse duration up to and including ms	Electrical energy source level		
	ES1 U_{peak} V	**ES2** U_{peak} V	**ES3** U_{peak} V
10	60	196	> ES2
20		178	
50		150	
80		135	
100		129	
200 and longer		120	

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 linear interpolation may be used between any two adjacent rows with the calculated peak voltage value rounded down to the nearest volt.

If the peak voltage for ES2 lies between the values in any two rows, the value of the time duration in the row above may be used or a linear interpolation may be used between any two adjacent rows with the calculated time duration rounded down to the nearest millisecond.

Table 7 – Current limits for single pulses

Pulse duration up to and including ms	Electrical energy source level		
	ES1 I_{peak} mA	**ES2** I_{peak} mA	**ES3** I_{peak} mA
10	2	200	> ES2
20		153	
50		107	
100		81	
200		62	
500		43	
1 000		33	
2 000 and longer		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 linear interpolation may be used between any two adjacent rows with the calculated value rounded down to the nearest milliampere.

If the peak current for ES2 lies between the values in any two rows, the value of the time duration in the row above may be used or a linear interpolation may be used between any two adjacent rows with the calculated time duration 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 8). 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.

Table 8 – Electrical energy source limits for repetitive pulses

Pulse off time		ES1	ES2	ES3
Less than 3 s	Current	0,707 mA peak	7,07 mA peak	> ES2
	Voltage	42,4 V peak	70,7 V peak	
3 s or more	Current	See 5.2.2.4	See 5.2.2.4	
	Voltage			

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.

5.3 Protection against electrical energy sources

5.3.1 General

Except as given below, protection requirements for parts **accessible** to **ordinary persons**, **instructed persons**, and **skilled persons** are given in 4.3.

Bare conductors at ES3 shall be located or guarded so that unintentional contact with such conductors during service operations by a **skilled person** is unlikely (see Figure 19).

5.3.2 Accessibility to electrical energy sources and safeguards

5.3.2.1 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**.

5.3.2.2 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 24).

The air gap shall either:

a) pass an electric strength test in accordance with 5.4.9.1 at a test voltage (d.c. or peak a.c.) that is equal to the test voltage for **basic insulation** in Table 27 corresponding to the **peak working voltage**; or

b) have a minimum distance according Table 9.

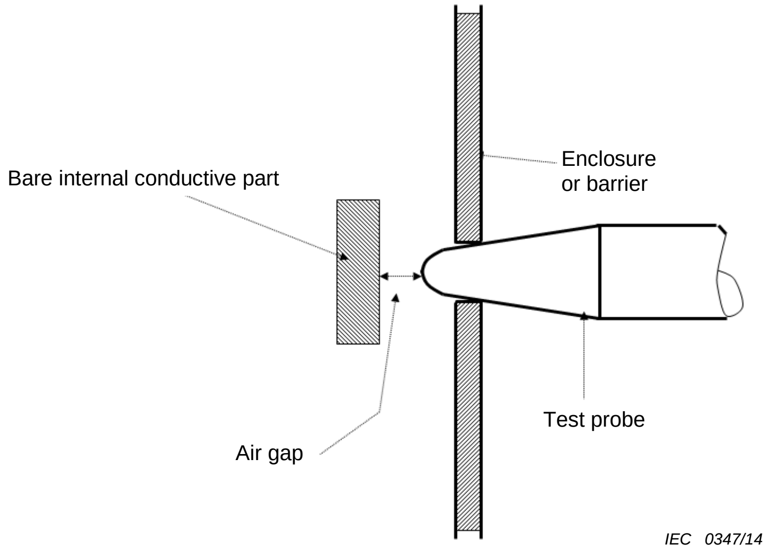


Figure 24 – Contact requirements to bare internal conductive parts

Table 9 – Minimum air gap 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 air gap distance being rounded up to the next higher 0,1 mm increment or the value in the next row below whichever is lower.		

5.3.2.3 Compliance criteria

Compliance is checked by the test of Clause T.3.

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 do not have to be tested when such components and subassemblies are used in the final product.

5.3.2.4 Terminals for connecting stripped wire

The use of a stripped wire to make connection with its associated terminal intended to be used by an **ordinary person** shall not result in contact with ES2 or ES3 (for audio signal voltages, see Table E.1 for values of ES2 and ES3). Parts of audio signal terminals provided with one of the **safeguards** in Table E.1 are not tested.

Compliance is checked by the test of V.1.6 for each wire terminal opening as well as any other openings within 25 mm from the terminal. During the test, no portion of the probe inserted into the terminal or opening shall contact ES2 or ES3.

5.4 Insulation materials and requirements

5.4.1 General

5.4.1.1 Insulation

Insulation consisting of insulating materials, **clearances**, **creepage distances** and **solid insulation**, and that is 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 Clause 5 and Annex T.

Insulating material shall not be hygroscopic as determined by 5.4.1.3.

5.4.1.3 Compliance criteria

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 using the insulation in question to the humidity treatment of 5.4.8. The insulation is then subjected to the relevant electric strength test of 5.4.9.1 while still in the humidity chamber, or in the room in which the samples were brought to the prescribed temperature.

5.4.1.4 Maximum operating temperatures for materials, components and systems

5.4.1.4.1 Requirements

Under **normal operating conditions**, insulating material temperatures shall not exceed the temperature limit of the EIS, including insulating materials of components, or the maximum temperature limit of the insulation system as given in Table 10.

For maximum temperatures below or equal to 100 ºC, no declared insulation system is required. An undeclared EIS is considered to be class 105.

5.4.1.4.2 Test method

Insulating material temperatures are measured in accordance with B.1.6.

*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 independently 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.

5.4.1.4.3 Compliance criteria

The temperature of the electrical insulation material or EIS shall not exceed the limits in Table 10.

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

For an EIS, the available thermal class data of the EIS as indicated by the manufacturer can be used if it is suitable for the applicable class of insulation.

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

Table 10 – 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 5.4.1.10
Components	See also Annex G and 4.1.2

The classes are related to the temperature classes of electrical insulating materials and EIS 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.

[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

a winding with embedded thermocouples.

5.4.1.5 Pollution degrees

5.4.1.5.1 General

The different degrees of pollution of the operating or micro-environment for products covered by this standard are given below.

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.

5.4.1.5.2 Test for pollution degree 1 environment and for an insulating compound

A sample is subjected to the thermal cycling sequence of 5.4.1.5.3.

It is allowed to cool to room temperature and is then subjected to the humidity conditioning of 5.4.8.

If the test is conducted for verification of the insulating compound forming ***solid insulation*** *as required by 5.4.4.3, the conditioning is immediately followed by the electric strength test of 5.4.9.1.*

For printed boards, compliance is checked by external visual inspection. There shall be no delamination which affects the ***creepage distances*** *required to fulfil the requirements of* ***pollution degree*** *1.*

For other than printed boards, compliance is checked by inspection of the cross-sectional area, and there shall be no visible voids, gaps or cracks in the insulating material.

5.4.1.5.3 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*	$(T_1 \pm 2)$ *°C;*
1 h	*at*	*(25 ± 2) °C;*
2 h	*at*	*(0 ± 2) °C;*
≥ 1 h	*at*	*(25 ± 2) °C.*

$T_1 = T_2 + T_{ma} - T_{amb} + 10$ *K, measured in accordance with B.1.6, 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 5.4.1.4.*

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.

5.4.1.6 Insulation in transformers with varying dimensions

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.

5.4.1.7 Insulation in circuits generating starting pulses

For circuits generating starting pulses exceeding ES1 (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.

NOTE 1 For **working voltages** in the above cases, see 5.4.1.8.1 i).

NOTE 2 If the starting pulse is an a.c. waveform, the pulse width is determined by connecting the peak values of the a.c. waveform.

The **clearances** are determined by one of the following methods:

– determine the minimum **clearance** in accordance with 5.4.2; or

– conduct one of the following electric strength tests, with the connection terminals of the starting pulse circuit (for example, a lamp) shorted together:

  - the test given in 5.4.9.1, or
  - apply 30 pulses having an amplitude equal to the required test voltage given in 5.4.9.1 generated by an external pulse generator. The pulse width shall be equal to or greater than that of the internally generated starting pulse.

Compliance is checked by inspection or test. During the test, the insulation shall show no breakdown or flashover.

5.4.1.8 Determination of working voltage

5.4.1.8.1 General

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 5.4.1.6, 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 5.4.1.6, 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 accross 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 5.4.1.7), the **peak working voltage** is the peak value of the pulses with the lamp connected but before the lamp ignites. The frequency of the **working voltage** to determine the minimum clearance may be assumed to be less than 30 kHz. The **working voltage** to determine minimum **creepage distances** is the voltage measured after the ignition of the lamp; and

j) **temporary overvoltages** and recurring peak voltages have to be considered.

5.4.1.8.2 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**.

5.4.1.8.3 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 0;

– 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.

5.4.1.9 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).

5.4.1.10 Thermoplastic parts on which conductive metallic parts are directly mounted

5.4.1.10.1 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**.

5.4.1.10.2 Compliance criteria

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 given below or by the ball pressure test of 5.4.1.10.3.

*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.*

5.4.1.10.3 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 °C) ± 2 °C (see B.2.6.1 for the explanation of T, T_{ma} and T_{amb}). However, a thermoplastic part supporting parts in a circuit supplied from the **mains** is tested at a minimum of 125 °C.*

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 requirements

Clearances shall be so dimensioned that the likelihood of breakdown due to

– **temporary overvoltages**, and
– transient voltages that may enter the equipment, and
– **peak working voltages** that are generated within the equipment, and
– frequencies that are generated within the equipment

is reduced.

All required **clearances** and test voltages apply to an altitude up to 2 000 m. For higher altitudes, the multiplication factors of 5.4.2.5 apply.

NOTE For air gaps between contacts of **safety interlocks**, see Annex K. For air gaps between contacts of **disconnect devices**, see Annex L. For air gaps between contacts in components, see Annex G. For connectors, see G.4.1.

Unless otherwise specified by the manufacturer and supplied with means to assure minimum **clearances** during all modes of normal operation, the voice coil and adjacent conductive parts of a loudspeaker are considered to be conductively connected.

To determine the **clearance**, the highest value of the following two procedures shall be used:

Procedure 1: Determine **clearances** according to 5.4.2.2 using the **peak working voltage**.

Procedure 2: Determine **clearances** according to 5.4.2.3 using the **required withstand voltages**. Alternatively, the adequacy of **clearances** may be determined using an electric strength test according to 5.4.2.4, in which case the values according to procedure 1 shall be maintained.

5.4.2.2 Procedure for determining clearance using peak working voltage

To determine the **peak working voltage**, the highest voltage of the following is taken into account as applicable:

– steady state voltages; and
– recurring peak voltages to be taken as 1,1 times the **mains** voltage (see 5.3.3.2.4 of IEC 60664-1:2007); and

– **temporary overvoltages** as given below (see also 5.3.3.2.3 of IEC 60664-1:2007).

The **temporary overvoltage** value is taken as 2 000 V peak if the nominal **mains** system voltage does not exceed 250 V and is taken as 2 500 V peak if the nominal **mains** system voltage exceeds 250 V but does not exceed 600 V.

Alternatively, the **temporary overvoltage** may be determined in accordance with 5.3.3.2.3 of IEC 60664-1:2007 at the discretion of the manufacturer.

The highest value of the **clearance** determined as given below shall be used:

– **clearance** values of Table 11 for circuits with fundamental frequencies up to 30 kHz;

– **clearance** values of Table 12 for circuits with fundamental frequencies higher than 30 kHz; or

– the highest **clearance** values of Table 11 and Table 12 for circuits where both frequencies lower than 30 kHz and higher than 30 kHz are present.

Table 11 – Minimum clearances for voltages with frequencies up to 30 kHz

<table>
<tr><th rowspan="3">Peak working voltage or d.c.

up to and including</th><th colspan="3">Basic insulation or supplementary insulation
mm</th><th colspan="3">Reinforced insulation
mm</th></tr>
<tr><th colspan="3">Pollution degree</th><th colspan="3">Pollution degree</th></tr>
<tr><th>1 [a]</th><th>2</th><th>3</th><th>1 [a]</th><th>2</th><th>3</th></tr>
<tr><td>330</td><td>0,01</td><td rowspan="5">0,2</td><td rowspan="8">0,8</td><td>0,02</td><td rowspan="5">0,4</td><td rowspan="7">1,5</td></tr>
<tr><td>400</td><td>0,02</td><td>0,04</td></tr>
<tr><td>500</td><td>0,04</td><td>0,08</td></tr>
<tr><td>600</td><td>0,06</td><td>0,12</td></tr>
<tr><td>800</td><td>0,13</td><td>0,26</td></tr>
<tr><td>1 000</td><td>0,26</td><td>0,26</td><td>0,52</td><td>0,52</td></tr>
<tr><td>1 200</td><td colspan="2">0,42</td><td colspan="2">0,84</td></tr>
<tr><td>1 500</td><td colspan="2">0,76</td><td colspan="2">1,52</td><td>1,6</td></tr>
<tr><td>2 000</td><td colspan="3">1,27</td><td colspan="3">2,54</td></tr>
<tr><td>2 500</td><td colspan="3">1,8</td><td colspan="3">3,6</td></tr>
<tr><td>3 000</td><td colspan="3">2,4</td><td colspan="3">4,8</td></tr>
<tr><td>4 000</td><td colspan="3">3,8</td><td colspan="3">7,6</td></tr>
<tr><td>5 000</td><td colspan="3">5,7</td><td colspan="3">11,0</td></tr>
<tr><td>6 000</td><td colspan="3">7,9</td><td colspan="3">15,8</td></tr>
<tr><td>8 000</td><td colspan="3">11,0</td><td colspan="3">20</td></tr>
<tr><td>10 000</td><td colspan="3">15,2</td><td colspan="3">27</td></tr>
<tr><td>12 000</td><td colspan="3">19</td><td colspan="3">33</td></tr>
<tr><td>15 000</td><td colspan="3">25</td><td colspan="3">42</td></tr>
<tr><td>20 000</td><td colspan="3">34</td><td colspan="3">59</td></tr>
<tr><td>25 000</td><td colspan="3">44</td><td colspan="3">77</td></tr>
<tr><td>30 000</td><td colspan="3">55</td><td colspan="3">95</td></tr>
<tr><td>40 000</td><td colspan="3">77</td><td colspan="3">131</td></tr>
<tr><td>50 000</td><td colspan="3">100</td><td colspan="3">175</td></tr>
<tr><td>60 000</td><td colspan="3">120</td><td colspan="3">219</td></tr>
<tr><td>80 000</td><td colspan="3">175</td><td colspan="3">307</td></tr>
<tr><td>100 000</td><td colspan="3">230</td><td colspan="3">395</td></tr>
<tr><td colspan="7">Linear interpolation may be used between the nearest two points, the calculated minimum clearances being rounded up to the next higher specified increment or the value in the next row below whichever is lower. For values:
– not exceeding 0,5 mm, the specified increment is 0,01 mm; and
– exceeding 0,5 mm, the specified increment is 0,1 mm.</td></tr>
<tr><td colspan="7">[a] The values for pollution degree 1 may be used if a sample complies with the tests of 5.4.1.5.2.</td></tr>
</table>

Table 12 – Minimum clearances for voltages with frequencies above 30 kHz

Peak working voltage up to and including	Basic insulation or supplementary insulation mm	Reinforced insulation mm
600	0,07	0,14
800	0,22	0,44
1 000	0,6	1,2
1 200	1,68	3,36
1 400	2,82	5,64
1 600	4,8	9,6
1 800	8,04	16,08
2 000	13,2	26,4

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

- not exceeding 0,5 mm, the specified increment is 0,01 mm; and
- exceeding 0,5 mm, the specified increment is 0,1 mm.

For **pollution degree** 1, use a multiplication factor of 0,8.

For **pollution degree** 3, use a multiplication factor of 1,4.

5.4.2.3 Procedure for determining clearance using required withstand voltage

5.4.2.3.1 General

The dimension for a **clearance** that is subject to transient voltages from the **mains** or an **external circuit** is determined from the **required withstand voltage** for that **clearance**.

Each **clearance** shall be determined using the following steps:

– Determine the transient voltage according to 5.4.2.3.2; and
– Determine the **required withstand voltage** according to 5.4.2.3.3; and
– Determine the minimum **clearance** according to 5.4.2.3.4.

5.4.2.3.2 Determining transient voltages

5.4.2.3.2.1 General

Transient voltages can be determined based on their origin, or can be measured in accordance with 5.4.2.3.2.5.

If different transient voltages affect the same **clearance**, the largest of those voltages is used. The values are not added together.

5.4.2.3.2.2 Determining a.c. mains transient voltages

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 and is given in Table 13. 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 requires additional transient voltage protection to be provided external to the equipment. In this case, the installation instructions shall state the need for such external protection.

Table 13 – Mains transient voltages

AC mains voltage [a] **up to and including** V r.m.s.	**Mains transient voltage** [b] V peak			
	Overvoltage category			
	I	**II**	**III**	**IV**
50	330	500	800	1 500
100 [c]	500	800	1 500	2 500
150 [d]	800	1 500	2 500	4 000
300 [e]	1 500	2 500	4 000	6 000
600 [f]	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] 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.

[d] Including 120/208 V and 120/240 V.

[e] Including 230/400 V and 277/480 V.

[f] Including 400/690 V.

5.4.2.3.2.3 Determining d.c. mains transient voltages

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 taken 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 taken 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 taken 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 with respect to earth shall be taken to be equal to the **mains transient voltage** in the **mains** from which the d.c. power is derived.

If 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 5.4.2.3.2.4.

If equipment is supplied from a dedicated **battery** that has no provision for charging from a **mains** supply without removal from the equipment, the transient voltage shall be disregarded.

5.4.2.3.2.4 Determining external circuit transient voltages

The applicable value of the transient voltage that may occur on an **external circuit** shall be determined using Table 14. Where more than one location or condition is applicable, the highest transient voltage 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 voltage.

If the transient voltage is less than the peak voltage of a short duration signal (such as a telephone ringing signal), the peak voltage of the short duration signal shall be used as the transient voltage.

If the **external circuit** transient voltages are known to be higher than indicated in Table 14, the known value shall 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 transient voltages presented to the equipment exceed the values specified in Table 14. In installations where transient voltages presented to the equipment are expected to exceed the values specified in Table 14, additional measures such as surge suppression can be necessary.

NOTE 3 In Europe the requirement for interconnection with **external circuit** is in addition given in EN 50491-3:2009, *General requirements for Home and Building Electronic Systems (HBES) and Building Automation and Control Systems (BACS) – Part 3: Electrical safety requirements*.

Table 14 – External circuit transient voltages

ID	Cable type	Additional conditions	Transient voltages
1	Paired conductor [a] – shielded or unshielded	The building or structure may or may not have equipotential bonding	1 500 V 10/700 μs Only differential if one conductor is earthed in the equipment
2	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
3	Coaxial cable in the cable distribution network	Equipment other than power-fed coaxial repeaters. Cable shield is earthed at the equipment	4 000 V 10/700 μs Centre conductor to shield
4	Coaxial cable in the cable distribution network	Power fed coaxial repeaters (up to 4,4 mm coaxial cable). Cable shield is earthed at the equipment	5 000 V 10/700 μs Centre conductor to shield
5	Coaxial cable in the cable distribution network	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 μs Centre conductor to shield 1 500 V 1,2/50 μs shield to earth
6	Coaxial cable	Cable connects to an outdoor antenna	no transient, see [c]
7	Paired conductor [a]	Cable connects to an outdoor antenna	no transient, see [c]
8	Coaxial cable within the building [b]	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

In general, for **external circuits** installed wholly within the same building structure, transients are not taken into account. However, a conductor is considered to leave the building if it terminates on equipment earthed to a different earthing network.

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.

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).

NOTE 1 Home appliances like audio, video and multimedia products are addressed by ID 6, 7 and 8.

NOTE 2 In Norway and Sweden, the cable shield on coaxial cables is normally not earthed at the building entrance (see the note in 5.7.6). For installation conditions, see EN 60728-11.

[a] A paired conductor includes a twisted pair.

[b] When determining the separation requirements in 5.4.10, the transients on **external circuits** are taken into account.

[c] These cables are not subject to any transients but they may be affected by a 10 kV electrostatic discharge voltage (from a 1 nF capacitor). The effect of such electrostatic discharge voltages is not taken into account when determining **clearances**. Compliance is checked by the test of G.10.3.2.

5.4.2.3.2.5 Determining transient voltage levels by measurement

The transient voltage across the **clearance** is measured using the following procedure.

During the measurement, the equipment is not connected to the **mains**, to the 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 measurement.

To measure the transient voltage across a **clearance**, the appropriate impulse test generator of Annex D is used to generate impulses. At least three impulses of each polarity, with intervals of at least 1 s between impulses, are applied between each of the relevant points.

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

The impulse test generator circuit 2 of Table D.1 is used to generate 1,2/50 μs impulses equal to the a.c. **mains transient voltages**, at the following points:

– line-to-line;

– all line conductors conductively joined together and neutral;

– all line conductors conductively joined together and protective earth; and

– neutral and protective earth.

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

The impulse test generator circuit 2 of Table D.1 is used to generate 1,2/50 μs impulses equal to the d.c. **mains transient voltages**, at the following points:

– the positive and negative supply connection points; and

– all supply connection points joined together and protective earth.

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

The appropriate test generator of Annex D is used to generate impulses as applicable and described in Table 14 and 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; and

– all terminals of a single interface type joined together and earth.

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

Where there are several identical circuits, only one is tested.

5.4.2.3.3 Determining required withstand voltage

The **required withstand voltage** is equal to the transient voltage as determined in 5.4.2.3.2, except for the following cases:

– If a circuit isolated from the **mains** is connected to a main protective earthing terminal that complies with 5.6.7, the **required withstand voltage** may be one overvoltage category lower in Table 13.

– 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 the **mains** supply without removal from the equipment, the transient voltage is zero and the **required withstand voltage** is equal to the **peak working voltage**.

5.4.2.3.4 Determining clearances using required withstand voltage

Each **clearance** shall comply with the relevant value of Table 15.

Table 15 – Minimum clearances using required withstand voltage

<table>
<tr><th>Required withstand voltage</th><th colspan="3">Basic insulation or supplementary insulation
mm</th><th colspan="3">Reinforced insulation
mm</th></tr>
<tr><th rowspan="2">V peak or d.c.
up to and including</th><th colspan="3">Pollution degree</th><th colspan="3">Pollution degree</th></tr>
<tr><th>1 [a]</th><th>2</th><th>3</th><th>1 [a]</th><th>2</th><th>3</th></tr>
<tr><td>330</td><td>0,01</td><td rowspan="6">0,2</td><td rowspan="8">0,8</td><td>0,02</td><td rowspan="6">0,4</td><td rowspan="8">1,5</td></tr>
<tr><td>400</td><td>0,02</td><td>0,04</td></tr>
<tr><td>500</td><td>0,04</td><td>0,08</td></tr>
<tr><td>600</td><td>0,06</td><td>0,12</td></tr>
<tr><td>800</td><td>0,10</td><td>0,2</td></tr>
<tr><td>1 000</td><td>0,15</td><td>0,3</td></tr>
<tr><td>1 200</td><td colspan="2">0,25</td><td colspan="2">0,5</td></tr>
<tr><td>1 500</td><td colspan="2">0,5</td><td colspan="2">1,0</td></tr>
<tr><td>2 000</td><td colspan="3">1,0</td><td colspan="3">2,0</td></tr>
<tr><td>2 500</td><td colspan="3">1,5</td><td colspan="3">3,0</td></tr>
<tr><td>3 000</td><td colspan="3">2,0</td><td colspan="3">3,8</td></tr>
<tr><td>4 000</td><td colspan="3">3,0</td><td colspan="3">5,5</td></tr>
<tr><td>5 000</td><td colspan="3">4,0</td><td colspan="3">8,0</td></tr>
<tr><td>6 000</td><td colspan="3">5,5</td><td colspan="3">8,0</td></tr>
<tr><td>8 000</td><td colspan="3">8,0</td><td colspan="3">14</td></tr>
<tr><td>10 000</td><td colspan="3">11</td><td colspan="3">19</td></tr>
<tr><td>12 000</td><td colspan="3">14</td><td colspan="3">24</td></tr>
<tr><td>15 000</td><td colspan="3">18</td><td colspan="3">31</td></tr>
<tr><td>20 000</td><td colspan="3">25</td><td colspan="3">44</td></tr>
<tr><td>25 000</td><td colspan="3">33</td><td colspan="3">60</td></tr>
<tr><td>30 000</td><td colspan="3">40</td><td colspan="3">72</td></tr>
<tr><td>40 000</td><td colspan="3">60</td><td colspan="3">98</td></tr>
<tr><td>50 000</td><td colspan="3">75</td><td colspan="3">130</td></tr>
<tr><td>60 000</td><td colspan="3">90</td><td colspan="3">162</td></tr>
<tr><td>80 000</td><td colspan="3">130</td><td colspan="3">226</td></tr>
<tr><td>100 000</td><td colspan="3">170</td><td colspan="3">290</td></tr>
<tr><td colspan="7">Linear interpolation may be used between the nearest two points, the calculated minimum clearances being rounded up to the next higher specified increment or the value in the next row below whichever is lower. For values:
– not exceeding 0,5 mm, the specified increment is 0,01 mm; and
– exceeding 0,5 mm, the specified increment is 0,1 mm.</td></tr>
<tr><td colspan="7">[a] The values for pollution degree 1 may be used if a sample complies with the tests of 5.4.1.5.2.</td></tr>
</table>

5.4.2.4 Determining the adequacy of a clearance using an electric strength test

*The **clearances** shall withstand an electric strength test. The test may be conducted using an impulse voltage or an a.c. voltage or a **d.c. voltage**. The **required withstand voltage** is determined as given in 5.4.2.3.*

The impulse withstand voltage test is carried out with a voltage having an appropriate waveform (see Annex D) with the values specified in Table 16. Five impulses of each polarity are applied with an interval of at least 1 s between pulses.

The a.c. voltage test is conducted using a sinusoidal voltage with a peak value as specified in Table 16 and is applied for 5 s.

*The **d.c. voltage** test is conducted using a **d.c. voltage** specified in Table 16 and applied for 5 s in one polarity and then for 5 s in reverse polarity.*

Table 16 – Electric strength test voltages

Required withstand voltage up to and including kV peak	**Test voltage for electric strength for clearances for basic insulation or supplementary insulation** kV peak (impulse or a.c. or d.c.)
0,33	0,36
0,5	0,54
0,8	0,93
1,5	1,75
2,5	2,92
4,0	4,92
6,0	7,39
8,0	9,85
12,0	14,77
U [a]	1,23 × U [a]
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**. If the EUT fails the a.c. or d.c. test, the impulse test shall be used. If the test is conducted at an altitude of 200 m or more above sea level, Table F.5 of IEC 60664-1:2007 may be used.	
[a] U is any **required withstand voltage** higher than 12,0 kV.	

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

For equipment intended to be used more than 2 000 m above sea level, the minimum **clearances** in Table 11, Table 12 and Table 15 and the electric strength test voltages in Table 16 are multiplied by the applicable multiplication factor for the desired altitude according to Table 17.

NOTE 1 Higher altitudes can be simulated in a vacuum chamber.

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

Table 17 – Multiplication factors for clearances and test voltages

Altitude m	**Normal barometric pressure** kPa	**Multiplication factor for clearances**	**Multiplication factor for electric strength test voltages**		
			< 1 mm	**≥ 1 mm to < 10 mm**	**≥ 10 mm to < 100 mm**
2 000	80,0	1,00	1,00	1,00	1,00
3 000	70,0	1,14	1,05	1,07	1,10
4 000	62,0	1,29	1,10	1,15	1,20
5 000	54,0	1,48	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.					

5.4.2.6 Compliance criteria

Compliance is checked by measurement and test 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;*
- *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;*
- *after the tests of Annex T, the dimensions for **clearances** are measured;*
- *after the tests of Annex T, the electric strength test shall be applied;*
- *for the impact test of 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; and*
- *components and parts, other than parts serving as an **enclosure**, are subjected to the test of Clause T.2. After the application of the force, **clearances** shall not be reduced below the required values.*

For circuits connected to coaxial cable distribution or outdoor antennas, compliance is checked by the tests of 5.5.8.

5.4.3 Creepage distances

5.4.3.1 General

Creepage distances 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 **basic insulation** and **supplementary insulation** for frequencies up to 30 kHz shall comply with Table 18. **Creepage distances** for **basic insulation** and **supplementary insulation** for frequencies greater than 30 kHz and up to 400 kHz shall comply with Table 19.

The **creepage distance** requirements for frequencies up to 400 kHz can be used for frequencies over 400 kHz until additional data is available.

NOTE 1 **Creepage distances** for frequencies higher than 400 kHz are under consideration.

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 2 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 5.4.3 apply.

The above minimum **creepage distances** for connectors do not apply to connectors listed in Clause G.4.

NOTE 3 For **creepage distances** below 2 mm, additional information is available in IEC 60664-5.

*If the minimum **creepage distance** derived from Table 18 or Table 19 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**.*

*For **reinforced insulation**, the values for **creepage distances** are twice the values for **basic insulation** in Table 18 or Table 19.*

5.4.3.2 Test method

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.7, and also without conductors;*

– *when measuring **creepage distances** from an **accessible** 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** outer surface of the **enclosure** 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 according to 4.4.4;*

– *for the glass breakage test of 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;*

– *components and parts, other than parts serving as an **enclosure**, are subjected to the test of Clause T.2. After the application of the force, **creepage distances** shall not be reduced below the required values.*

5.4.3.3 Material group and CTI

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

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

The material group is checked 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.

5.4.3.4 Compliance criteria

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

Table 18 – 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 [b]
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			
32 000	125	160	220	320			
40 000	160	200	280	400			
50 000	200	250	360	500			
63 000	250	320	450	600			

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 5.4.1.5.2.

[b] Material group IIIb is not recommended for applications in **pollution degree** 3 with an **r.m.s. working voltage** above 630 V.

Table 19 – Minimum values of creepage distances (in mm) for frequencies higher than 30 kHz and up to 400 kHz

Peak working voltage kV	30 kHz < f ≤ 100 kHz	100 kHz < f ≤ 200 kHz	200 kHz < f ≤ 400 kHz
0,1	0,0167	0,02	0,025
0,2	0,042	0,043	0,05
0,3	0,083	0,09	0,1
0,4	0,125	0,13	0,15
0,5	0,183	0,23	0,25
0,6	0,267	0,38	0,4
0,7	0,358	0,55	0,68
0,8	0,45	0,8	1,1
0,9	0,525	1,0	1,9
1	0,6	1,15	3

The values for the **creepage distances** in the table apply for **pollution degree** 1. For **pollution degree** 2 a multiplication factor of 1,2 and for **pollution degree** 3, a multiplication factor 1,4 shall be used.

Linear interpolation may be applied.

The data given in this Table 19 (from Table 2 of IEC 60664-4:2005) does not take into account the influence of tracking phenomena. For that purpose Table 18 has to be taken into account. Therefore, if values in Table 19 are smaller than those in Table 18, the values of Table 18 apply.

5.4.4 Solid insulation

5.4.4.1 General requirements

The requirements of this subclause apply to solid insulation, including compounds and gel materials used as insulation.

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.6.2.

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** and **creepage distances** shall not be reduced below the specified values.

For printed boards, see Clause G.13. 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**, no minimum distance through insulation is 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** required if:

– the insulating compound completely fills the casing of a component or subassembly, including a semiconductor device (for example, an optocoupler); and
– the component or subassembly meets the minimum distances through insulation of 5.4.4.2; and
– a single sample passes the tests of 5.4.1.5.2.

NOTE Some examples of such treatment are variously known as potting, encapsulation and vacuum impregnation.

Such constructions containing cemented joints shall also comply with 5.4.4.5.

Alternative requirements for semiconductor devices are given in 5.4.4.4.

For printed boards, see Clause G.13 and for wound components, see 5.4.4.7.

Compliance is checked by sectioning the sample. There shall be no visible voids in the insulating material.

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:

– passes the **type tests** and inspection criteria of 5.4.7; and passes **routine tests** for electric strength during manufacturing, using the appropriate test in 5.4.9.1; or
– complies with Clause G.12.

Such constructions containing cemented joints shall also comply with 5.4.4.5.

Alternatively, a semiconductor may be evaluated according to 5.4.4.3.

5.4.4.5 Insulating compound forming cemented joints

The requirements specified below apply when an insulating compound forms a cemented joint between two non-conductive parts or between another non-conductive part and itself. These requirements do not apply to optocouplers that comply with IEC 60747-5-5.

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 5.4.1.5.2. 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 5.4.7.

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 used.

For b) and c) above, the tests of 5.4.1.5.2 and 5.4.7 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 5.4.1.4 does not exceed 90 °C.

NOTE 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; or

– 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 29.

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; and

– the insulation is within the equipment **enclosure**; and

– 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.

The two or more layers are not required 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 20 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 20.

Table 20 – 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 5.4.9.1 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 test voltage specified in 5.4.9.1 for ***supplementary insulation*** *or* ***reinforced insulation*** *as appropriate.*

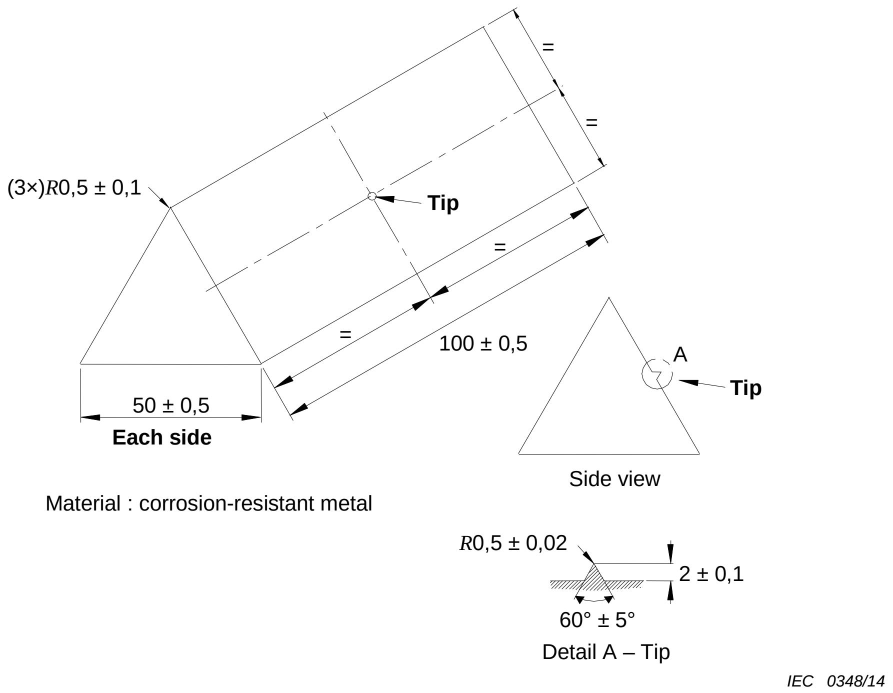
NOTE Unless all the layers are of the same material and have the same thickness, there is a possibility that the test voltage will be divided unequally between layers, causing breakdown of a layer that would have passed if tested separately.

5.4.4.6.5 Mandrel test

*The test requirements for **reinforced insulation** made of three or more thin insulating sheets of material that are inseparable are specified below.*

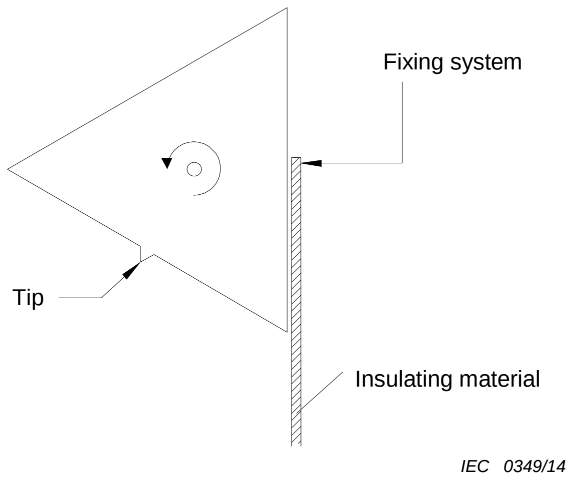
NOTE This test is based on IEC 61558-1 and will give the same results.

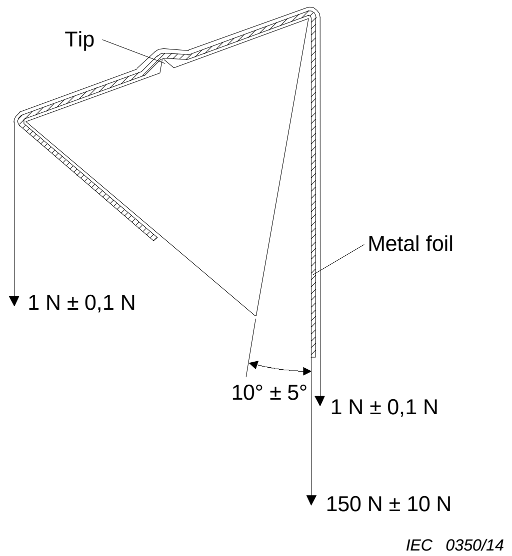
*Three test samples, each individual sample consisting of three or more layers of non-separable thin sheet material forming **reinforced insulation**, are used. One sample is fixed to the mandrel of the test fixture given in Figure 25. The fixing shall be performed as shown in Figure 26.*



Dimensions in millimetres

Figure 25 – Mandrel





The final position of the mandrel is rotated 230° ± 5° from the initial position.

Dimensions in millimetres

Figure 26 – Initial position of mandrel

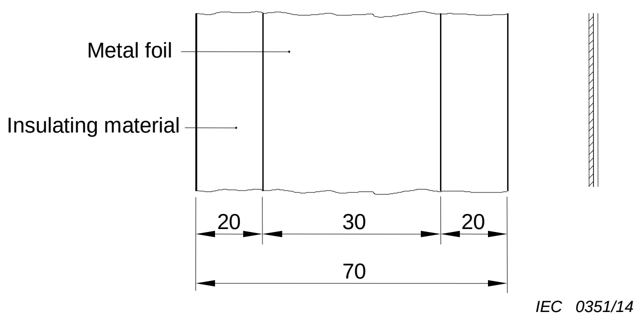
Figure 27 – Final position of mandrel

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 26) to the final position (Figure 27) and back;*
- *a second time from the initial position to the final position.*

If a sample breaks during rotation where it is fixed to the mandrel or to the clamping device, this does not constitute a failure. If a sample breaks at any other place, the test has failed.

After the above test, a sheet of metal foil, 0,035 mm ± 0,005 mm thick, at least 200 mm long, is placed along the surface of the sample, hanging down on each side of the mandrel (see Figure 27). 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 28). The foil is then tightened by two equal weights, one at each end, using appropriate clamping devices.



Dimensions in millimetres

Figure 28 – 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 5.4.9.1. The test voltage is 150 % of U_{test}*, but not less than 5 kV r.m.s.* U_{test} *is the test voltage specified in 5.4.9.1 for* ***reinforced insulation*** *as appropriate.*

The test is repeated on the other two samples.

5.4.4.7 Solid insulation in wound components

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

– the insulation on wound components (see Clause G.5); or

– the insulation on other wire (see Clause G.6); or

– a combination of the two.

Wound components containing cemented joints shall also comply with 5.4.4.5.

Planar transformers shall comply with the requirements of Clause G.13.

5.4.4.8 Compliance criteria

Compliance with the requirements of 5.4.4.2 to 5.4.4.7 for the adequacy of ***solid insulation*** *is checked by inspection and measurement, taking into account Annex O, by the electric strength tests of 5.4.9.1 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 at **mains** power frequency E_{P} in kV/mm for the insulating material. See Table 21 for examples of commonly used materials at **mains** power frequency.

– Determine the reduction factor K_{R} for the breakdown electric field strength of the insulating material at the applicable frequency from Table 22 or Table 23. If the material is not one listed in Table 22 or Table 23, use the average reduction factor in the last row of Table 22 or Table 23 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}.

$$E_{\mathrm{F}} = E_{\mathrm{P}} \times K_{\mathrm{R}}$$

– 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.

$$V_{\mathrm{W}} = E_{\mathrm{F}} \times d$$

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

$$V_{\mathrm{W}} > 1{,}2 \times V_{\mathrm{PW}}$$

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

$$V_{\mathrm{W}} > 1{,}2 \times 2 \times V_{\mathrm{PW}}$$

As an alternative to the above,

– the electric strength test of 5.4.9.1 may be applied under the following conditions:
  - the field strength is approximately uniform; and
  - no voids or air gaps are present in the **solid insulation**; or

– the insulation may be subjected to the high-frequency breakdown test according to 7.4 of IEC 60664-4:2005 with the test potential at the frequency of the actual measured **working voltage**.

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

Table 21 – 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 [a]	9,2	-	-	-	-
Silicon-glass [a]	14	-	-	-	-
Phenolic [a]	17	-	-	-	-
Ceramic [a]	19	-	-	-	-
Teflon® [a] [3]	27	-	-	-	-
Melamine-glass [a]	27	-	-	-	-
Mica [a]	29	-	-	-	-
Paper phenolic [a]	38	-	-	-	-
Polyethylene [b]	49	-	-	52	-
Polystyrene [c]	55	65	-	-	-
Glass [a]	60	-	-	-	-
Kapton® [a] [4]	303	-	-	-	-
FR530L [a]	33	-	-	-	-
Mica-filled phenolic [a]	28	-	-	-	-
Glass-silicone laminate [a]	18	-	-	-	-
Cellulose-acetobutyrate [d]	-	-	120	-	210
Polycarbonate [d]	-	-	160	-	270
Cellulose-triacetate [d]	-	-	120	-	210

NOTE Missing values in the above and the values for other materials not in the list are under investigation.

[a] For the breakdown electric field strength of the specified materials, the E_P value of 0,75 mm thickness may be used for all thicknesses.

[b] The E_P value of 0,05 mm thickness is used for the insulation equal to or thinner than 0,05 mm. The E_P value of 0,75 mm thickness is used otherwise.

[c] The E_P value of 0,08 mm thickness is used for the insulation equal to or thinner than 0,08 mm. The E_P value of 0,75 mm thickness is used otherwise.

[d] The E_P value of 0,03 mm thickness is used for the insulation equal to or thinner than 0,03 mm. The E_P value of 0,06 mm thickness is used for the insulation equal to or thinner than 0,06 mm and greater than 0,03 mm.

[3] Teflon® is the trademark of a product supplied by DuPont. This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of the product named. Equivalent products may be used if they can be shown to lead to the same results.

[4] Kapton® is the trademark of a product supplied by DuPont. This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of the product named. Equivalent products may be used if they can be shown to lead to the same results.

Table 22 – 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
If the frequency lies between the values in any two columns, the reduction factor value in the next column shall be used or a logarithmic interpolation may be used between any two adjacent columns with the calculated value rounded down to the nearest 0,01 value.											
[a] This data is for materials that are 0,75 mm thick.											

Table 23 – Reduction factors for the value of breakdown electric field strength E_P at higher frequencies for thin materials

Thin 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
If the frequency lies between the values in any two columns, the reduction factor value in the next column shall be used or a logarithmic interpolation may be used between any two adjacent columns with the calculated value rounded down to the nearest 0,01 value											

5.4.5 Antenna terminal insulation

5.4.5.1 General

The insulation

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

shall withstand electrostatic discharges 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 5.6.7.

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 conditioned as described in G.10.3.1 and tested as described in G.10.3.2. 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 criteria

Compliance is checked by measuring the insulation resistance with 500 V d.c.

The equipment complies with the requirement if the insulation resistance measured after 1 min is not less than the values given in Table 24.

Table 24 – 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

*As an alternative to the above, compliance may be checked by an electric strength test in accordance with 5.4.9.1 for **basic insulation** or **reinforced insulation** as applicable. The test voltage shall be the highest of the test voltages determined by methods 1, 2 and 3. There shall be no insulation breakdown.*

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**.

Where wire insulation is used 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**; and

– 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; and

– the wire is routed and fixed such as not to touch unearthed **accessible** conductive parts; and

– the wire insulation passes the electric strength test of 5.4.9.1 for **supplementary insulation**; and

– the distance through the wire insulation shall be at least as given in Table 25.

Table 25 – 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 5.4.9.1.

5.4.7 Tests for semiconductor components and for cemented joints

Three samples are subjected to the thermal cycling sequence of 5.4.1.5.3. 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 5.4.9.1, immediately after the last period at (T_1 ± 2) °C during thermal cycling, except that the test voltage is multiplied by 1,6; and*

– *the other samples are subjected to the relevant electric strength test of 5.4.9.1 after the humidity conditioning of 5.4.8, except that the test voltage is multiplied by 1,6.*

Compliance is checked by test and the following inspections:

Except for cemented joints on the same inner surface of a printed board, compliance is checked by inspection of the cross-sectional area, and there shall be no visible voids, gaps or cracks in the insulating material.

In the case of insulation between conductors on the same inner surface of printed boards and the insulation between conductors on different surfaces of multilayer boards, compliance is checked by external visual inspection. There shall be no delamination.

5.4.8 Humidity conditioning

Humidity conditioning is carried out for 48 h in a cabinet or room containing air with a relative humidity of (93 ± 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 ± 2) °C and a relative humidity of (93 ± 3) %.

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

5.4.9 Electric strength test

5.4.9.1 Test procedure for type testing of solid insulation

Unless otherwise specified, compliance is checked either

- *immediately following the temperature test in 5.4.1.4, 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 5.4.1.4 (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 26 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 27 using the* ***peak working voltage****.*
- *Method 3: Determine the test voltage according to Table 28 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 for the time specified below and then repeat it 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 5.4.9.2).*

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. A varistor complying with Clause G.8 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****.*

Where capacitors are in parallel with the insulation under test (for example, radio-frequency filter capacitors), d.c. test voltages shall be used.

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, may be disconnected.

Where insulation of a transformer winding varies along the length of the winding in accordance with 5.4.1.6, an electric strength test method is used that stresses the insulation accordingly.

EXAMPLE Such a test method may be 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 26 – Test voltages for electric strength tests based on transient voltages

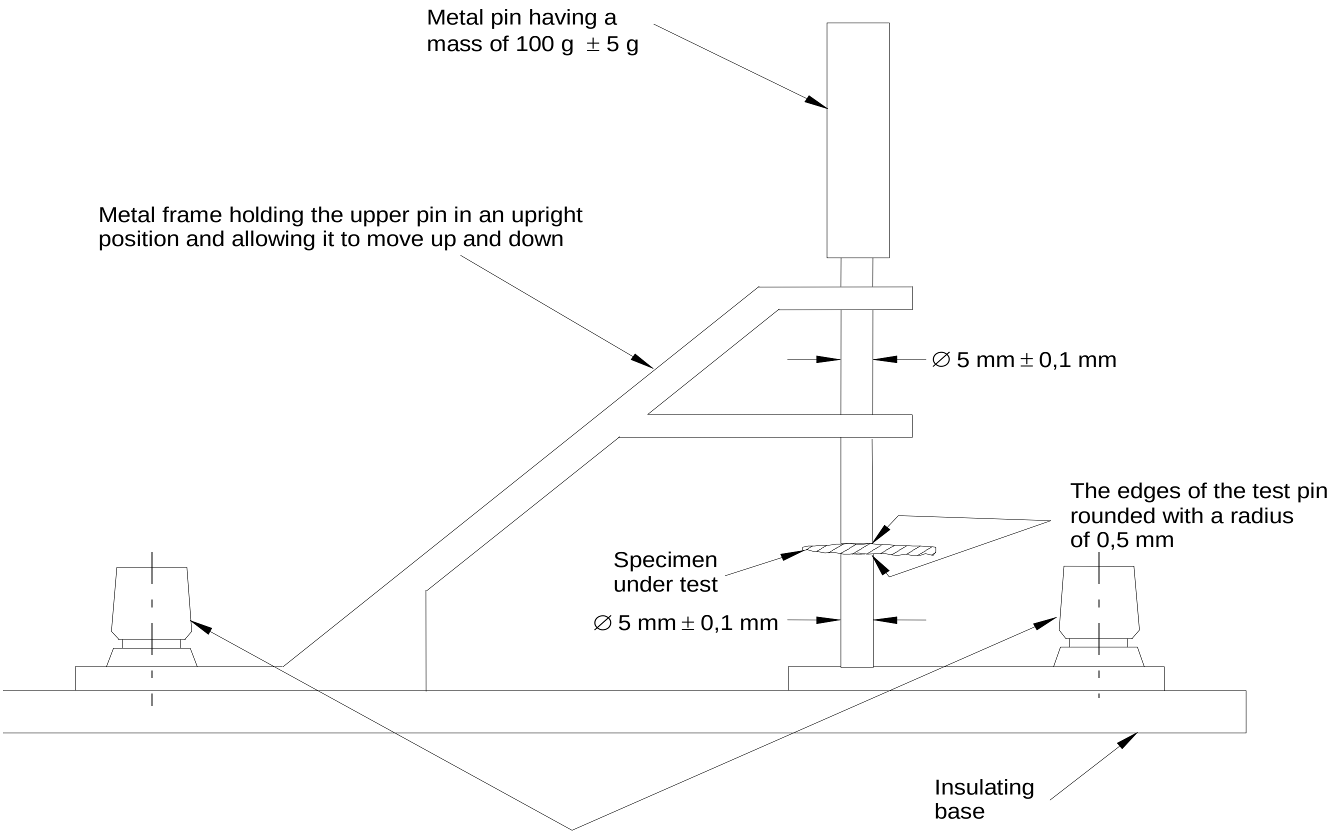
Required withstand voltage up to and including kV peak	**Test voltage for basic insulation or supplementary insulation**	**Test voltage for reinforced insulation**
	kV peak or d.c.	
0,33	0,33	0,5
0,5	0,5	0,8
0,8	0,8	1,5
1,5	1,5	2,5
2,5	2,5	4
4	4	6
6	6	8
8	8	12
12	12	18
U_R [a]	U_R [a]	$1,5 \times U_R$ [a]
Linear interpolation may be used between the nearest two points.		
[a] U_R is any **required withstand voltage** higher than 12 kV.		

Table 27 – 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	0,8
0,8	1,04	1,28
1,5	1,95	2,4
2,5	3,25	4
4	5,2	6,4
6	7,8	9,6
8	10,4	12,8
12	15,6	19,2
U_P [a]	$1,3 \times U_P$ [a]	$1,6 \times U_P$ [a]
Linear interpolation may be used between the nearest two points.		
[a] U_P is any **peak working voltage** higher than 12 kV.		

Table 28 – 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.	kV peak or d.c.	
Up to and including 250	2	4
Over 250 up to and including 600	2,5	5



Dimensions in millimetres

Figure 29 – Example of electric strength test instrument for solid insulation

NOTE Thin sheet insulation can be tested using the instrument of Figure 29.

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.

5.4.9.2 Test procedure for routine tests

Routine tests *are performed according to 5.4.9.1, 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 voltage may be reduced by 10 %.*

NOTE The above test conditions are 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.

5.4.10 Safeguards against transient voltages from external circuits

5.4.10.1 Requirements

Adequate electrical separation shall be provided between **external circuits** of equipment as indicated in Table 14, ID number 1, Figure 30 and:

a) non-conductive parts and unearthed 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);

b) **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;

c) another ES1 or ES2 part separated from the **external circuit**. The requirement for separation applies whether or not the ES1 or ES2 part is **accessible**.

These requirements do not apply where circuit analysis and equipment investigation indicate that adequate protection is assured by other means (for example, between two circuits each of which has a permanent connection to protective earth).

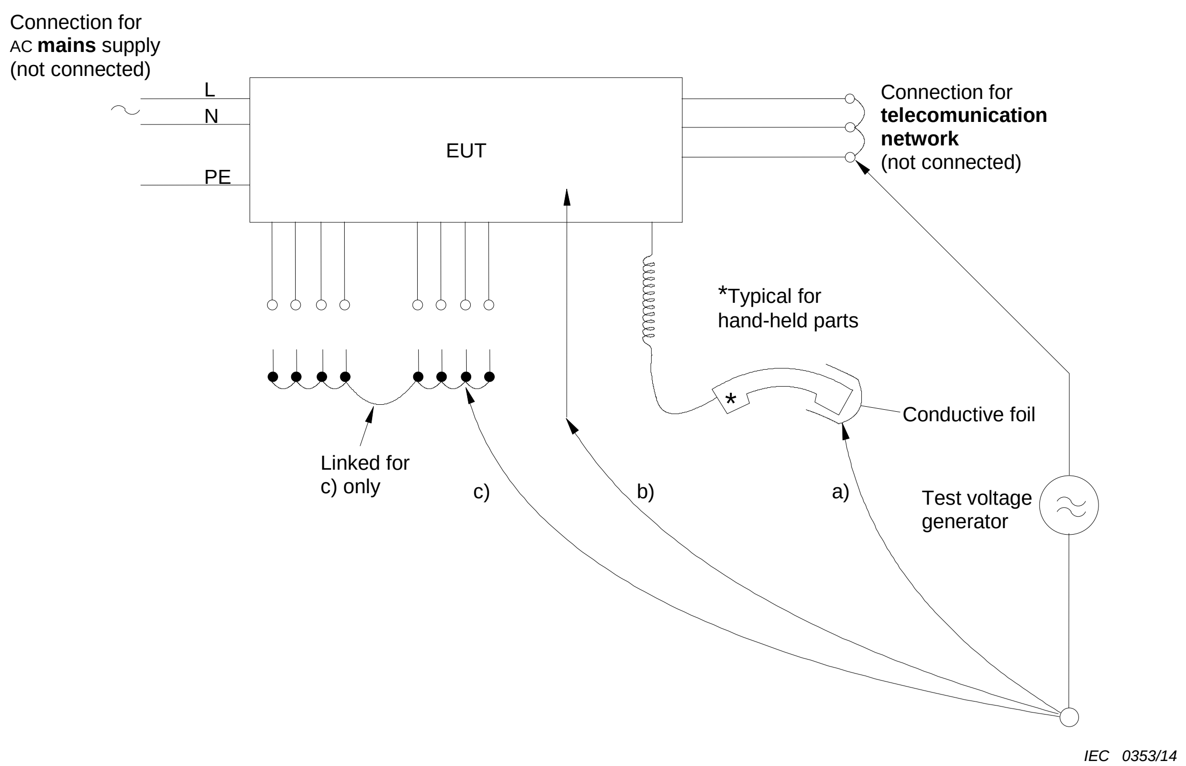


Figure 30 – Application points of test voltage

5.4.10.2 Test methods

5.4.10.2.1 General

The separation is checked by the test of either 5.4.10.2.2 or 5.4.10.2.3.

During the test:

– *all conductors intended to be connected to the **external circuit** are connected together, including any conductors that may be connected to earth in the **external circuit**; and*

– *all conductors intended to be connected to other **external circuits** are also connected together.*

Table 29 – Test values for electric strength tests

Parts	Impulse test	Steady state test
Parts indicated in 5.4.10.1 a) [a]	2,5 kV 10/700 μs	1,5 kV
Parts indicated in 5.4.10.1 b) and c) [b]	1,5 kV 10/700 μs [c]	1,0 kV

[a] Surge suppressors shall not be removed.

[b] Surge suppressors may be removed, provided that such devices pass the impulse test of 5.4.10.2.2 when tested as components outside the equipment.

[c] During this test, it is allowed for a surge suppressor to operate and for a sparkover to occur in a GDT.

5.4.10.2.2 Impulse test

The electrical separation is subjected to ten impulses of alternating polarity. The interval between successive impulses is 60 s with a voltage as given in Table 29.

5.4.10.2.3 Steady-state test

The electrical separation is subjected to an electric strength test according to 5.4.9.1, with a voltage as given in Table 29.

5.4.10.3 Compliance criteria

During the tests of 5.4.10.2.2 and 5.4.10.2.3:

– *there shall be no insulation breakdown; and*

– *except as indicated in Table 29, footnote [b], a surge suppressor shall not operate, or a sparkover shall not occur within a GDT.*

For the electric strength 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.

For the impulse tests, insulation breakdown is verified in one of the following two ways:

– *during the application of the impulses, by observation of oscillograms, surge suppressor operation or breakdown through insulation is judged from the shape of an oscillogram.*

– *after application of all the impulses, by an insulation resistance test. Disconnection of surge suppressors is permitted while insulation resistance is being measured. The test voltage is 500 V d.c. or, if surge suppressors are left in place, a d.c. test voltage that is 10 % less than the surge suppressor operating or striking voltage. The insulation resistance shall not be less than 2 MΩ.*

5.4.11 Separation between external circuits and earth

5.4.11.1 General

These requirements apply only to equipment intended to be connected to **external circuits** indicated in Table 14, ID numbers 1 and 2.

These requirements do not apply to:

– **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**.

5.4.11.2 Requirements

There shall be separation 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 separation 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:

$$U_{\text{op}} = U_{\text{peak}} + \Delta U_{\text{sp}} + \Delta U_{\text{sa}}$$

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.

($\Delta U_{\text{sp}} + \Delta U_{\text{sa}}$) may be a single value provided by the component manufacturer.

5.4.11.3 Test method and compliance criteria

Compliance is checked by inspection and by the electric strength test of 5.4.9.1.

Components, other than capacitors, that bridge the separation, 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 31 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 31 shall not exceed 10 mA.

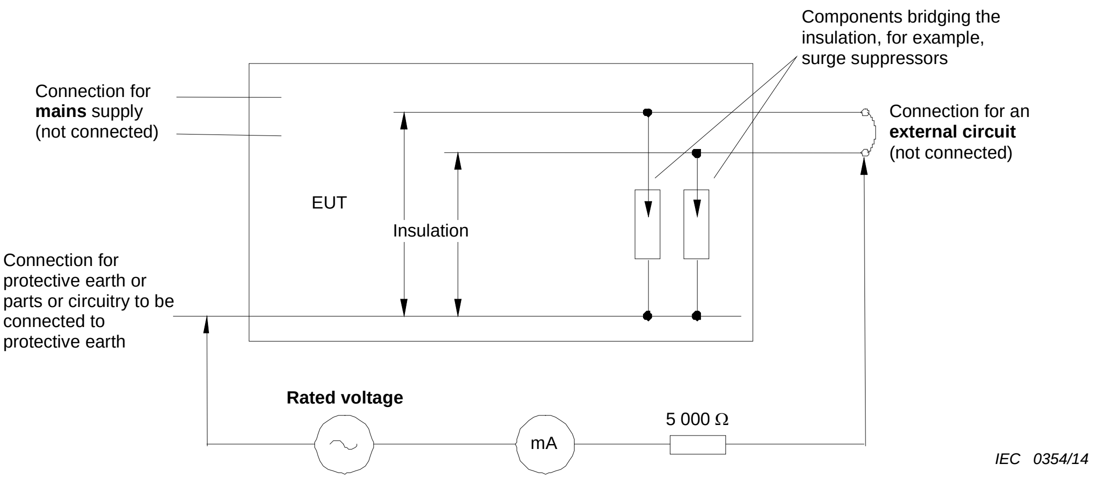


Figure 31 – Test for separation between an external circuit and earth

5.5 Components as safeguards

5.5.1 General

A component used as a **safeguard** shall:

– comply with all the applicable requirements for that **safeguard**; and
– be used within its rating.

NOTE See Annex G for the qualification of components used as a **safeguard**.

5.5.2 Capacitors and RC units

5.5.2.1 General requirements

Capacitors and RC units that serve as (electrical) **safeguards** shall comply with IEC 60384-14. RC units may consist of discrete components.

Capacitors or RC units with one or multiple capacitors shall:

– comply with Clause G.11, however, the requirements of Clause G.11 do not apply to the capacitor and RC unit used as a **basic safeguard** between:
  - ES3 isolated from the **mains** and protective earth; and
  - ES2 and protective earth; and
  - ES2 and ES1;

  and
– pass the electric strength test of 5.4.9.1, taking into account the total **working voltage** across the capacitor(s) and RC unit. Capacitors complying with IEC 60384-14 do not need to be tested if:

- the required peak impulse test voltage of Table G.8; and
- the required r.m.s. test voltage of Table G.8 multiplied by 1,414,

are equal to or greater than the required test voltage of 5.4.9.1.

When multiple capacitors are used, the test voltages of Table G.8 are multiplied by the number of capacitors used.

Under **single fault conditions,** if a capacitor or RC unit consists of more than one capacitor, the voltage on each of the remaining individual capacitors shall not exceed the voltage rating of the relevant individual capacitors.

NOTE 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

– **supplementary safeguard**.

Class X capacitors shall not be used as a **reinforced safeguard**.

5.5.2.2 Safeguards against capacitor discharge after disconnection of a connector

Where a capacitor voltage becomes **accessible** upon disconnection of a connector (for example, the **mains** connector) the **accessible** voltage measured 2 s after disconnection of the connector, shall comply with:

– the ES1 limits of Table 5 under **normal operating conditions** for an **ordinary person**; and

– the ES2 limits of Table 5 under **normal operating conditions** for an **instructed person**; and

– the ES2 limits of Table 5 under **single fault conditions** for both an **ordinary person** and an **instructed person**.

If an IC including capacitor discharge function (ICX) is used to comply with the above then under a **single fault condition** of an ICX or of any one component in the associated capacitor discharge circuit:

– the **accessible** voltage (for example, at the **mains** connector) shall not exceed the limits given above; or

– the ICX with the associated circuitry as provided in the equipment shall comply with the requirements of Clause G.16. Any impulse attenuating components (such as varistors and GDTs) are disconnected; or

– three samples of the ICX tested separately shall comply with the requirements of Clause G.16.

The measurement is made with an instrument having an input impedance consisting of a resistance of 100 MΩ ± 5 MΩ in parallel with an input capacitance of 25 pF or less.

If a switch (for example, the **mains** switch) has an influence on the test result, it is placed in the most unfavorable position. The disconnection of the connector (start of discharge time) has to be done at the moment when the input capacity of the device under test is charged to its peak value.

Other methods that give a similar result as the above method may be used.

5.5.3 Transformers

Transformers used as a **safeguard** shall comply with G.5.3.

5.5.4 Optocouplers

Insulation of optocouplers used as a **safeguard** shall comply with the requirements of 5.4 or with Clause G.12.

5.5.5 Relays

Insulation of relays used as a **safeguard** shall comply with the requirements of 5.4.

5.5.6 Resistors

The requirements below apply to resistors:

– used as a **safeguard**; or

– that bridge **basic insulation**, **supplementary insulation** or **reinforced insulation**.

A single resistor or a group of resistors shall comply with **clearance** and **creepage distance** requirements of 5.4.2 and 5.4.3 respectively between its terminations for the total **working voltage** across the insulation (see Figure O.4).

A single resistor used as a **reinforced safeguard** or bridging a **reinforced insulation** shall comply with G.10.1 and the test of G.10.2.

NOTE In Finland, Norway and Sweden, resistors used as a **basic safeguard** or for bridging **basic insulation** in **class I pluggable equipment type A** shall comply with G.10.1 and the test of G.10.2.

For a group of resistors used as a **reinforced safeguard** or for bridging **reinforced insulation** the **clearance** and **creepage distance** are assessed as if each resistor were short-circuited in turn unless the group complies with G.10.1 and the test of G.10.2.

5.5.7 SPDs

5.5.7.1 Use of an SPD connected to reliable earthing

Where a varistor is used between the **mains** and earth:

– the earth connection shall comply with 5.6.7; and

– the varistor shall comply with Clause G.8.

5.5.7.2 Use of an SPD between mains and protective earth

Where an SPD is used between the **mains** and protective earth, it shall consist of a varistor and a GDT connected in series, where the following applies:

– the varistor shall comply with Clause G.8;

– the GDT shall comply with:

  • the electric strength test of 5.4.9.1 for **basic insulation**; and

  • the external **clearance** and **creepage distance** requirements of 5.4.2 and 5.4.3 respectively for **basic insulation**.

NOTE 1 Some examples of SPDs are MOVs, varistors and GDTs. A varistor is sometimes referred to as a VDR or a metal oxide varistor (MOV).

The above requirements do not apply to SPDs:

– intended for attenuating transient voltages from **external circuits**; and

– connected to reliable earth (see 5.5.7.1).

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

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

5.5.8 Insulation between the mains and an external circuit consisting of a coaxial cable

The insulation between the **mains** and the connection to a coaxial cable, including any resistor in parallel with this insulation, shall be able to withstand surges from the **external circuit** and from the **mains**.

This requirement does not apply in any of the following equipment:

– equipment for indoor use 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 5.6.7.

The combination of the insulation with the resistor is tested after the conditioning of G.10.3.1 as follows:

– *for equipment intended to be connected to a coaxial cable connected to an outdoor antenna, the voltage surge test of G.10.3.2; or*
– *for equipment intended to be connected to another coaxial cable, the impulse test of G.10.3.3; or*
– *for equipment intended to be connected to both an outdoor antenna and other coaxial connections, the voltage surge test of G.10.3.2 and the impulse test of G.10.3.3.*

After the tests:

– *the insulation shall comply with 5.4.5.3 and the resistor may be removed during this test; and*
– *the resistors shall comply with G.10.3.4, unless available data shows compliance of the resistor.*

5.6 Protective conductor

5.6.1 General

Under **normal operating conditions**, a **protective conductor** may serve:

– as a **basic safeguard** to prevent **accessible** conductive parts from exceeding ES1 limits; and
– as a means to limit transient voltages in an earthed circuit.

Under **single fault conditions**, a **protective conductor** may serve as a **supplementary safeguard** to prevent **accessible** conductive parts from exceeding ES2 limits.

5.6.2 Requirements for protective conductors

5.6.2.1 General requirements

Protective conductors shall not contain switches, current limiting devices or overcurrent protective devices.

The current-carrying capacity of **protective conductors** shall be adequate for the duration of the fault current under **single fault conditions**.

The connections for the **protective conductors** shall make earlier and shall break 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**;

NOTE It is good practice 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.

– a plug on a power supply cord;

– an appliance coupler.

Solder shall not serve as the sole means to provide mechanical securement of the **protective conductor**.

The **protective conductor** termination shall be made such that it is not likely to be loosened during servicing, other that servicing of the actual conductor itself. The **protective earthing conductor** termination shall not serve as a means to fix any other component.

5.6.2.2 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.

5.6.3 Requirements for protective earthing conductors

Protective earthing conductors shall comply with the minimum conductor sizes in Table G.5.

NOTE 1 For **permanently connected equipment** provided with terminal(s) for connection to **mains** supply, reference is made to the national building wiring requirements for the size of the **protective earthing conductor**.

NOTE 2 IEC 60364-5-54 can also be used to determine the minimum conductor size.

For cord connected equipment supplied from a d.c. **mains**, the protective earth connection may be provided by a separate terminal.

A **protective earthing conductor** serving as a **reinforced safeguard** may be used on **pluggable equipment type B** or on **permanently connected equipment** only and shall:

– be included in and protected by a sheathed supply cord that complies with G.7.1 and which is not lighter than heavy duty; or

NOTE 3 Heavy duty is defined in either IEC 60227-1 or IEC 60245-1.

– have a minimum conductor size not less than 4 mm^2 if not protected from physical damage; or

– have a minimum conductor size not less than 2,5 mm^2 if protected from physical damage; or

– be protected by a conduit intended to be connected to the equipment and have a minimum size in accordance with Table 30.

NOTE 4 For **mains** supply cords, see also Clause G.7.

NOTE 5 A heavy duty cord jacket is considered suitable for protection against physical damage.

Table 30 – 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
Metallic flexible conduit	2,5
Non-flexible metal conduit	1,5
The **protective earthing conductor** is intended for installation by a **skilled person**.	

A **protective earthing conductor** serving as a **double safeguard** may be used on **pluggable equipment type B** or on **permanently connected equipment** only and shall consist of two independent **protective earthing conductors**.

*Compliance is checked by inspection and measurement of **protective earthing conductor** sizes in accordance with Table 30 or Table G.5 as applicable.*

5.6.4 Requirements for protective bonding conductors

5.6.4.1 Requirements

Protective bonding conductors of parts required to be earthed for safety purposes shall comply with one of the following:

– the minimum conductor sizes in Table G.5; or

– the requirements of 5.6.6 and, if the **rated current** of the equipment or the **protective current rating** of the circuit is more than 25 A, with the minimum conductor sizes in Table 31; or

– the requirements of 5.6.6 and, if the **rated current** of the equipment or the **protective current rating** of the circuit does not exceed 25 A; either

  - with the minimum conductor sizes in Table 31; 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 The value of the **protective current rating** is used in Table 31 and in the test of 5.6.6.2.

Table 31 – Minimum protective bonding conductor size of copper conductors

Smaller of the rated current of the equipment or the protective current rating of the circuit under consideration A up to and including	Minimum conductor sizes	
	Cross-sectional area mm^2	**AWG** [cross-sectional area in mm^2]
3	0,3	22 [0,324]
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 mm^2]
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.

5.6.4.2 Determination of the protective current rating

5.6.4.2.1 Mains supply as the source

Where the source is the **mains** supply, the **protective current rating** of the circuit is the rating of the overcurrent protective device provided in the building installation, or as part of the equipment.

Where the overcurrent protective device is provided in the building installation, 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), with a minimum of 16 A;

NOTE 1 In most countries, 16 A is considered to be suitable as the **protective current rating** of the circuit supplied from the **mains**.

NOTE 2 In Canada and the USA, the **protective current rating** of the circuit supplied from the **mains** is taken as 20 A.

NOTE 3 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.

5.6.4.2.2 Other than mains supply as the source

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. If the current is limited by an impedance, a fuse, a PTC device or a circuit breaker, the current is measured 60 s after the application of the load. If the current is limited by other means, the current is measured 5 s after the application of the load.

5.6.4.2.3 Internal circuit as the source

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.

5.6.4.3 Current limiting and overcurrent protective devices

The current limiting device (a PTC device) or the overcurrent protective device (a fuse or a circuit breaker) shall not be connected in parallel with any other component that could fail to a low-resistance state.

5.6.4.4 Compliance criteria

*Compliance is checked by inspection and measurement of the **protective bonding conductor** sizes in accordance with Table 31 or Table G.5 and the test of 5.6.6 or Annex R as applicable.*

5.6.5 Terminals for protective conductors

5.6.5.1 Requirements

Terminals for connecting **protective earthing conductors** shall comply with the minimum terminal sizes in Table 32.

Terminals for connecting **protective bonding conductors** shall comply with one of the following:

– the minimum terminal sizes in Table 32; or

– the requirements of 5.6.6 and, if the **rated current** of the equipment or the **protective current rating** of the circuit is more than 25 A, with terminal sizes that are not more than one size smaller than in Table 32; or

– the requirements of 5.6.6 and, if the **rated current** of the equipment or the **protective current rating** of the circuit does not exceed 25 A; either

- with terminal sizes that are not more than one size smaller than in Table 32; or
- with the limited short-circuit test of Annex R;

– for components only, be not smaller than the terminal sizes supplying power to the component.

Table 32 – Sizes of terminals for protective conductors

Conductor size mm^2 (from Table G.5)	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]
1	3,0	3,5	7	9,6
1,5	3,5	4,0	9,6	12,6
2,5	4,0	5,0	12,6	19,6
4	4,0	5,0	12,6	19,6
6	5,0	5,0	19,6	19,6
10 [b]	6,0	6,0	28	28
16 [b]	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.

[b] As an alternative to the requirements of this table, the **protective earthing conductor** may be attached to special connectors, or suitable clamping means (for example, an upturned spade or closed loop pressure type; clamping unit type; saddle clamping unit type; mantle clamping unit type; etc.) that is secured by a screw and nut mechanism to the metal chassis of the equipment. The sum of the cross-sectional areas of the screw and the nut shall not be less than three times the cross-sectional area of the conductor size in Table 31 or Table G.5 as applicable. The terminals shall comply with IEC 60998-1 and IEC 60999-1 or IEC 60999-2.

Compliance is checked by inspection and measurement of protective terminal sizes in accordance with Table 32, the test of 5.6.6 or Annex R as applicable.

5.6.5.2 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 of the materials of the conductors and terminals and associated parts and determination of the potential difference.

5.6.6 Resistance of the protective bonding system

5.6.6.1 Requirements

Protective bonding conductors and their terminations shall not have excessive resistance.

NOTE A protective bonding system in the equipment consists of a single conductor or a combination of conductive parts, connecting a main protective earthing terminal to a part of the equipment that is to be earthed for safety purposes.

Protective bonding conductors that meet the minimum conductor sizes in Table G.5 throughout their length and whose terminals all meet the minimum sizes in Table 32 are considered to comply without test.

On equipment where the protective earth connection to a subassembly or to a separate unit is made by means of one core of a multicore cable that also supplies power to that subassembly or unit and where the cable is protected by a suitably rated protective device that takes into account the size of the conductor, the resistance of the **protective bonding conductor** in that cable is not included in the measurement.

5.6.6.2 Test method

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** and of any earthed conductor in other external wiring 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.*

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 and duration of the test are as follows:

*a) For equipment powered from the **mains** where the **protective current rating** of the circuit under test is 25 A or less, the test current is 200 % of the **protective current rating** applied for 2 min.*

*b) For equipment powered from the **mains** where the **protective current rating** of the circuit under test exceeds 25 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 33.*

Table 33 – 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

*c) As an alternative to b), 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.*

*d) For equipment powered from a d.c. **mains**, if the **protective current rating** of the circuit under test exceeds 25 A, the test current and duration are as specified by the manufacturer.*

*e) For equipment receiving its power from an **external circuit**, the test current is 1,5 times the maximum current available from the **external circuit** or 2 A, whichever is greater, for a duration of 2 min. 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 the relevant test method of either a), b), c) or d) based on the power source assumed.*

5.6.6.3 Compliance criteria

*Where the **protective current rating** is less than 25 A, the resistance of the protective bonding system, calculated from the voltage drop, shall not exceed 0,1 Ω.*

*Where the **protective current rating** is 25 A or more, the voltage drop over the protective bonding system shall not exceed 2,5 V.*

5.6.7 Reliable earthing

For **permanently connected equipment** earthing is considered to be reliable.

For cord connected **mains** equipment, earthing is also considered to be reliable for:

– **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**.

For equipment connected to an **external circuit** as indicated in Table 14, ID numbers 1, 2, 3, 4 and 5, earthing is considered to be reliable for **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

Measurements of **prospective touch voltage**, **touch current**, and **protective conductor current** are made with the EUT operating at the most unfavourable supply voltage (see B.2.3).

5.7.2 Measuring devices and networks

5.7.2.1 Measurement of touch current

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.

5.7.2.2 Measurement of voltage

Equipment, or parts of equipment, that are intended to be earthed in the intended application, but are unearthed as provided, shall be connected to earth during the measurement at the point by which the highest **prospective touch voltage** is obtained.

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, 5.3 and 5.4 of IEC 60990:1999.

Equipment provided with a connection to earth separate from the **protective earthing 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 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**.

5.7.5 Protective conductor current

The **protective conductor current** shall not exceed the ES2 limits in 5.2.2.2, unless all of the following conditions are met:

– the current shall not exceed 5 % of the input current measured under **normal operating conditions**;

– the construction of the **protective conductor** circuit and its connections shall have:

  - a **protective earthing conductor** serving as a **reinforced safeguard** or two independent **protective earthing conductors** serving as **double safeguard** as specified in 5.6.3, and
  - a reliable earthing as specified in 5.6.7.

If the **protective conductor current** exceeds the ES2 limits of 5.2.2.2, then an **instructional safeguard** shall be provided in accordance with Clause F.5, except that element 3 is optional.

The elements of the **instructional safeguard** shall be as follows:

– element 1a: , IEC 60417-6042 (2010-11) and

, IEC 60417-6173 (2012-10) and

, IEC 60417-5019 (2006-08)

– element 2: “Caution” or equivalent word or text, and “High touch current” or equivalent text

– element 3: optional

– element 4: “Connect to earth before connecting to supply” or equivalent text

The **instructional safeguard** shall be affixed to the equipment adjacent to the equipment supply connection.

NOTE In Denmark the installation instruction shall be affixed to the equipment if the **protective conductor current** exceeds the limits of 3,5 mA a.c. or 10 mA d.c.

5.7.6 Prospective touch voltage and touch current due to external circuits

5.7.6.1 Touch current from coaxial cables

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 1 In Norway and Sweden, the screen of the television distribution system is normally not earthed at the entrance of the building and there is normally no equipotential bonding system within the building. Therefore the protective earthing of the building installation needs to be isolated from the screen of a cable distribution system.

It is however accepted to provide the insulation external to the equipment by an adapter or an interconnection cable with galvanic isolator, which may be provided by a retailer, for example.

The user manual shall then have the following or similar information in Norwegian and Swedish language respectively, depending on in what country the equipment is intended to be used in:

"Apparatus connected to the protective earthing of the building installation through the mains connection or through other apparatus with a connection to protective earthing – and to a television distribution system using coaxial cable, may in some circumstances create a fire hazard. Connection to a television distribution system therefore has to be provided through a device providing electrical isolation below a certain frequency range (galvanic isolator, see EN 60728-11)"

NOTE 2 In Norway, due to regulation for CATV-installations, and in Sweden, a galvanic isolator shall provide electrical insulation below 5 MHz. The insulation shall withstand a dielectric strength of 1,5 kV r.m.s., 50 Hz or 60 Hz, for 1 minute.

Translation to Norwegian (the Swedish text will also be accepted in Norway):

"Apparater som er koplet til beskyttelsesjord via nettplugg og/eller via annet jordtilkoplet utstyr – og er tilkoplet et koaksialbasert kabel-TV nett, kan forårsake brannfare. For å unngå dette skal det ved tilkopling av apparater til kabel-TV nett installeres en galvanisk isolator mellom apparatet og kabel-TV nettet."

Translation to Swedish:

"Apparater som är kopplad till skyddsjord via jordat vägguttag och/eller via annan utrustning och samtidigt är kopplad till kabel-TV nät kan i vissa fall medfőra risk főr brand. Főr att undvika detta skall vid anslutning av apparaten till kabel-TV nät galvanisk isolator finnas mellan apparaten och kabel-TV nätet.".

5.7.6.2 Prospective touch voltage and touch current from external circuits

For **external circuits** ID 1 of Table 14:

– the **prospective touch voltage** shall comply with ES2; or

– the **touch current** shall not exceed 0,25 mA.

The above requirements do not apply to **external circuits** connected to a **protective earthing conductor**.

Compliance is checked by measurement according to 5.7.2 and 5.7.3 by using the measurement arrangement in Figure 32 for single-phase equipment and Figure 33 for three-phase equipment.

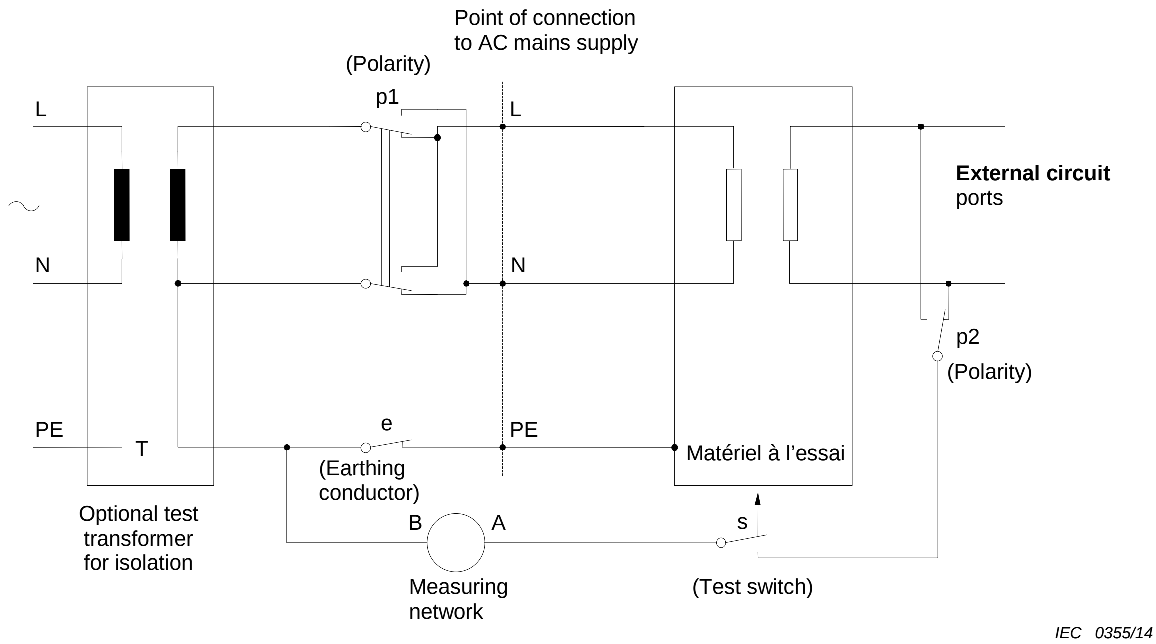


Figure 32 – Test circuit for touch current of single-phase equipment

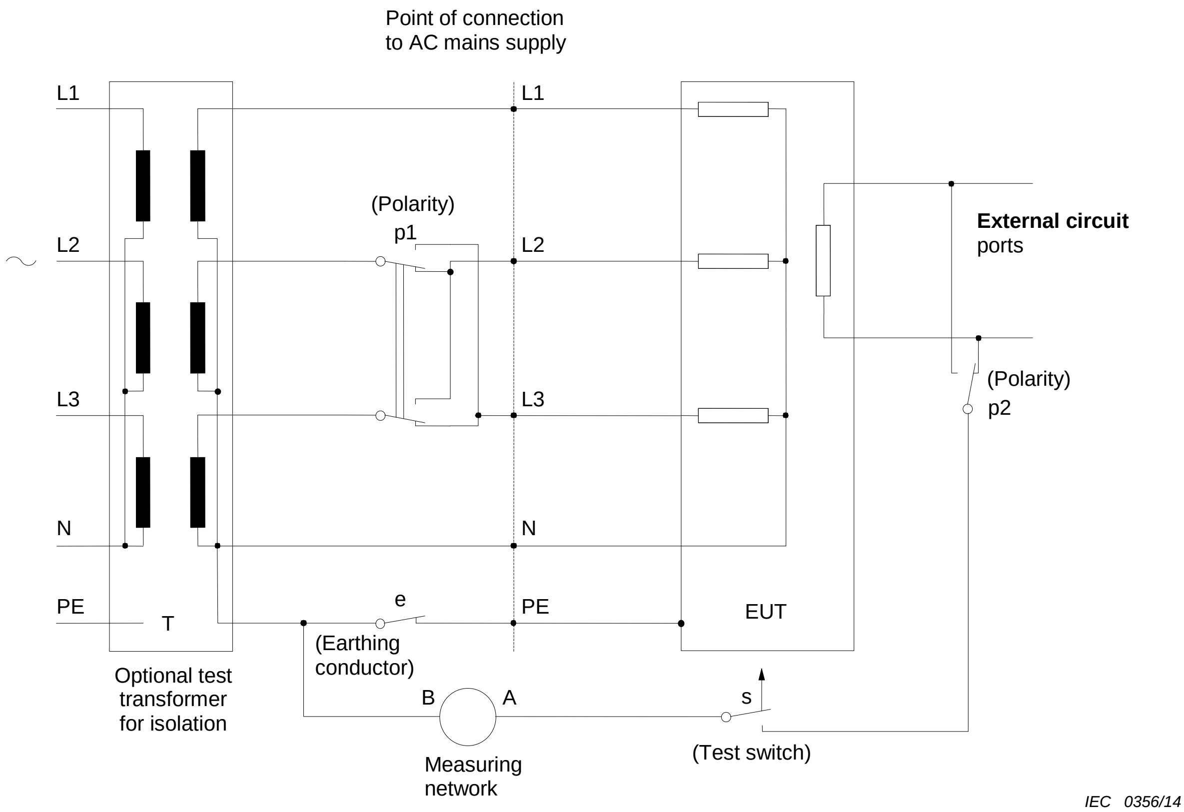


Figure 33 – Test circuit for touch current of three-phase equipment

5.7.7 Summation of touch currents from external circuits

The requirements below specify 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.

The requirements apply only to equipment with **external circuits** such as described in Table 14, ID numbers 1, 2, 3 and 4.

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).

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 mm^2, if mechanically protected, or otherwise 4,0 mm^2; and

– provide a marking in accordance with 5.7.5 and Clause F.3.

2) Such equipment shall comply with 5.7.5. The value of I_2 shall be used to calculate the 5 % input current limit per phase specified in 5.7.5.

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 5, 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

To reduce the likelihood of injury or property damage due to an electrically-caused fire originating within the equipment, equipment shall be provided with the **safeguards** specified in Clause 6.

6.2 Classification of power sources (PS) and potential ignition sources (PIS)

6.2.1 General

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.

The electrical power source classification shall be determined by measuring the maximum power 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 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 34 and Figure 35.

6.2.2.2 Power measurement for worst-case fault

With reference to Figure 34:

– *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}*);*

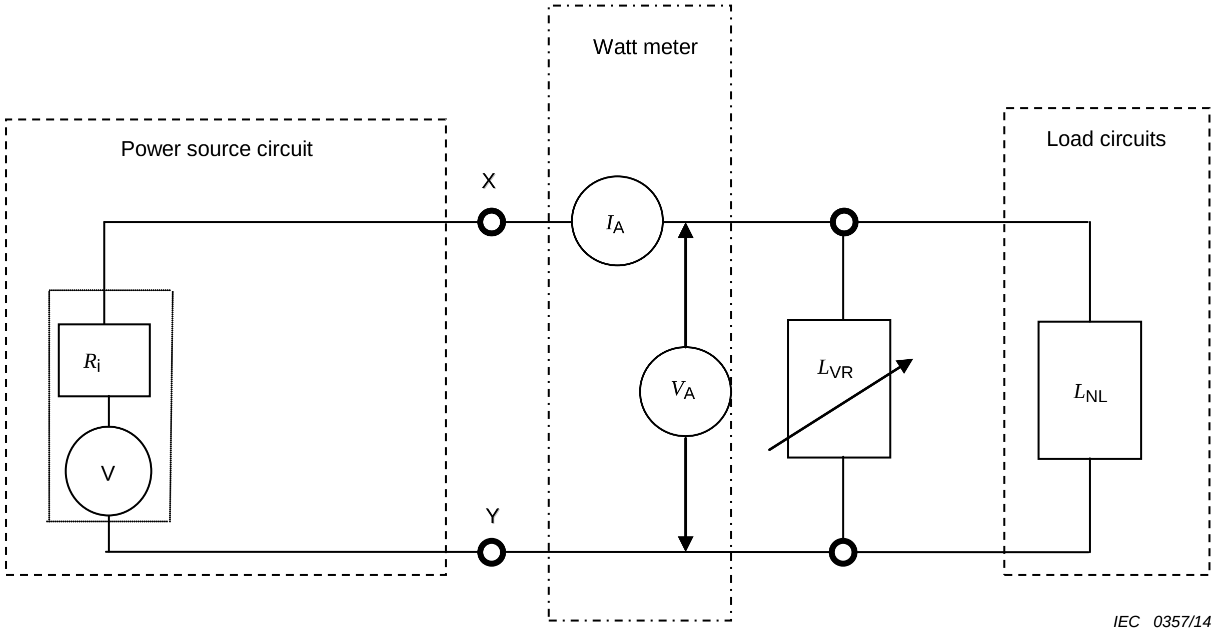
– *connect a variable resistor,* L_{VR} *as shown;*

– *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 operates during the test, the measurement shall be repeated at 125 % of the current rating of the overcurrent protective device.

If a power limiting circuit operates during the test, the measurement shall be repeated at a point just below the current at which the power limiting circuit operated.

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 34 – Power measurement for worst-case fault

6.2.2.3 Power measurement for worst-case power source fault

With reference to Figure 35:

- *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.*

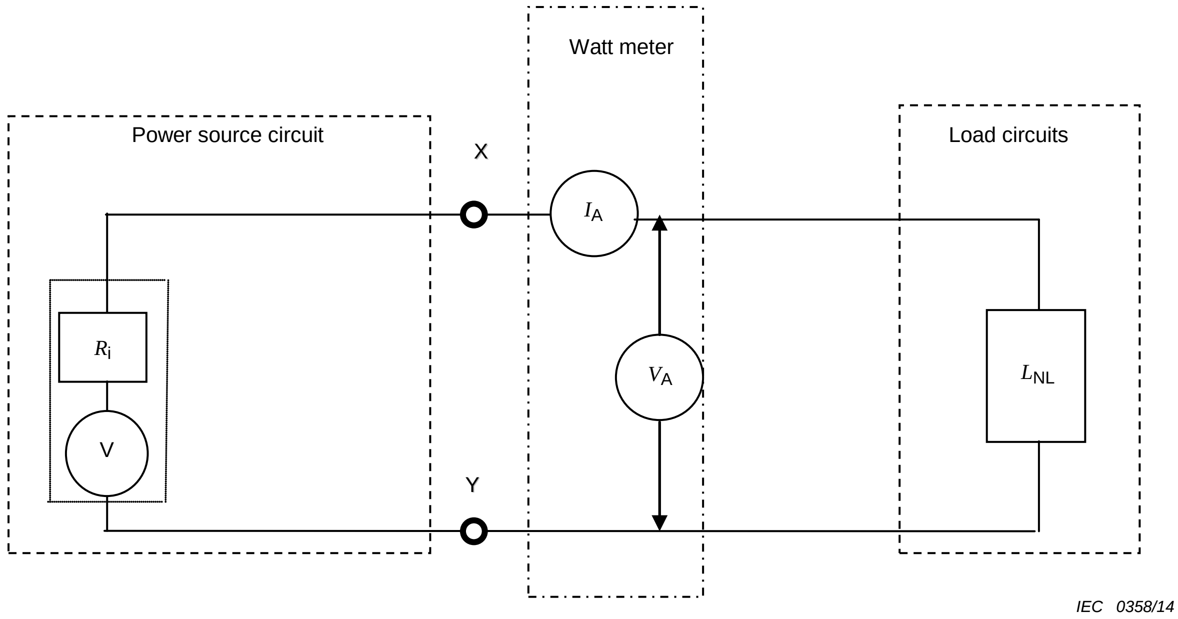
If an overcurrent protective device operates during the test, the measurement shall be repeated at 125 % of the current rating of the overcurrent protective device.

If a power limiting circuit operates during the test, the measurement shall be repeated at a point just below the current at which the power limiting circuit operated.

When the tests are repeated, a variable resistance may be used to simulate the component under fault.

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 Experimentation can 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 35 – Power measurement for worst-case power source fault

6.2.2.4 PS1

PS1 is a circuit where the power source, (see Figure 36) measured according to 6.2.2, does not exceed 15 W measured after 3 s.

The power available from **external circuits** described in Table 14, ID numbers 1 and 2, are considered to be PS1.

6.2.2.5 PS2

PS2 is a circuit where the power source, (see Figure 36) 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 36).

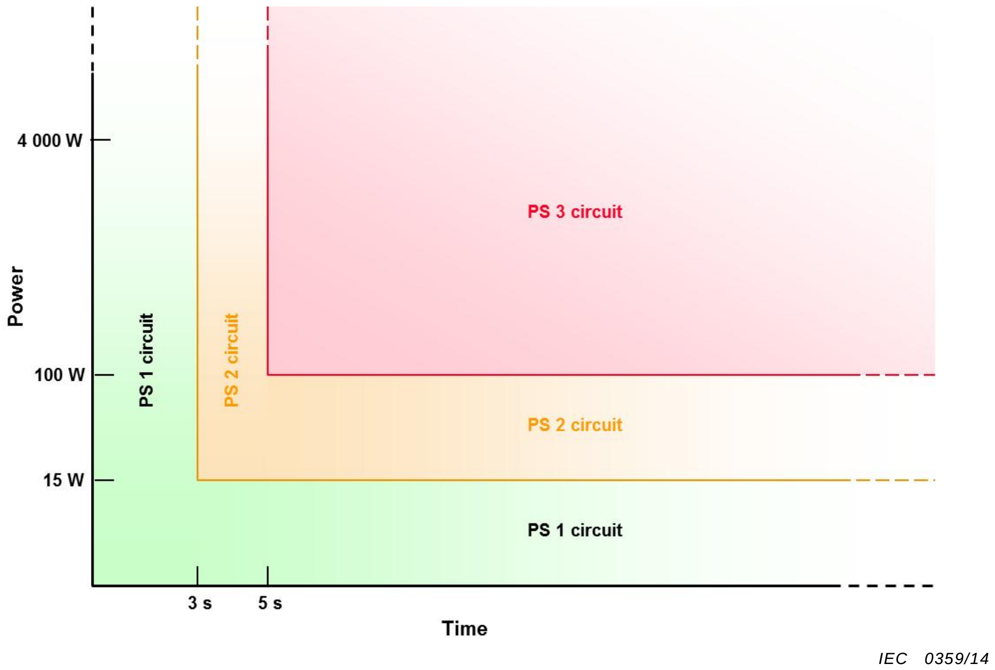


Figure 36 – Illustration of power source classification

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 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 Other means to avoid the occurrence of an **arcing PIS** can be used.

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, taking into account 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:

– dissipates 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.

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 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**.

These requirements do not apply to:

– parts with a size of less than 1 750 mm^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;

– 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 criteria

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.1.6 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

Requirements for **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) are specified in 6.4.3.2.

6.4.3.2 Requirements

The likelihood of ignition can be reduced by using the following **supplementary safeguards** as applicable:

– providing separation from an **arcing PIS** or a **resistive PIS** as specified in 6.4.7;

– using protective devices that comply with G.3.1 to G.3.4 or the relevant IEC component standards for such devices;

– using components that comply with G.5.3, G.5.4 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 below, 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.*

NOTE 1 See B.1.6 for details on thermal equilibrium.

Spontaneous ignition temperatures of surrounding materials of the heat source shall be taken into account.

NOTE 2 Temperature rise can be observed after interruption of the current due to thermal inertia.

If the temperature is limited by a fuse, under a ***single fault condition***

– *a fuse complying with the IEC 60127 series shall open within 1 s; or*

– *a fuse not complying with the IEC 60127 series shall open within 1 s for three consecutive times; or*

– *the fuse shall comply with the following test.*

The fuse is short-circuited and the current that would have passed through the fuse under the relevant ***single fault condition*** *is measured.*

– *If the fuse current remains less than 2,1 times the current rating of the fuse, 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 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 under consideration, both the fuse and the short-circuit link are removed after an additional time corresponding to the maximum pre-arcing time of the fuse 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 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 criteria

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

For the purposes of reducing the likelihood of fire spread in PS2 circuits to nearby **combustible materials**, circuits that meet the requirements of Annex Q are considered to be PS2 circuits.

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** or **VTM-1 class material**;

– wire insulation and tubing shall comply with IEC 60332-1-2, IEC 60332-1-3, IEC 60332-2-2 or IEC/TS 60695-11-21;

All other components in a PS2 circuit shall:

– be mounted on **V-1 class material** or **VTM-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

– not ignite during **single fault conditions** as specified in 6.4.3.3; or

– comply with the requirements of the relevant IEC component standard; or

– comply with G.5.4 for motors; or

– comply with G.5.3 for transformers; or

– be in a sealed **enclosure** of 0,06 m^3 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 criteria

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

Fire spread in PS3 circuits shall be controlled by applying all of the following **supplementary safeguards**:

– conductors and devices within a PS3 circuit shall meet the requirements of 6.4.5;

– 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 mm^3;

– 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 mm^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;

– 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 $\geq$ 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 60332-1-3, IEC 60332-2-2 or IEC/TS 60695-11-21;

– components, including connectors, complying with the requirements of 6.4.8.2.1, 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, G.4.1 and Clause G.7;

– motors complying with G.5.4;

– transformers complying with G.5.3.

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

The minimum separation requirements between a **PIS** and **combustible materials**, in order to reduce the likelihood of sustained flaming or spread of fire, may 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 6.4.8.4.

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 37, Figure 38, Figure 39 and Figure 40.

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**.

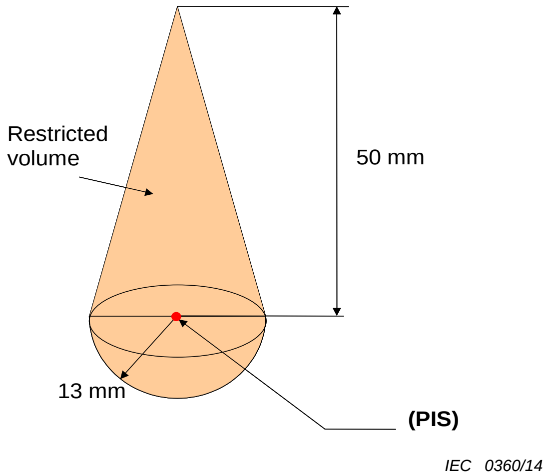
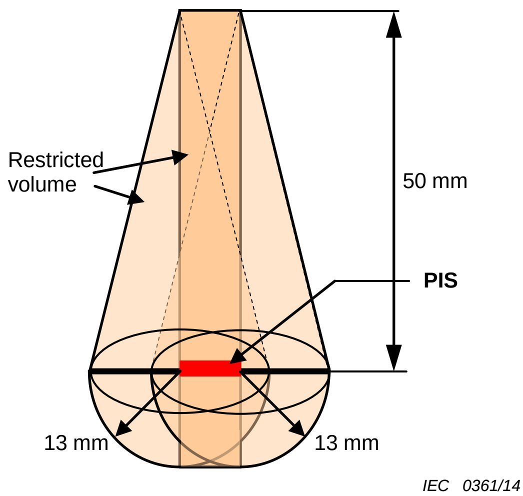


Figure 37 – Minimum separation requirements from an arcing PIS



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 surface of the component is used.

Figure 38 – 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 37, Figure 38 and Figure 40 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 39) to 45° in the direction of the forced airflow.

Any available data, including manufacturer's data, may be used in determining direction of forced airflow where it is not clear. Consequential air flow due to the by-product of a moving part that is not for air moving purposes may be ignored.

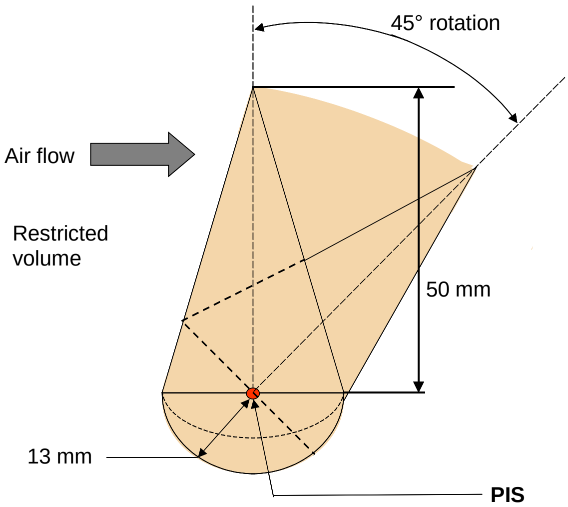


Figure 39 – Rotated separation requirements due to forced air flow

When the distance between a **PIS** and **combustible materials** is less than specified in Figure 37, Figure 38 and Figure 39 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 6.4.8.2.1 (see Figure 40).

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.

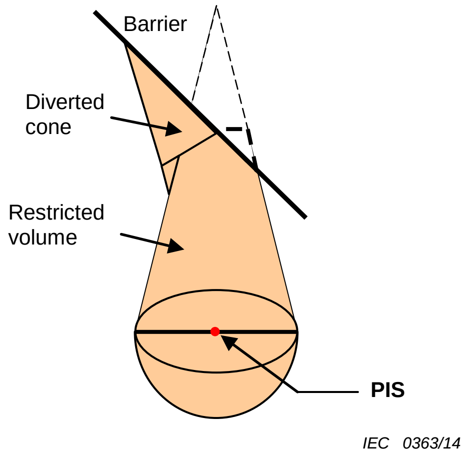


Figure 40a – Illustration showing an angled barrier

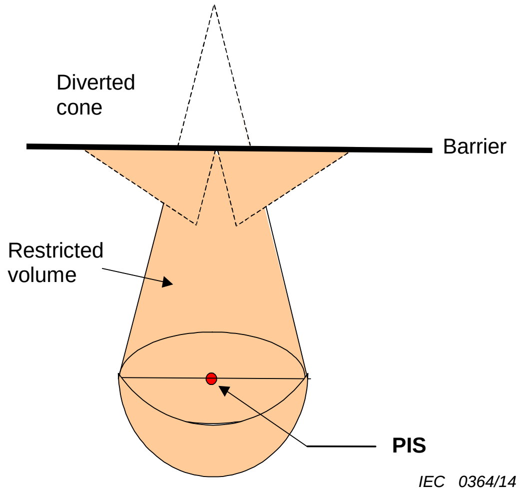


Figure 40b – Illustration showing a horizontal barrier

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. Different shapes of barriers might give different flame shapes and result in a different restricted area and separation requirements.

NOTE 2 Dimensions are identical to Figure 37 and Figure 38 but, except as required in 6.4.8.4, the distance of the barrier from the **PIS** is not significant.

Figure 40 – Deflected separation requirements from a PIS when a fire barrier is used

6.4.7.4 Compliance criteria

Compliance is checked by inspection or measurement or both.

6.4.8 Fire enclosures and fire barriers

6.4.8.1 General

The **safeguard** function of the **fire enclosure** and the fire barrier is to impede the spread of fire through the **enclosure** or barrier.

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**.

6.4.8.2 Fire enclosure and fire barrier material properties

6.4.8.2.1 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**.

6.4.8.2.2 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.

6.4.8.2.3 Compliance criteria

Compliance is checked by inspection of applicable data sheets or test.

*The **material flammability class** is checked for the thinnest significant thickness used.*

6.4.8.3 Constructional requirements for a fire enclosure and a fire barrier

6.4.8.3.1 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 41 and Figure 42.

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.

When the forced airflow across a **PIS** is moving due to air moving devices, the vertical orientation of the volume described in Figure 38 is rotated (tilted) around the **PIS** location from 0° (vertical orientation shown in Figure 38) to 45° in the direction of the forced airflow (see also Figure 39).

6.4.8.3.2 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 40).

6.4.8.3.3 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 41.

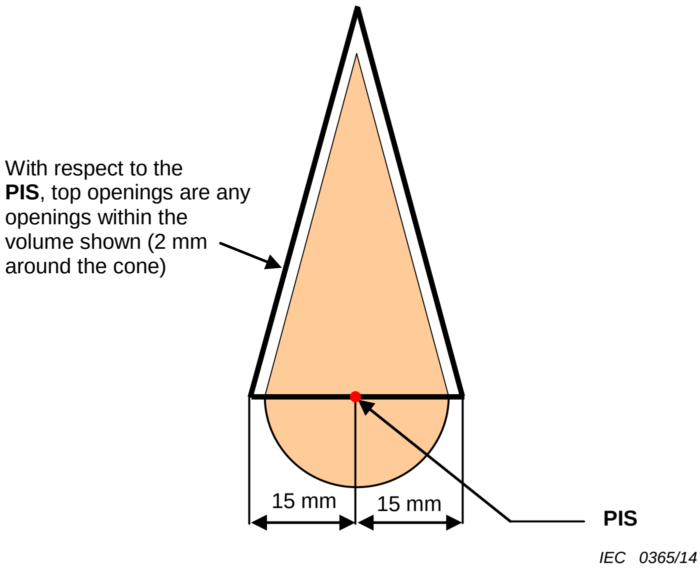
NOTE Any openings within the zone as shown in Figure 41 are regarded to be top openings, including side openings.

Top openings that fall within the volume defined in Figure 41 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 37 and Figure 38.

Figure 41 – Top openings

No test is required provided that the openings do not exceed:

– *5 mm in any dimension, or*

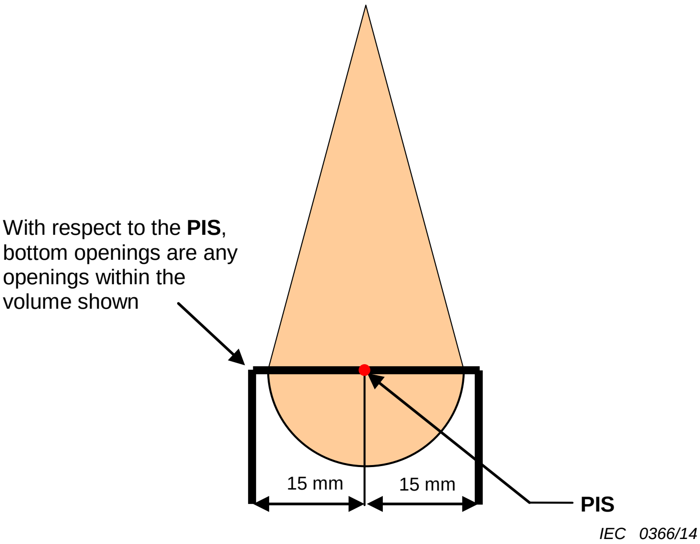
– *1 mm in width regardless of length.*

6.4.8.3.4 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 42.

NOTE Any openings within the zone as shown in Figure 42 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 37 and Figure 38.

Figure 42 – 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.
d) the openings in the metal bottom **enclosure** comply with Table 34.

Table 34 – Size and spacing of holes in metal bottoms of fire enclosures

	Circular holes		Other shaped openings	
Metal bottom minimum thickness mm	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

6.4.8.3.5 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 if an **instructional safeguard** is provided for correct removal and reinstallation of the door or cover.

6.4.8.3.6 Compliance criteria

Compliance is checked by inspection of applicable data sheets and, where necessary, by test.

6.4.8.4 Separation of a PIS from a fire enclosure and a fire barrier

A **fire enclosure** or fire barrier made of **combustible material** shall:

– have a minimum distance of 13 mm to an **arcing PIS**; and

– 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 6.4.8.3.3 or 6.4.8.3.4 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 Requirements

In PS2 circuits or PS3 circuits, the insulation on internal or external wiring shall pass the test methods described below.

For conductors with a cross-sectional area of 0,5 mm^2 or greater, the test methods in IEC 60332-1-2 and IEC 60332-1-3 shall be used.

For conductors with a cross-sectional area of less than 0,5 mm^2, the test methods in IEC 60332-2-2 shall be used.

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 or IEC 60332-2-2.

6.5.2 Compliance criteria

The insulated conductor or cable shall be acceptable if it complies with the recommended performance requirements of the applicable IEC 60332 standards or with the requirements of IEC/TS 60695-11-21.

6.5.3 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 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 Clause Q.1.

Circuits providing power to devices or external components that are intended for use in the same room as the EUT are not subject to this requirement. See 6.6 for connection to secondary equipment.

External paired conductor cable circuits, such as those described in Table 14, ID numbers 1 and 2 having a minimum wire diameter of 0,4 mm, shall have the current limited to 1,3 A.

EXAMPLE 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.1.2.

6.5.4 Compliance criteria

Compliance is checked by test, inspection and where necessary by the requirements of Annex Q.

6.6 Safeguards against fire due to the connection of additional 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 or shall comply with Clause Q.1.

Compliance is checked by inspection or measurement.

7 Injury caused by hazardous substances

7.1 General

To reduce the likelihood of injury due to exposure to **hazardous substances**, equipment shall be provided with the **safeguards** specified in Clause 7.

NOTE These **safeguards** are not intended to be the only means to reduce the likelihood of such injury.

7.2 Reduction of exposure to hazardous substances

The exposure to **hazardous substances** shall be reduced. Reduction of exposure to **hazardous substances** shall be controlled by using containment of the **hazardous substances**. 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 according to 4.4.4, following which there shall be no leakage from the container.*

7.3 Ozone exposure

For equipment that produces ozone, the installation and operating instructions shall indicate that precaution shall be taken to ensure that the concentration of ozone is limited to a safe value.

NOTE 1 Currently, the typical long term exposure limit for ozone is considered to be $0{,}1 \times 10^{-6}$ (0,2 mg/m^3) 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 personal safeguards (PPE)

Where **safeguards**, such as containment of a chemical, are not practical, a **personal safeguard** and its use shall be specified in the instructions that are provided with the equipment.

Compliance is checked by inspection of instructions or accompanying documents.

7.5 Use of instructional safeguards and instructions

Where a **hazardous substance** 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 and their protection circuits

Batteries and their protection circuits shall comply with Annex M.

8 Mechanically-caused injury

8.1 General

To reduce the likelihood of injury due to exposure to mechanical hazards, equipment shall be provided with the **safeguards** specified in Clause 8.

NOTE 1 In some cases, the person is the source of the kinetic energy.

NOTE 2 Where not specifically mentioned in Clause 8, 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 35.

Table 35 – 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]
3a	Plastic fan blades [a] See Figure 44	$\frac{N}{15\ 000} + \frac{K}{2\ 400} \leq 1$	> MS1; and $\frac{N}{44\ 000} + \frac{K}{7\ 200} \leq 1$	> MS2
3b	Other fan blades [a] See Figure 43	$\frac{N}{15\ 000} + \frac{K}{2\ 400} \leq 1$	> MS1; and $\frac{N}{22\ 000} + \frac{K}{3\ 600} \leq 1$	> MS2
4	Loosening, exploding or imploding parts	NA	NA	See [d]
5	Equipment mass	≤ 7 kg	7 kg < mass ≤ 25 kg	> 25 kg
6	Wall/ceiling mount	Equipment mass ≤ 1 kg mounted ≤ 2 m [e]	Equipment mass > 1 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:

– 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.

[e] This classification can only be used if the manufacturer's instructions state that the equipment is only suitable for mounting at heights ≤ 2 m.

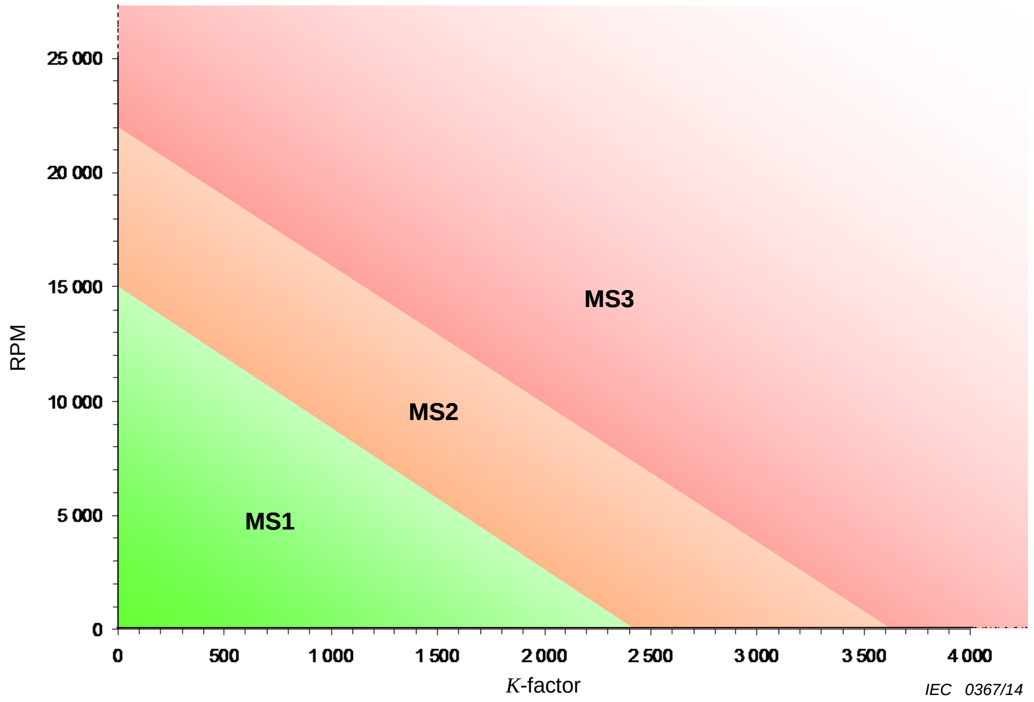


Figure 43 – Limits for moving fan blades made of non-plastic materials

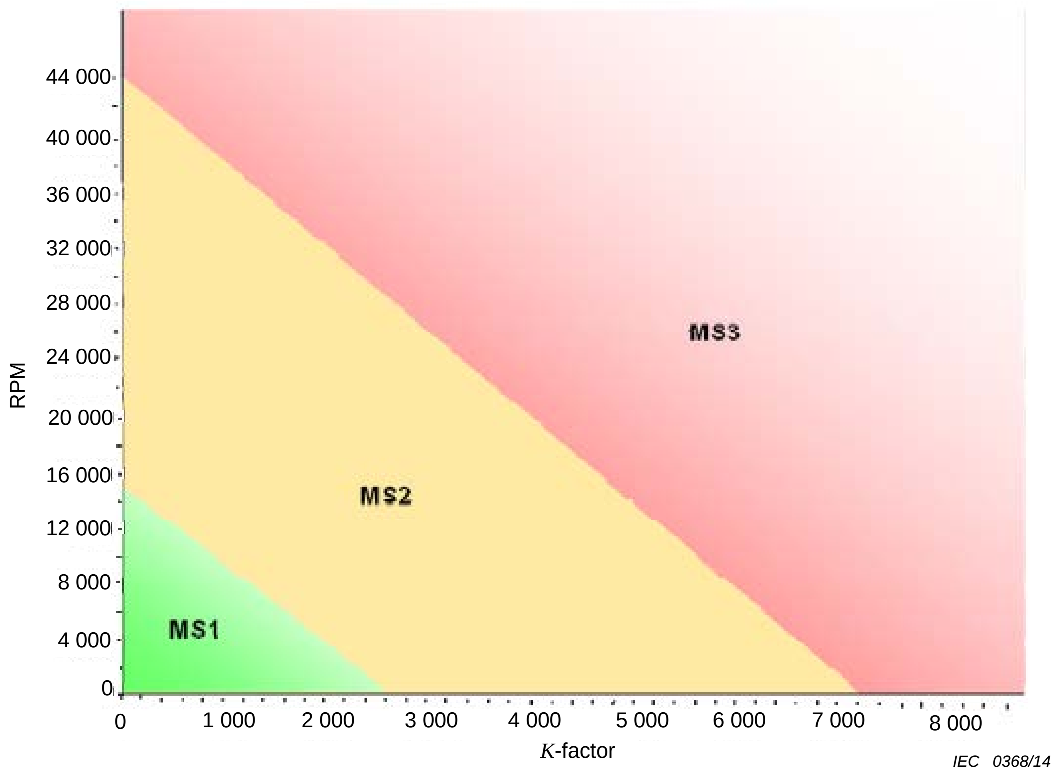


Figure 44 – Limits for moving fan blades made of plastic materials

8.2.2 MS1

MS1 is a class 1 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**.

8.2.3 MS2

MS2 is a class 2 mechanical energy source with levels not exceeding MS2 limits under **normal operating conditions**, **abnormal operating conditions**, and **single fault conditions**, but is not MS1.

8.2.4 MS3

MS3 is a class 3 mechanical energy source with levels exceeding MS2 limits under **normal operating conditions**, **abnormal operating conditions** or **single fault conditions**, or any mechanical energy source declared to be treated as MS3 by the manufacturer.

8.3 Safeguards against mechanical energy sources

Except as given below, **safeguard** requirements for parts **accessible** to **ordinary persons**, **instructed persons** and **skilled persons** are given in 4.3.

An **instructional safeguard** shall be provided for MS2 that is not obvious to an **instructed person** or for MS3 that is not obvious to a **skilled person**.

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.

8.4 Safeguards against parts with sharp edges and corners

8.4.1 Requirements

Safeguards that reduce the likelihood of injury by parts with sharp edges and corners in **accessible** areas of the equipment are specified below.

Classification of the energy sources shall be done according to Table 35, line 1.

Where a sharp edge or corner is required to be **accessible** for the function of the equipment:

- any potential 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 provided to reduce the risk of unintentional contact in accordance with Clause F.5, except that element 3 is optional.

The elements of the **instructional safeguard** shall be as follows:

- element 1a: , IEC 60417-6043 (2011-01)
- element 2: “Sharp edges” or equivalent text
- element 3: optional
- element 4: “Do not touch” or equivalent text

8.4.2 Compliance criteria

Where a sharp edge or corner is required to be ***accessible*** *for the function of the equipment, compliance is checked by inspection.*

Where a sharp edge or corner is not required to be ***accessible*** *for the function of the equipment compliance is checked by the relevant tests 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

Safeguards that reduce the likelihood of injury caused by moving parts of the equipment (for example, pinch points, meshing gears and parts that may start moving due to unexpected resetting of a control device) are specified below.

Plastic fan blades are classified according to Table 35, line 3a. Other fan blades are classified according to Table 35, line 3b. Other moving parts are classified according to Table 35, line 2.

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.

If a **safety interlock** is used as **safeguard**, it shall comply with Annex K. The movement of the part shall be reduced to MS1 before the part is **accessible**.

Unless otherwise specified, where the likelihood exists that fingers, jewellery, clothing, hair, etc., can come into contact with moving MS2 or MS3 parts, an **equipment safeguard** shall be provided to prevent entry of body parts or entanglement of such items.

If a moving MS2 part is required to be **accessible** for the function of the equipment to an **ordinary person** or a moving MS3 part to an **ordinary person** or an **instructed person**:

– 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** as given in 8.5.2 shall be used; 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.

Moving MS3 parts:

– that are only **accessible** to a **skilled person**; and
– where the MS3 moving part is not obvious (for example, a device having intermittent movement),

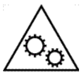
shall have an **instructional safeguard** as given in 8.5.2. Unless the moving part is arranged, located, enclosed or guarded in such a way that the possibility of contact with the moving parts is unlikely, a stopping device shall be placed in a clearly visible and prominent position within 750 mm of the MS3 part.

8.5.2 Instructional safeguard requirements

An **instructional safeguard** shall be provided to reduce the likelihood of unintentional contact with a moving part in accordance with Clause F.5, except that element 3 is optional.

The elements of the **instructional safeguard** shall be as follows:

– element 1a:  IEC 60417-6056 (2011-05) for moving fan blades or

 IEC 60417-6057 (2011-05) for other moving parts

– element 2: “Moving parts” or “Moving fan blade” as applicable, or equivalent text

– element 3: optional

– element 4: “Keep body parts away from moving parts” or “Keep body parts away from fan blades” or “Keep body parts out of the motion path” as applicable, or equivalent text

During **ordinary person** servicing conditions, where it is necessary to defeat or bypass the **equipment safeguard** preventing access to a moving part classified as MS2, an **instructional safeguard** shall be provided to:

– disconnect the power source prior to defeating or bypassing the **equipment safeguard**; and

– restore the **equipment safeguard** before restoring power.

8.5.3 Compliance criteria

The accessibility of moving parts shall be checked by inspection and, if necessary, be evaluated according to the relevant parts of Annex V.

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 m^3 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

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 are specified below. 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.

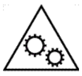
NOTE 2 This equipment design typically applies to commercial or industrial equipment expected to be installed in locations where only adults are normally present.

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

For equipment installed where children may be present, an **instructional safeguard** shall be provided in accordance with Clause F.5, except that element 3 is optional.

The elements of the **instructional safeguard** shall be as follows:

– element 1a: , IEC 60417-6057 (2011-05)

– element 2: optional

– element 3: optional

– element 4: “This equipment is not intended for use by children” and “Avoid touching the media feed opening with the hands, clothing or hair” and “Unplug this equipment when not in use for an extended period of time” or equivalent text

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

The media destruction device is tested with the wedge probe of Figure V.4 applied in any direction relative to the opening:

– *with a force up to 45 N for a strip-cut type device; and*

– *with a force up to 90 N for a cross-cut type device.*

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 criteria

Compliance is checked in accordance with V.1.2 and V.1.5. 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 High pressure lamps

8.5.5.1 General

The containment mechanism for high pressure lamps that are considered MS3 according to Line 4 of Table 35 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.

8.5.5.2 Test method

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 easier for the inspection of potential glass debris if the sticky mat has a dark blue colour.

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.

8.5.5.3 Compliance criteria

Compliance is checked by physical inspection or, if necessary, by the tests of 8.5.5.2.

When tested in accordance with 8.5.5.2, inspect the dark sticky mat for glass particles, and:

– *glass particles less than 0,8 mm in the longest axis shall not be found beyond 1 m of the **enclosure** opening; and*

– *glass particles equal to or greater than 0,8 mm in the longest axis shall not be found.*

*For professional equipment, where it is unlikely that the particles will be within reach of an **ordinary person**, the value of 0,8 mm may be replaced with 5 mm.*

8.6 Stability of equipment

8.6.1 Requirements

Classification of products for the purposes of assessing equipment stability is to be done according to Table 35, line 5.

In case units are fixed together, the MS class is determined by the total weight of the units. If units are intended to be separated for relocation, the MS class is determined by the individual weight.

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.

Equipment shall comply with the requirements and tests given in 8.6.2, 8.6.3, 8.6.4 and 8.6.5 according to Table 36. Where an "x" is given, it means that the test is applicable.

Table 36 – Overview of requirements and tests

Equipment type		Type of test				
		Static stability 8.6.2.2	Downward force 8.6.2.3	Relocation 8.6.3	Glass slide 8.6.4	Horizontal force 8.6.5
MS1	All equipment	No stability requirements				
MS2	Floor standing			x		
	Non-floor standing	x				
	Controls or display [a]				x	x
	Fixed [b]	No stability requirements				
MS3	Floor standing	x	x	x		
	Non-floor standing	x				
	Controls or display [a]	x			x	x
	Fixed [b]	No stability requirements				

[a] Equipment with front mounted **accessible** user controls and equipment having displays with moving images likely to be used in the home or similar installation environments where the equipment may be **accessible** to children.

[b] Where equipment is expected to be installed by an **ordinary person**, equipment having a screw hole or other means to secure the equipment, such as for securement to a table or for earth quake protection, is not considered to be fixed. Such securements are considered to be **supplementary safeguards**.

Where thermoplastic materials are involved in the construction, the relevant stability tests shall be conducted after the stress relief test in Clause T.8 when the equipment has cooled to room temperature.

MS2 and MS3 television sets shall have an **instructional safeguard** in accordance with Clause F.5, except that the **instructional safeguard** may be included in the installation instructions or equivalent document accompanying the equipment.

The elements of the **instructional safeguard** shall be as follows:

– element 1a: not available
– element 2: "Stability Hazard" or equivalent word
– element 3: "The television set may fall, causing serious personal injury or death" or equivalent text
– element 4: the text below or equivalent text

Never place a television set in an unstable location. A television set 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 television set.
- Only using furniture that can safely support the television set.
- Ensuring the television set is not overhanging the edge of the supporting furniture.
- Not placing the television set on tall furniture (for example, cupboards or bookcases) without anchoring both the furniture and the television set to a suitable support.
- Not placing the television set on cloth or other materials that may be located between the television set and supporting furniture.
- Educating children about the dangers of climbing on furniture to reach the television set or its controls.

If the existing television set is going to be retained and relocated, the same considerations as above should be applied.

8.6.2 Static stability

8.6.2.1 Test setup

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.

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.*

Where 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 tests of 8.6.2.2 and 8.6.2.3 shall be performed as indicated in Table 36.

8.6.2.2 Static stability test

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. The test may be applied at any height not exceeding 1,5 m from the base of the equipment. The test force shall be discontinued if the equipment remains stable after being tilted 10° from vertical. Alternatively, the equipment shall be tipped at any angle from the vertical up to and including 10°.

8.6.2.3 Downward force test

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 surface within 10° of horizontal of at least 125 mm by at least 200 mm, at any height up to 1 m from the base of the equipment. 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 apparatus in contact with the equipment, however 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.

8.6.2.4 Compliance criteria

During the tests, the equipment shall not tip over.

8.6.3 Relocation stability test

8.6.3.1 Requirements

Equipment shall be stable when it is being relocated.

Compliance is checked by the test of 8.6.3.2. The equipment shall not tip over during the test. Equipment with wheels having a minimum diameter of 100 mm is considered to comply with the above requirements without test.

8.6.3.2 Test method

The equipment is 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 the equipment not normally in contact with the supporting surface would touch the horizontal plane, the equipment is placed on the edge of the horizontal support during the test so that the contact is not made. 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°.

Equipment expected to be moved or relocated by ***ordinary persons*** *shall have*

- *all doors and drawers not having a positive means of retention and that can be opened inadvertently, and*
- *casters, adjustable feet and the like*

arranged in any combination that results in the least stability.

Equipment expected to be moved or relocated by an ***instructed person*** *or a* ***skilled person****, 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.

8.6.4 Glass slide test

8.6.4.1 Requirements

Equipment shall be so constructed that it will not slide or tip over on a supporting surface made of glass.

8.6.4.2 Test method and compliance criteria

The equipment 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 test, the equipment shall not slide or tip over.

8.6.5 Horizontal force test and compliance criteria

The 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:

– *an external horizontal force of 13 % of the weight of the equipment or 100 N, whichever is less, is applied 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 the supporting surface; or*
– *the equipment shall be moved through any angle of tilt up to and including 15° from the vertical; or*
– *the equipment is placed on a plane and is rotated through an angle of 360° about its normal vertical axis while tilted at an angle of 15°.*

During the test, the equipment shall not tip over.

8.7 Equipment mounted to a wall or ceiling

8.7.1 Requirements

Classification of equipment for the purposes of assessing wall mounting means is done according to Table 35, line 6.

For MS2 or MS3 equipment:

– If the manufacturer specifies a specific wall or ceiling mount, the combination of the mount and the equipment shall comply with 8.7.2, Test 1. The hardware used to fix the mounting means to the equipment shall either be provided with the equipment, or described in detail in the user instructions (for example, length of screws, diameter of the screws, etc.).
– If the manufacturer does not specify a specific wall or ceiling mount, but the equipment is provided with any part (for example, a hook or threaded hole) which facilitates attaching such a mount to the equipment, such parts shall comply with 8.7.2, Test 2, as appropriate. The user instruction shall advise on the safe use of such parts (for example, screw size including thread size and length, number of screws, etc.).
– If the equipment is provided with threaded parts for attachment of the mounting means, the threaded parts without the mounting means shall additionally comply with 8.7.2, Test 3.

NOTE The tests are meant to test the fixing of the mounting means to the equipment and not to test the fixing to the wall or ceiling.

8.7.2 Test methods

If the construction involves polymeric materials, the tests shall be performed after the stress relief test of Clause T.8.

Test 1

The equipment is mounted in accordance with the manufacturer's instructions and the mounting means positioned, when possible, to represent the most severe stress on the supports.

A force in addition to the weight of the equipment is applied downwards through the centre of gravity of the equipment, for 1 min. The additional force shall be:

- *three times the weight of the equipment; or*
- *the weight of the equipment plus 880 N,*

whichever is less.

In addition, for wall mounted equipment, a horizontal force of 50 N is applied laterally for 60 s.

Test 2

The test force shall be equivalent to the least of the following divided by the number of attachment points in the mounting system:

- *four times the weight of the equipment; or*
- *two times the weight of the equipment plus 880 N.*

Each point in the mounting system shall be subjected to a shear force perpendicular to its centre axis for 1 min. The force shall be applied in four directions, one direction at a time, separated by 90°.

Each point in the mounting system, one at a time, shall be subjected to an inward directed push force parallel to its centre axis for 1 min.

Each point in the mounting system, one at a time, shall be subjected to an outward directed pull force parallel to its centre axis for 1 min.

Test 3

If the mounting system design relies upon threaded parts, a torque according to Table 37 shall be applied to each threaded part, one at a time. If a corresponding screw fastener is supplied by the manufacturer, it shall be used for the test. If no corresponding screw fastener is supplied by the manufacturer, even though a screw type may be recommended in the user instructions, any screw with the same diameter shall be used for the test.

Table 37 – Torque to be applied to screws

Nominal diameter of screw **mm**		**Torque** **Nm**
	up to and including 2,8	0,4
over 2,8	up to and including 3,0	0,5
over 3,0	up to and including 3,2	0,6
over 3,2	up to and including 3,6	0,8
over 3,6	up to and including 4,1	1,2
over 4,1	up to and including 4,7	1,8
over 4,7	up to and including 5,3	2,0
over 5,3	up to and including 6,0	2,5

8.7.3 Compliance criteria

Compliance is checked by inspection and by the tests of 8.7.2, as applicable. The equipment or its associated mounting means shall not become dislodged and shall remain mechanically intact and secure during the test.

8.8 Handle strength

8.8.1 General

A handle that is declared by the manufacturer for the purpose of lifting or carrying the equipment shall comply with the tests as specified in 8.8.2.

The equipment is classified according to Table 35, line 5.

If equipment having handles is designed, or provided with instructions, for lifting or carrying multiple units together, the class is determined taking into account the weight that may be carried.

8.8.2 Test method and compliance criteria

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;*

  NOTE No tests apply to MS1 equipment having only one handle.

– *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 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

The likelihood of MS3 and some MS2 equipment, including carts, stands and similar carriers that support the equipment, from tipping over during movement shall be reduced. The equipment is classified according to Table 35, 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. 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.*

During the test, the wheels or casters shall not be damaged or pull free from its securing means.

8.10 Carts, stands, and similar carriers

8.10.1 General

The equipment shall be stable with the cart, stand or similar carrier. The classifications of Table 35, 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 8.6.5.

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 8.6.3 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.

The elements of the **instructional safeguard** shall be as follows:

– element 1a: not available
– element 2: “Caution” or equivalent text
– element 4: “This (cart, stand, or carrier) is intended for use only with (manufacturer's name), (model number or series), (equipment name).” or equivalent text
– element 3: “Use with other equipment may result in instability causing injury” or equivalent text

The elements shall be in the order 2, 4, and 3.

The **instructional safeguard** shall be affixed to the cart, stand or carrier, or included in the installation instructions or equivalent document accompanying the equipment.

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 and be comprised of:

– element 1a: not available

– element 2: "Caution" or equivalent word or text
– element 4: "This (equipment name) is for use only with (manufacturer's name), (model number or series), (cart, stand, or carrier)" or equivalent text
– element 3: "Use with other (carts, stands, or carriers) may result in instability causing injury" or equivalent text

The elements shall be in the order 2, 4, and 3.

The **instructional safeguard** shall be affixed to the equipment or included in the installation instructions or equivalent document accompanying the equipment.

8.10.3 Cart, stand or carrier loading test and compliance criteria

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 4.4.4.6.

8.10.5 Mechanical stability

A cart, stand or carrier, including floor standing types, shall be subjected to the applicable tests described in 8.6.3 and 8.6.5 by itself, and where applicable in combination with its intended MS2 or MS3 equipment .

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 8.6.3 and 8.6.5 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 General

This subclause specifies requirements for the slide-rail to reduce the likelihood of injury by retaining the slide-rail mounted equipment (SRME) in a stable position and not allowing the slide-rails to buckle, means of attachment to break, or the SRME to slide past the end of the slide-rails.

The requirements below apply to the mounting means of MS2 and MS3 SRME that is:

– installed in a rack and that is intended to be extended on slide-rails away from the rack for installation, use or service; and

– SRME that extends the full width of the rack; and

– having a top installation position more than 1 m in height from the supporting surface.

The requirements do not apply to:

– equipment subassemblies; or

– other equipment fixed in place in the rack; or

– equipment that is not intended to be serviced while extended on slide-rails.

The mechanical mounting means for the SRME are referred to as slide-rails. The SRME may be the actual product configured in its worst case mechanical loading, or a representative **enclosure** with weights to simulate worst case loading.

NOTE 1 Slide-rails include bearing slides, friction slides or other equivalent mounting means.

NOTE 2 Subassemblies of the end product (for example, removable modules, component drawers, pull out paper/heater trays in copiers/printers) are not considered to be SRME.

8.11.2 Requirements

Classification of products for the purposes of assessing equipment stability is to be done according to Table 35, line 5.

NOTE For assessing equipment stability, see 8.6.

Slide-rails shall retain the SRME and have end stops that prevent the SRME from unintentionally sliding off the mounting means.

The slide-rails shall be installed in a representative rack with the SRME, or in an equivalent setup in accordance with the manufacturer's instructions.

Slide-rails and their mounting means shall meet the mechanical strength tests of 8.11.3 and 8.11.4. Following each test, the slide-rails and the SRME may be replaced before conducting the next test.

8.11.3 Mechanical strength test

With the SRME in its extended position, a force in addition to the weight of the SRME is to be applied downwards through the centre of gravity for 1 min.

The additional force applied to the slide-rails shall be equal to the greater of the following two values:

– *50 % of the SRME weight plus a force of 330 N; or*

– *50 % of the SRME weight, plus an additional weight, where the additional weight is equal to the SRME weight or a force of 530 N, whichever is less.*

NOTE This additional force is intended to take into account other items or devices that are stacked on top of the installed SRME while in the extended position during installation of other SRME.

For slide-rail mounted shelves, the shelf shall be tested with a weight of 125 % of the maximum weight that is intended to be placed on the shelf.

A marking shall be provided on the shelf to indicate the maximum weight that can be added to the shelf.

8.11.4 Mechanical strength test, 250 N, including end stops

A 250 N static push force is applied laterally, in both directions at or near the end of the SRME with the slide rails in their fully extended (service) position for a period of 1 min. The applied weight need not be in full contact with uneven surfaces (for example, corrugated or curved surfaces) but shall be concentrated within 30 mm of the end of the SRME.

To test the integrity of the end stops, a 250 N pull and push force is applied at the front of the SRME in an attempt to cause the SRME to come off the slide-rail. The test is performed with the SRME in both the fully extended (service) position and the installed (use) position.

NOTE Additional requirements for a dynamic force test on end stops are being considered at this time.

8.11.5 Compliance criteria

Compliance is checked by inspection and available manufacturer's data. If data is not available, then the tests according to 8.11.3 and 8.11.4 are conducted.

Following each test, the SRME and its associated slide-rails shall remain secure for one complete cycle of travel on its slide-rails. 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 SRME at its centre point with the intent to completely retract the SRME into the rack.

The mounting means shall not bend or buckle to any extent that could introduce an injury. End stops shall retain the SRME in a safe position and shall not allow the SRME 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.11.

9 Thermal burn injury

9.1 General

To reduce the likelihood of painful effects and injury due to thermal burns, equipment shall be provided with the **safeguards** specified in Clause 9.

NOTE Electric burns due to radio frequency (RF) energy sources are a special case in this standard. They are controlled by limiting accessibility above a specified frequency. These limits and conditions are defined in the notes [d] and [e] defined in Table 4.

9.2 Thermal energy source classifications

9.2.1 General

The different thermal energy sources and their limits under **normal operating conditions**, **abnormal operating conditions** and **single fault conditions** at a normal room ambient of 25 °C are specified below. Touch temperature limits and classifications for various **accessible** parts are given in Table 38.

9.2.2 TS1

TS1 is a class1 thermal energy source with temperature levels

– not exceeding TS1 limits under **normal operating conditions**; and
– not exceeding TS2 limits under
  - **abnormal operating conditions**; or
  - **single fault conditions**.

9.2.3 TS2

TS2 is a class 2 thermal energy source where:

– the temperature exceeds the TS1 limits; and
– under **normal operating conditions**, **abnormal operating conditions** or **single fault conditions** the temperature does not exceed the TS2 limits.

Where the malfunction of the equipment is evident, no limits apply.

9.2.4 TS3

TS3 is a class 3 thermal energy source where the temperature exceeds the TS2 limits in Table 38 under **normal operating conditions** or under **abnormal operating conditions**, or under **single fault conditions**.

9.2.5 Test method and compliance criteria

The temperature tests are run with the room ambient conditions as defined in B.1.6, except that the room ambient temperature shall be 25^{-5}_{+0} *°C. If the test is performed at a temperature deviating from 25 °C, the results are adjusted to reflect a value of 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.*

9.2.6 Touch temperature levels

Table 38 – Touch temperature limits for accessible parts

	Accessible parts [a]	**Maximum temperature (T_{max})** °C			
		Metal [f]	**Glass, porcelain and vitreous material**	**Plastic and rubber**	**Wood**
TS1	Handles, knobs, grips, etc., and external surfaces either held, touched or worn against the body in normal use (> 1 min) [b, 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
TS2	Handles, knobs, grips, etc., and external surfaces held in normal use (> 1 min) [c]	58	58	58	58
TS2	Handles, knobs, grips, etc., and external surfaces held for short periods of time or touched occasionally (> 10 s and < 1 min) [d]	61	66	70	70
TS2	Handle, knobs, grips etc., and external surfaces touched occasionally for very short periods (> 1 s and < 10 s) [d]	70	81	87	117
TS2	External surfaces that need not be touched to operate the equipment (< 1 s) [d]	80 (100) [e]	90 (100) [e]	104	150
TS3	Higher than the TS2 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 parts in continuous contact with the skin, lower temperatures should be considered, see IEC Guide 117.

[c] Examples of these surfaces include a telephone handset, a headset, the palm rest surface of a notebook computer and surfaces that need to be touched for disconnection.

[d] Time of contact shall be determined by the manufacturer and shall be consistent with the intended use in accordance with the equipment instructions

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 temperature limit of the plastic and rubber is allowed.

[e] The values in parentheses may be used for the following areas and external surfaces:

– 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.

Under **abnormal operating conditions** and **single fault conditions**, for other areas and external surfaces of the equipment, an **equipment basic safeguard** is required.

[f] For external metal parts that are covered with plastic or rubber material of at least 0,3 mm thick, the temperature limit of plastic and rubber is allowed.

9.3 Safeguards against thermal energy sources

Except as given below, safeguard requirements for parts **accessible** to **ordinary persons**, **instructed persons** and **skilled persons** are given in 4.3.

For protection of an **ordinary person** against TS2, an **instructional safeguard** in accordance with 9.4.2 may be used as **basic safeguard** (see condition [e] of Table 38).

For protection of an **ordinary person** or an **instructed person** against TS3, the **supplementary safeguard** may be replaced with an **instructional safeguard** in accordance with 9.4.2. 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).

9.4 Requirements for safeguards

9.4.1 Equipment safeguard

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 classified in Table 38.

Temperature limits are applied only for those **abnormal operating conditions** where the equipment continues to operate in accordance with the manufacturer's instructions and, hence, the **abnormal operating condition** is not obvious. If the equipment stops functioning, then the limits are not applicable.

9.4.2 Instructional safeguard

An **instructional safeguard** shall be provided in accordance with Clause F.5, except that element 3 is optional.

The elements of the **instructional safeguard** shall be as follows:

– element 1a: , IEC 60417-5041 (2002-10)

– element 2: "CAUTION" and "Hot surface" or equivalent word or text

– element 3: optional

– element 4: "Do not touch" or equivalent text

10 Radiation

10.1 General

To reduce the likelihood of painful effects and injury due to laser, visible, infra-red, ultraviolet, x-ray, and acoustic energy, equipment shall be provided with the **safeguards** specified in this clause.

10.2 Radiation energy source classifications

10.2.1 General classification

Radiation energy source classifications are given in Table 39.

Table 39 – Radiation energy source classifications

Line	Category	RS1	RS2	RS3
1	Lasers	Class 1 [a]	Class 1M, Class 2, Class 2M, and Class 3R (visible) [a]	Class 3R (invisible), Class 3B, and Class 4 [a]
2	Lamps and LEDs	Exempt group, RG-1 and RG-2 [b]		RG-3 [b]
3	X-Ray	≤ 36 pA/kg at 50 mm [c]	> RS1 and ≤ 185 pA/kg at 100 mm [d]	> RS2
4	Acoustic	≤ 85 dB(A)	> RS1 and ≤ 100 dB(A)	> RS2

[a] The different classes are defined in IEC 60825-1.

[b] The different classes are defined in IEC 62471. Low power application of LEDs are in the exempt group.

UV radiation from general purpose incandescent and fluorescent lamps, with ordinary glass envelopes, are taken as RS1.

EXAMPLE RS1 LEDs 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 1 If optical radiation is broadband visible and IR-A radiation and the luminance of the source does not exceed 10^4 cd/m^2, it is expected that the radiation does not exceed the exposure limits given in 4.3 of IEC 62471:2006 (see 4.1 of IEC 62471:2006).

For UV-C limits (wavelengths between 180 nm and 200 nm), the value of IEC 62471 for 200 nm is used.

[c] 36 pA/kg equals 5 μSv/h or 0,5 mR/h. This value is consistent with International Commission on Radiation Protection (ICRP) Publication 60.

[d] 185 pA/kg equals 25 μSv/h or 2,5 mR/h.

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 as specified below.

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 μSv/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 EUT 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 EUT 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.

10.2.2 RS1

RS1 is a class 1 radiation energy source that

– does not exceed RS1 limits under
  - **normal operating conditions**, and
  - **abnormal operating conditions** that do not lead to a **single fault condition**, and
  - **single fault conditions** for laser, visible, infra-red, ultra-violet and x-radiation; and
– does not exceed RS2 limits under
  - **single fault conditions** for acoustic radiation.

10.2.3 RS2

RS2 is a class 2 radiation energy source that does not exceed RS2 limits under

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

is not RS1.

10.2.4 RS3

RS3 is a class 3 radiation energy source that exceeds RS2 limits under

– **normal operating conditions**, or
– **abnormal operating conditions**, or
– **single fault conditions**.

10.3 Safeguards against laser radiation

10.3.1 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.

Diodes emitting coherent light shall be threated as laser radiation.

NOTE In IEC 60825-1, such diodes are identified as “laser diodes”.

Unless RS2 is required to be **accessible** for the function of the equipment, laser radiation that exits the equipment shall not exceed RS1 under **normal operating conditions**, **abnormal operating conditions**, and **single fault conditions**. If RS2 is required to be **accessible** for the function of the equipment, the equipment shall be provided with an **instructional safeguard** in accordance with IEC 60825-1.

Unless the equipment complies with IEC 60825-2, where an RS3 laser is present, a **tool** shall be required to gain access.

10.3.2 Compliance criteria

Compliance is determined by measurement or by checking the available manufacturer’s data sheet.

10.4 Safeguards against visible, infra-red, and ultra-violet radiation

10.4.1 General

Except as given below, protection requirements for parts **accessible** to **ordinary persons**, **instructed persons**, and **skilled persons** are given in 4.3.

For an **ordinary person** or an **instructed person**, RS3 shall be contained by the **enclosure** of the lamps and lamp system or the **enclosure** of the equipment.

If RS3 is **accessible** to a **skilled person**, then a **personal safeguard** (PPE) shall be required, and an **instructional safeguard** in accordance with 10.4.2 shall be provided.

Unless RS2 is required to be **accessible** for the function of the equipment, visible, infra-red, and ultra-violet radiation **accessible** to an **ordinary person** or an **instructed person** shall not exceed RS1 under **normal operating conditions**, **abnormal operating conditions** and **single fault conditions**. If RS2 is required to be **accessible** for the function of the equipment, the equipment shall be provided with an **instructional safeguard** in accordance with IEC/TR 62471-2.

Enclosure material used as a **safeguard** shall be opaque to the radiation. An opaque **enclosure** that complies with the test of Annex T according to 4.4.4 is taken as a **reinforced safeguard**.

UV radiation emitted through glass having a 90 % UV attenuation up to 400 nm is taken as RS1. Glass with a thickness of 2 mm is considered to have such attenuation.

Materials that comprise a **safeguard** and are exposed to UV radiation from a lamp in the equipment shall be sufficiently resistant to degradation to the extent that the **safeguard** function remains effective for the equipment lifetime. Metal, glass and ceramic materials do not need to be assessed.

Equipment with optical energy sources in excess of the limits specified in IEC 62471 in the wavelength range 200 nm to 3 000 nm impinging on the human body shall be provided with the **safeguards** specified in this subclause.

In general, optical radiation from the equipment shall either:

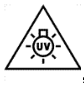
– be contained by the **enclosure** of the lamps and lamp system or the **enclosure** of the equipment; or

– not exceed the relevant limits for the exempt group given in IEC 62471 for **normal operating conditions**.

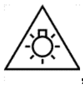
10.4.2 Instructional safeguard

Where required, an **instructional safeguard** shall be in accordance with Clause F.5.

The elements of the **instructional safeguard** shall be as follows:

– element 1a: the UV radiation symbol 

, IEC 60417-6040 (2010-08), or

the visible radiation symbol , IEC 60417-6041 (2010-08), or

the infrared radiation symbol 

, IEC 60417-6151 (2012-02)

– element 2: “UV light”, “Bright light” or “Infrared light” as applicable, or equivalent text
– element 3: “Possible skin or eye damage” or equivalent text
– element 4: “Disconnect power before servicing” or equivalent text

Alternatively, the cautionary statement for Risk Groups RG-1 and RG-2 specified in IEC/TR 62471-2 may be used as an **instructional safeguard**.

If the **safeguard** is a **safety interlock**, then an **instructional safeguard** is not required.

10.4.3 Compliance criteria

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.

Compliance against material degradation from UV radiation is checked by the relevant tests in Annex C.

10.5 Safeguards against x-radiation

10.5.1 Requirements

Equipment x-radiation that exits the equipment shall not exceed RS1 under **normal operating conditions**, **abnormal operating conditions**, and **single fault conditions**.

An **equipment safeguard** is required between RS2 or RS3 and all persons.

Doors and covers acting as a **safeguard** that, when open, would allow access to RS2 or RS3 for a **skilled person** shall be provided with an **instructional safeguard** in accordance with Clause F.5.

10.5.2 Compliance criteria

Compliance is checked by inspection and, where necessary, by the test of 10.5.3.

10.5.3 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 mm^2 or by measuring equipment of other types giving equivalent results.

*Measurements are made with the EUT 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/m^2 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.

10.6 Safeguards against acoustic energy sources

10.6.1 General

Safeguard requirements for protection against long-term exposure to excessive sound pressure levels from personal music players closely coupled to the ear are specified below. Requirements for earphones and headphones intended for use with personal music players are also covered.

A personal music player is a portable equipment intended for use by an **ordinary person**, that:

– is designed to allow the user to listen to audio or audiovisual content / material; and
– uses a listening device, such as headphones or earphones that can be worn in or on or around the ears; and
– has a player that can be body worn (of a size suitable to be carried in a clothing pocket) and is intended for the user to walk around with while in continuous use (for example, on a street, in a subway, at an airport, etc.).

NOTE 1 Examples are portable CD players, MP3 audio players, mobile phones with MP3 type features, PDAs or similar equipment.

Personal music players shall comply with the requirements below.

NOTE 2 Protection against acoustic energy sources from telecom applications is referenced to ITU-T P.360.

These requirements are valid for music or video mode only.

The requirements do not apply to:

– professional equipment;

  NOTE 3 Professional equipment is equipment sold through special sales channels. All products sold through normal electronics stores are considered not to be professional equipment.

– hearing aid equipment and other devices for assistive listening;
– the following type of analogue personal music players:
  - long distance radio receiver (for example, a multiband radio receiver or world band radio receiver, an AM radio receiver), and
  - cassette player/recorder;

  NOTE 4 This exemption has been allowed because this technology is falling out of use and it is expected that within a few years it will no longer exist. This exemption will not be extended to other technologies.

– a player while connected to an external amplifier that does not allow the user to walk around while in use.

10.6.2 Classification

10.6.2.1 RS1 limits

RS1 is a class 1 acoustic energy source that does not exceed the following:

– for equipment provided as a package (player with its listening device), the L_{Aeq},T acoustic output shall be ≤ 85 dB(A) when playing the fixed "programme simulation noise" described in EN 50332-1.

– for equipment provided with an electrical output socket for a listening device, the unweighted r.m.s. output voltage shall be ≤ 27 mV or 25 dB below full scale when playing the fixed "programme simulation noise" described in EN 50332-1.

NOTE 1 Unless otherwise specified, wherever the term acoustic output is used in 10.6, L_{Aeq},T is the A-weighted equivalent sound pressure level over a 30 s period.

For music where the average sound pressure (long term L_{Aeq},T) measured over the duration of the song is lower than the average produced by the programme simulation noise, the warning does not need to be given as long as the average sound pressure of the song does not exceed the basic limit of 85 dB(A). In this case, T becomes the duration of the song.

NOTE 2 Classical music typically has an average sound pressure (long term L_{Aeq},T) which is much lower than the average programme simulation noise. Therefore, if the player is capable to analyse the song and compare it with the programme simulation noise, the warning does not need to be given as long as the average sound pressure of the song does not exceed the basic limit of 85 dB(A).

For example, if the player is set with the programme simulation noise to 85 dB(A), but the average music level of the song is only 65 dB(A), there is no need to give a warning or ask an acknowledgement as long as the average sound level of the song is not above the basic limit of 85 dB(A).

For equipment that is clearly designed or intended for use by children, the limits of the relevant toy standards may apply.

NOTE 3 In Europe, the relevant requirements are given in EN 71-1:2011, 4.20 and the related tests methods and measurement distances apply.

10.6.2.2 RS2 limits

RS2 is a class 2 acoustic energy source that does not exceed the following:

– for equipment provided as a package (player with its listening device), the L_{Aeq},T acoustic output shall be ≤ 100 dB(A) when playing the fixed "programme simulation noise" as described in EN 50332-1.

– for equipment provided with an electrical output socket for a listening device, the unweighted r.m.s. output voltage shall be ≤ 150 mV or 10 dB below full scale when playing the fixed "programme simulation noise" as described in EN 50332-1.

10.6.2.3 RS3 limits

RS3 is a class 3 acoustic energy source that exceeds RS2 limits.

10.6.3 Measurement methods

All volume controls shall be turned to maximum during tests.

Measurements shall be made in accordance with EN 50332-1 or EN 50332-2 as applicable.

10.6.4 Protection of persons

Except as given below, protection requirements for parts **accessible** to **ordinary persons**, **instructed persons** and **skilled persons** are given in 4.3.

NOTE 1 Volume control is not considered a **safeguard.**

Between RS2 and an **ordinary person**, the **basic safeguard** may be replaced by an **instructional safeguard** in accordance with Clause F.5, except that the **instructional safeguard** shall be placed on the equipment, or on the packaging, or in the instruction manual. Alternatively, the **instructional safeguard** may be given through the equipment display during use.

The elements of the **instructional safeguard** shall be as follows:

– element 1a: the symbol , IEC 60417-6044 (2011-01)
– element 2: "High sound pressure" or equivalent wording
– element 3: "Hearing damage risk" or equivalent wording
– element 4: "Do not listen at high volume levels for long periods." or equivalent wording

An **equipment safeguard** shall prevent exposure of an **ordinary person** to RS2 power source without intentional physical action from the **ordinary person** and shall automatically return to an output level not exceeding RS1 when the power is switched off.

The equipment shall provide a means to actively inform the user of the increased sound pressure when the equipment is operated with an acoustic output exceeding RS1. Any means used shall be acknowledged by the user before activating a mode of operation which allows for an acoustic output exceeding RS1. The acknowledgement does not need to be repeated more than once every 20 h of cumulative listening time.

NOTE 2 Examples of means include visual or audible signals. Action from the user is always needed.

NOTE 3 The 20 h listening time is the accumulative listening time, independent of how often and how long the personal music player has been switched off.

A **skilled person** shall not be unintentionally exposed to RS3.

10.6.5 Requirements for listening devices (headphones, earphones, etc.)

10.6.5.1 Corded passive listening devices with analogue input

With 94 dB(A) L_{Aeq} acoustic pressure output, the input voltage of the fixed "programme simulation noise" as described in EN 50332-1 shall be ≥ 75 mV.

This requirement is applicable in any music play mode where the headphones can operate, including any available setting (for example, a built-in volume level control, an additional sound feature like equalization, etc.).

NOTE The values of 94 dB(A) and 75 mV correspond with 85 dB(A) and 27 mV or 100 dB(A) and 150 mV.

10.6.5.2 Corded listening devices with digital input

With any playing device playing the fixed "programme simulation noise" described in EN 50332-1, the $L_{\mathrm{Aeq},T}$ acoustic output of the listening device shall be ≤ 100 dB(A).

This requirement is applicable in any music play mode where the headphones can operate, including any available setting (for example, a built-in volume level control, an additional sound feature like equalization, etc.).

10.6.5.3 Cordless listening devices

In cordless mode,

– with any playing and transmitting device playing the fixed programme simulation noise described in EN 50332-1; and

– respecting the cordless transmission standards, where an air interface standard exists that specifies the equivalent acoustic level; and

– with volume and sound settings in the receiving device (for example, built-in volume level control, additional sound feature like equalization, etc.) set to the combination of positions that maximize the measured acoustic output for the above mentioned programme simulation noise,

the $L_{\mathrm{Aeq},T}$ acoustic output of the listening device shall be ≤ 100 dB(A).

10.6.5.4 Measurement method

Measurements shall be made in accordance with EN 50332-2 as applicable.

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.

B.1.5 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.1.6 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 °C when the equipment is operating. However, the manufacturer may specify a different maximum ambient air temperature.

Measurements are made with the EUT operating at the most unfavourable supply voltage (see B.2.3).

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, steady state is considered to exist if the temperature rise does not exceed 3 K in 30 min. If the measured temperature is at least 10 % less than the specified temperature limit, steady state is considered to exist if the temperature rise does not exceed 1 K in 5 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 ± 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**; and

– tolerance on **rated voltage** as declared by the manufacturer.

Unless the manufacturer declares a wider tolerance, the minimum tolerance shall be taken as +10 % and −10 % for a.c. **mains** and +20 % and −15 % for d.c. **mains**. Equipment intended by the manufacturer to be restricted to connection to a conditioned power supply system (for example, a UPS) may be provided with a narrower tolerance if the equipment is also provided with instructions specifying such restriction.

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 14, ID numbers 1 and 2.

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 EUT;

– loads due to other units of equipment intended by the manufacturer to draw power from the EUT;

– loads that could be connected to any standard supply 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 Clause E.1;

– 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.

The measured input current or input power under **normal operating conditions**, but at the **rated voltage** or at each end of each **rated voltage range**, shall not exceed the **rated current** or **rated power** by more than 10 %.

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****;*

– *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***

- *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****,*
- *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****.*

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 can be useful to conduct several tests at different values of T_{amb}.

NOTE 2 The least favourable value of T_{amb} can 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 ($T_{max} + T_{amb} - T_{ma}$).

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

B.2.7 Battery charging and discharging under normal operating conditions

Under **normal operating conditions**, **battery** charging and discharging conditions 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/m^2 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.

Except as specified below, there are no requirements for blocking openings in the bottom of the equipment.

In addition, equipment with ventilation openings likely to be used on a soft support (like bedding, blankets etc.), shall comply with one of the following:

– Openings in the bottom, sides and back of the equipment are to be covered simultaneously. External surfaces shall not exceed the TS2 limits in Table 38.

– An **instructional safeguard** shall be provided in accordance with Clause F.5, except that element 3 is optional.

The elements of the **instructional safeguard** shall be as follows:

- element 1a: not available
- element 2: "Do not cover ventilation openings" or equivalent wording
- element 3: optional
- element 4: "This equipment is not intended to be used on soft support (like beddings, blankets etc.)." or equivalent wording

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 criteria 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 consequential fault, the compliance criteria of B.4.8 apply.*

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 construction, circuit diagrams, component specifications, including **functional insulation** are examined to determine those **single fault conditions** that might reasonably be expected and that:

– might bypass a **safeguard**, or

– cause the operation of a **supplementary safeguard**, or

– otherwise affect the safety of the equipment.

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 integrated circuit current limiters complying with Clause G.9, a component failure simulated by short-circuiting any two leads and open-circuiting any one lead of the component one at a time;

– when required by B.4.4, a failure of **functional insulation**.

B.4.2 Temperature controlling device

Except for temperature controlling **safeguards**, according G.3.1 to G.3.4, 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.1.6.

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 criteria

Compliance is checked by inspection and examination of the available data or by testing according to G.5.4.

B.4.4 Functional insulation

B.4.4.1 Clearances for functional insulation

Unless the **clearance** for **functional insulation** complies with:

– the **clearance** for **basic insulation** as specified in 5.4.2; or

– the electric strength test of Table 26 for **basic insulation**;

a **clearance** for **functional insulation** shall be short-circuited.

B.4.4.2 Creepage distances for functional insulation

Unless the **creepage distance** for **functional insulation** complies with:

– the **creepage distance** for **basic insulation** as specified in 5.4.3; or

– the electric strength test of 5.4.9.1 for **basic insulation**;

a **creepage distance** for **functional insulation** shall be short-circuited.

B.4.4.3 Functional insulation on coated printed boards

Unless the **functional insulation** complies with:

– the separation distance of Table G.13; or

– the electric strength test of 5.4.9.1 for **basic insulation**;

a **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 60730-1:2010, Clauses 15, 17, J.15 and J.17;

– a PTC providing IEC 60730-1 Type 2.AL action;

– resistors complying with the tests of 5.5.6;

– capacitors complying with IEC 60384-14 and assessed according to 5.5.2 of this standard;

– isolating components (for example, optocouplers and transformers) complying with the relevant component requirements in Annex G for **reinforced insulation**; and

– other components that serve as a **safeguard** complying with the relevant requirements of Annex G or with the safety requirements of the relevant IEC component standard.

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 criteria during and after single fault conditions

*During and after a **single fault condition**, an **accessible** part shall not exceed the relevant energy class as specified in 5.3, 8.3, 9.3, 10.3, 10.4.1, 10.5.1 and 10.6.4 for the related person depending on the hazard involved. During and after **single fault conditions**, any flame inside the equipment shall extinguish within 10 s and no surrounding parts shall have ignited. Any part showing flames shall be regarded as a **PIS.***

B.4.9 Battery charging and discharging under single fault conditions

Under **single fault conditions**, **battery** charging and discharging conditions 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 usually act as a **safeguard** and can 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	ISO 179-1	70 %
	Izod impact [c] or	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 and compliance criteria

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 °C ± 3 °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 W/m^2 at 340 nm, a black-panel temperature of 63 °C ± 3 °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. Do not confuse water spray 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 4892-4 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. Do not confuse water spray 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 impulse 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 impulse is typical of earth potential rises due to either lightning strikes to power lines or power line faults;

– the circuit 3 impulse is typical of voltages induced into antenna system wiring due to nearby lightning strikes to earth.

NOTE During the tests, use extreme care 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 14, ID numbers 1, 2, 3, 4 and 5.

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 15) 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.*

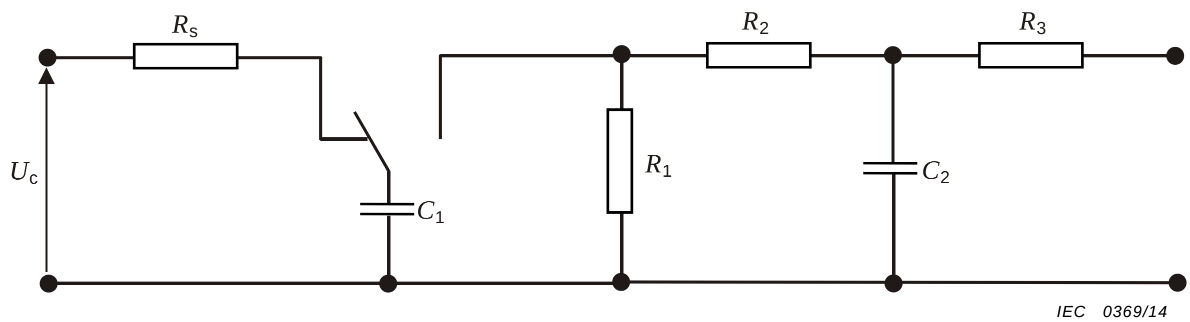


Figure D.1 – 1,2/50 µs and 10/700 µs voltage impulse generator

D.2 Antenna interface test generator

The circuit in Figure D.2 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.

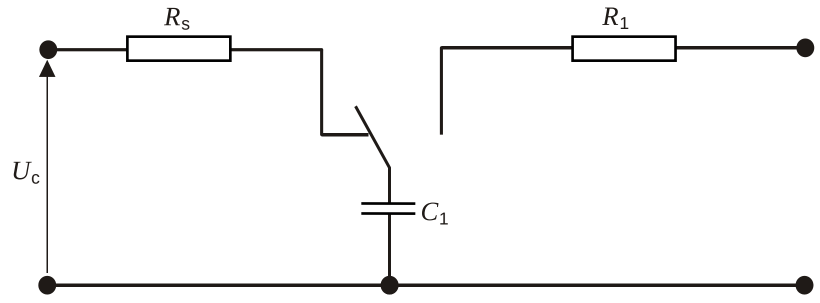
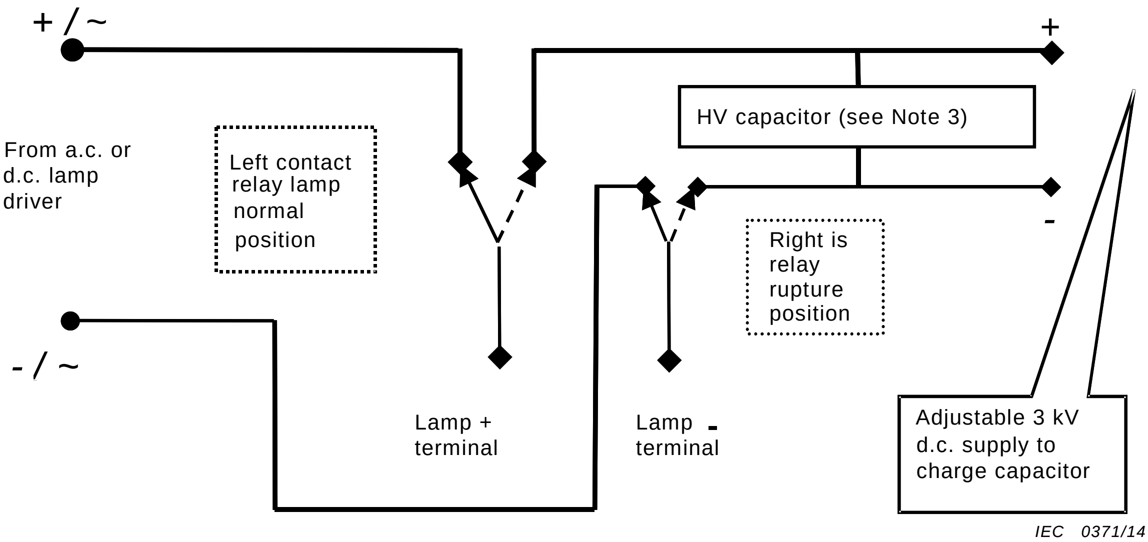


Figure D.2 – Antenna interface test generator circuit

Table D.1 – Component values for Figure D.1 and Figure D.2

	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 MΩ	1 nF	-	1 kΩ	-	-
Alternative test generators may be used provided they give the same result. 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 can typically be used as the 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 μF 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

Equipment containing an audio amplifier shall be operated using a sine wave audio signal source at a frequency of 1 000 Hz. In the case where an amplifier is not intended for operation at 1 000 Hz, the **peak response frequency** shall be used.

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 pink noise test signal shall be limited by a filter of a characteristic as shown in Figure E.1.

If visible clipping cannot be established, the maximum attainable power shall be considered as the **non-clipped output power**.

When classifying audio signals (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.

Tone controls are to be set at mid-range.

In addition, all of the following conditions shall be considered under **normal operating conditions**:

– The most unfavourable **rated load impedance** or the actual loudspeaker, when provided, is connected to the amplifier output.
– All amplifier channels are operated simultaneously.
– Organs or similar instruments that have a tone-generator unit shall not be operated with the 1 000 Hz signal, but instead 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.
– 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 equipment containing multi-channel amplifiers, where some channels cannot be operated independently, those channels shall be operated using the **rated load impedance** at the output power level that corresponds, by design, to 1/8 of the **non-clipped output power** of the adjustable amplifier channel(s).
– Where continuous operation is not possible, the amplifier shall be operated at the maximum output power level that allows continuous operation.

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

Class	Audio signal voltage V r.m.s.	Examples of safeguards between energy source and ordinary person	Example of safeguards between energy source and instructed person
ES1	0 up to 71	No **safeguard** necessary	No **safeguard** necessary
ES2	Above 71 and up to 120	Insulated terminals [a] marked with ISO 7000, symbol  0434a (2004-01) or symbol  0434b (2004-01)	No **safeguard** necessary
		Instructional safeguard for uninsulated parts of terminals and bare wiring [b]	
ES3	Above 120	Connectors conforming to the requirements of IEC 61984 and marked with the symbol of IEC 60417-6042 (2010-11) 	

[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.

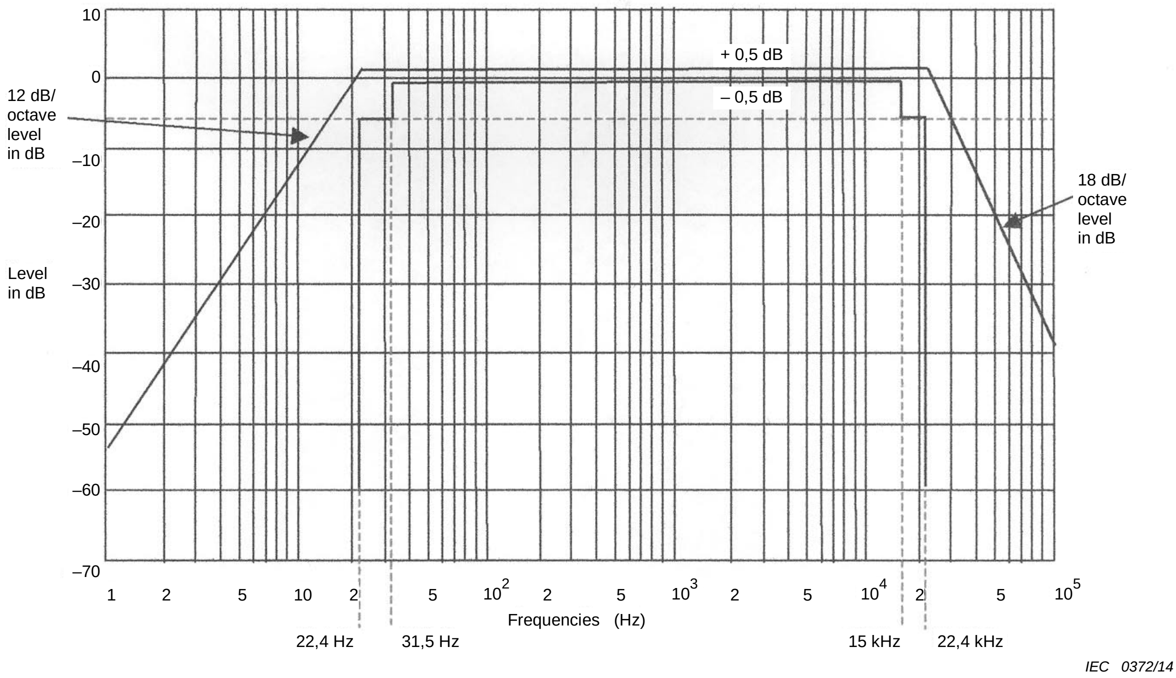


Figure E.1 – Band-pass filter for wide-band noise measurement

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** shall 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 this standard, it also applies to instructions and required elements of an **instructional safeguard**.

NOTE 2 See Table F.1 for examples of markings.

Care shall be taken so that additional markings and instructions not required by this standard do not contradict the markings and instructions required by this standard.

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 placed on the equipment, whether required by this standard or not, shall be in accordance with IEC 60417, ISO 3864-2, ISO 7000 or ISO 7010, if available. In the absence of suitable symbols, the manufacturer may design specific graphical symbols.

F.2.3 Compliance criteria

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 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 example:

– 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.

Compliance is checked by inspection.

F.3.2.2 Model identification

The model number, model name, or equivalent shall be identified by means of a marking on the equipment.

Compliance is checked by inspection.

F.3.3 Equipment rating markings

F.3.3.1 Equipment with direct connection to mains

If a unit is provided with a means for direct connection to the **mains**, it shall be marked with an electrical rating, as specified in F.3.3.3 to F.3.3.6.

F.3.3.2 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. However, any **rated power** or **rated current** marking on the equipment shall comply with B.2.5.

F.3.3.3 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 ∼ , IEC 60417-5032 (2002-10), shall be used for a.c. and the symbol ⎓, IEC 60417-5031 (2002-10), 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.3.3.4 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.3.3.5 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.3.3.6 Rated current or rated power

The **rated current** or **rated power** of the equipment 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 B.2.5 establishes criteria for the way in which **rated current** or **rated power** are measured.

NOTE 2 The **rated current** or **rated power** need not be stated to more than one significant digit.

NOTE 3 In some countries, for markings on equipment, a period 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.3.3.7 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.3.3.8 Compliance criteria

Compliance is checked by inspection.

F.3.4 Voltage setting device

If the equipment uses 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 uses 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 shall also be changed.

Compliance is checked by inspection.

F.3.5 Markings on 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 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 the fuse current rating and the following as appropriate:

- 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** shall 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 Terminal marking location

The terminal markings specified in F.3.6.1 and F.3.6.2.2 shall not be placed on screws, removable washers, or other parts that can be removed when conductors are being connected.

F.3.5.6 Compliance criteria

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 (2006-08).

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 (2006-08), or with symbol ⏚, IEC 60417-5017 (2006-08).

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.

If such terminals are identified, they shall be marked with the earth symbol , IEC 60417-5017 (2006-08). However, a component terminal or a terminal for bonding wiring from the appliance inlet already marked with the symbol , IEC 60417-5019 (2006-08), is acceptable as identification of a **protective bonding conductor** terminal.

F.3.6.2 Class II equipment

F.3.6.2.1 Equipment class marking

Class II equipment without **functional earth** connection shall bear the symbol , IEC 60417-5172 (2003-02).

Class II equipment with **functional earth** connection shall bear the symbol , IEC 60417-6092 (2011-10).

The above symbols shall not be used for **class I equipment**.

Equipment providing protective earthing to other equipment cannot be regarded as **class II equipment**.

For **class II equipment** provided with a **mains** cord having a conductor with green-and-yellow insulation that is used only to provide a connection to **functional earth**, there are no requirements other than those in 4.6 regarding the termination of this conductor at the equipment end.

F.3.6.2.2 Functional earth terminal marking

Wiring terminals to be used only for the connection of **functional earth** shall be marked with the symbol , IEC 60417-5020 (2002-10). These terminals shall not be marked with the symbol , IEC 60417-5017 (2006-08) or with the symbol , IEC 60417-5019 (2006-08).

However, these symbols may be used for a wiring terminal provided on a component (for example, a terminal block) or subassembly.

F.3.6.3 Compliance criteria

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.

Compliance is checked by inspection.

F.3.8 External power supply output marking

The d.c. output of an external power supply shall be marked with the voltage rating, the current rating and the polarity.

The a.c. output of an external power supply shall be marked with the voltage rating, the current rating and the frequency if it is different from the input frequency.

Compliance is checked by inspection and measurement.

F.3.9 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 shall 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.

Printed or screened markings shall also be permanent.

Compliance is checked by inspection. Permanency is determined by the tests of F.3.10.

F.3.10 Test for the permanence of markings

F.3.10.1 General

Each required printed or screened marking shall be tested. However, if the data sheet for a label confirms compliance with the test requirements, the test need not be performed.

F.3.10.2 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.3.10.3.

F.3.10.3 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 is further identified as a certified ACS (American Chemical Society) reagent grade hexane (CAS# 110-54-3).

F.3.10.4 Compliance criteria

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.

– Instructions to ensure correct and safe installation and interconnection of the equipment.
– For equipment intended only for use in a **restricted access area**, the instructions shall so state.
– If the equipment is intended to be fastened in place, the instructions shall explain how to securely fasten the equipment.
– 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 used 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).
– For equipment with **protective conductor current** on the **protective earthing conductor** exceeding the ES2 limits of 5.2.2.2, the equipment shall bear an **instructional safeguard** in accordance with 5.7.5.
– Graphical symbols placed on the equipment and used as an **instructional safeguard** shall be explained.
– 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.
– 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 element 2, or both, together with element 3 and element 4. If a suitable symbol for element 1a is not available, then element 1b may be used instead.

Unless otherwise specified in this standard, the location of the **instructional safeguard** shall be as follows:

– 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 only element 2 is used, the text shall be preceded by the word “Warning” or “Caution” or similar wording.

Any **instructional safeguard** element placed on the equipment shall be visible to the person prior to potential exposure to the class 2 energy source or class 3 energy source parts and as close as reasonably possible to the energy source parts.

Elements 1a, 1b, 2, 3, and 4 are specified in Table F.1.

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 such as ISO 7000-0434 (2004-01) or a combination of this symbol and ISO 7000-1641 (2004-01) 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 symbols for elements 1a and 1b shall be from IEC 60417, ISO 3864-2, ISO 7000, ISO 7010 or the equivalent.		

Hot parts!

Burned fingers when handling the parts

Wait one-half hour after switching off before handling parts

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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.

Hot parts!

Burned fingers when handling the parts

Wait one-half hour after switching off before handling parts

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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 (2002-10)	
AC, IEC 60417-5032 (2002-10)	~
DC, IEC 60417-5031 (2002-10)	⎓
Class II equipment, IEC 60417-5172 (2003-02)	
Caution, ISO 7000, 0434a or 0434b (2004-01)	
Dangerous voltage, IEC 60417-5036 (2002-10)	
Earth; ground, IEC 60417-5017 (2006-08)	
Protective earth; protective ground, IEC 60417-5019 (2006-08)	

Annex G
(normative)

Components

G.1 Switches

G.1.1 General

Requirements for switches that are located in PS3 are specified below.

A switch may be tested separately or in the equipment.

G.1.2 Requirements

Switches used as **disconnect devices** shall comply with the requirements in Annex L.

A switch shall not be fitted in a **mains** supply cord.

A switch shall comply with all of the following:

– comply with the requirements of IEC 61058-1:2008, whereby the following applies:
  - 10 000 operating cycles (see 7.1.4.4 of IEC 61058-1:2008);
  - the switch shall be suitable for use in the **pollution degree** environment in which it is used, typically a **pollution degree** 2 environment (see 7.1.6.2 of IEC 61058-1:2008);
  - the switch have a glow wire temperature of 850 °C (see 7.1.9.3 of IEC 61058-1:2008);
  - for **mains** switches used in CRT televisions, the speed of contact making and breaking shall be independent of the speed of actuation;

    NOTE This is because there is a high inrush current due to the degausing coil.
  - 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 61058-1:2008);
    – the classification of the switch according to:
      - nature of supply (see 7.1.1 of IEC 61058-1:2008);
      - type of load to be controlled by the switch (see 7.1.2 of IEC 61058-1:2008);
      - ambient air temperature (see 7.1.3 of IEC 61058-1:2008);

  Compliance is checked according to IEC 61058-1:2008.

– the switch shall be so constructed that it does not attain excessive temperatures under **normal operating conditions**;

  Compliance is checked in the on-position according to 16.2.2 d), l) and m) of IEC 61058-1:2008, except the current is the sum of the equipment current and the maximum current supplied to other equipment, if any.

– a **mains** switch controlling connectors supplying power to other equipment shall withstand the electrical endurance test according to 17.2 of IEC 61058-1:2008, with an additional load according to Figure 9 of IEC 61058-1:2008. The total current rating of the additional load shall correspond to the marking of the connectors supplying power to other equipment. The peak surge current of the additional load shall have a value as shown in Table G.1.

Table G.1 – Peak surge current

Current rating A	Peak surge current A
up to and including 0,5	20
up to and including 1,0	50
up to and including 2,5	100
over 2,5	150

G.1.3 Test method and compliance criteria

The tests of IEC 61058-1:2008 shall be applied with the modifications shown in G.1.2.

After the tests, the switch shall show no deterioration of its ***enclosure*** *and no loosening of electrical connections or mechanical fixings.*

G.2 Relays

G.2.1 Requirements

The requirements for relays that are located in a PS3 circuit are specified below.

A relay may be tested separately or in the equipment.

For resistance to heat and fire, see Clause 16 in IEC 61810-1:2008.

A relay shall comply with the requirements of IEC 61810-1:2008, taking into account the following:

– materials shall comply with 6.4.5.2 or pass a glow wire test at 750 °C or a needle flame test;

– 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);

  • release voltage (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 voltage shall be the required test voltage specified in 5.4.9.1 of this standard;

– if the **required withstand voltage** (referred to as impulse withstand voltage in IEC 61810-1) exceeds 12 kV, **clearances** shall comply with Table 15 of this standard;

– if the **r.m.s. working voltage** (referred to as voltage r.m.s. in IEC 61810-1) exceeds 500 V, **creepage distances** shall comply with Table 18 of this standard;

– **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.2.2 Overload test

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.2.3 Relay controlling connectors supplying power to other equipment

*A **mains** relay controlling connectors supplying power to other equipment shall withstand the endurance test of Clause 11 of IEC 61810-1:2008, with an additional load that is equal to the total marked load of the connectors supplying power to other equipment.*

G.2.4 Test method and compliance criteria

*For **mains** relays, the tests of IEC 61810-1 and this standard shall be applied with the modifications shown in Clause G.2 of this standard.*

*After the tests, the relay shall show no deterioration of its **enclosure**, no reduction of **clearances** and **creepage distances** and no loosening of electrical connections or mechanical fixings.*

G.3 Protective devices

G.3.1 Thermal cut-offs

G.3.1.1 Requirements

A **thermal cut-off** used as a **safeguard** shall comply with requirements a) and b), or c).

NOTE In IEC 60730-1, a “thermal cut-off” is a “thermal cut-out”.

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 60730-1:2010);
   - the **thermal cut-off** shall have at least micro-disconnection, Type 2B (see 6.4.3.2 and 6.9.2 of IEC 60730-1:2010);
   - 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 60730-1:2010);
   - 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 60730-1:2010),
     - 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 60730-1:2010),

- 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 60730-1:2010);

– 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 60730-1:2010);

– 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 60730-1:2010);

– 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 60730-1:2010.

b) The characteristics of the **thermal cut-off** with regard to

– the ratings of the **thermal cut-off** (see Clause 5 of IEC 60730-1:2010);

– the classification of the **thermal cut-off** according to the:

- nature of supply (see 6.1 of IEC 60730-1:2010),
- type of load to be controlled (see 6.2 of IEC 60730-1:2010),
- degree of protection provided by **enclosures** against ingress of solid objects and dust (see 6.5.1 of IEC 60730-1:2010),
- degree of protection provided by **enclosures** against harmful ingress of water (see 6.5.2 of IEC 60730-1:2010),
- pollution situation for which the **thermal cut-off** is suitable (see 6.5.3 of IEC 60730-1:2010),
- maximum ambient temperature limit (see 6.7 of IEC 60730-1:2010);

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 60730-1:2010; 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 at the maximum ambient temperature specified by the manufacturer, whichever is higher; 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.3.1.2 Test method and compliance criteria

*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.*

*During the test, no sustained arcing shall occur. After the test, the **thermal cut-off** shall show no loosening of electrical connections or mechanical fixings.*

G.3.2 Thermal links

G.3.2.1 Requirements

A thermal link used as a **safeguard** 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 5.4.9.1 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 at the maximum ambient temperature specified by the manufacturer, whichever is higher; and
   - subjected to such **single fault conditions** of the equipment that cause the thermal link to operate. During the test, no sustained arcing 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.3.2.2 Test method and compliance criteria

If a thermal link is tested as a separate component according to G.3.2.1 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.3.2.1 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.

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.3.3 PTC thermistors

PTC thermistors used as **safeguards** shall comply with Clauses 15, 17, J.15 and J.17 of IEC 60730-1:2010.

For PTC thermistors:

- whose continuous power dissipation that appears at its maximum voltage at an ambient temperature of 25 °C or otherwise specified by the manufacturer for tripped state, determined as given in 3.38 of IEC 60738-1:2009, exceeds 15 W; and
- with a size of 1 750 mm^3 or more; and
- located in a PS2 or PS3 circuit;

the encapsulation or tubing shall be made of **V-1 class material** or equivalent material.

NOTE Tripped state means the state in which PTC thermistors are shifted to a high resistance condition at a given temperature.

Compliance is checked by inspection.

G.3.4 Overcurrent protective devices

Except for devices covered by G.3.5, overcurrent protective devices used as a **safeguard** shall comply with their applicable IEC standards.

Compliance is checked by inspection.

G.3.5 Safeguard components not mentioned in G.3.1 to G.3.4

G.3.5.1 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.3.5.2 Test method and compliance criteria

*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.4 Connectors

G.4.1 Clearance and creepage distance requirements

The **clearance** and **creepage distance** between the outer insulating surface 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** and **creepage distance** between the outer insulating surface 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** and **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.

The tests of 5.3.2 apply to such connectors after removal of the subassembly.

G.4.2 Mains connectors

Mains connectors that are listed in IEC/TR 60083 or that comply with one of the following standards IEC 60309 series, IEC 60320 series, IEC 60906-1 or IEC 60906-2, are considered acceptable without further evaluation.

G.4.3 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.

EXAMPLE Connectors meeting this requirement are those constructed as described in IEC 60130-2, IEC 60130-9, IEC 60169-3 or IEC 60906-3. An example of a connector not meeting the requirements of this subclause is the so-called "banana" plug. Standard 3,5 mm audio plugs are not considered likely to be put in the **mains** socket outlet.

Compliance is checked by inspection.

G.5 Wound components

G.5.1 Wire insulation in wound components

G.5.1.1 General

This clause applies to wound components comprising **basic insulation**, **supplementary insulation** or **reinforced insulation**.

G.5.1.2 Protection against mechanical stress

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.5.2.

Additionally, if the above construction provides **basic insulation**, **supplementary insulation** or **reinforced insulation**, the finished wound component shall pass a **routine test** for electric strength in accordance with 5.4.9.1.

G.5.1.3 Test method and compliance criteria

Compliance is checked by 5.4.4.1 and, where required, by G.5.2. If the tests of Annex J are required, they are not repeated if the material data sheets confirm compliance.

G.5.2 Endurance test

G.5.2.1 General test requirements

Where required by G.5.1.2, three samples of the wound component are subjected to 10 test cycles as follows:

– *The samples are subjected to the heat run test of G.5.2.2. After the test, the samples are allowed to cool down to ambient temperature.*

– *The samples are then subjected to the vibration test of G.15.3.4.*

– *The samples are then subjected for two days to the humidity conditioning of 5.4.8.*

The tests described below are made before the start of the 10 cycles and after each cycle.

The electric strength test of 5.4.9.1 is carried out.

After the electric strength test, the test of G.5.2.3 is made on wound components that are supplied from the ***mains****, except for switching mode power supply.*

G.5.2.2 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.2. The 10 cycles are carried out with the same combination.

The temperature in the heating cabinet shall be maintained within a tolerance of ± 5 °C.

Table G.2 – 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.5.2**							
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 EIS 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.5.2.3 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.5.2.4 Compliance criteria

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.5.3 Transformers

G.5.3.1 General

Transformers shall comply with one of the following:

– meet the requirements given in G.5.3.2 and G.5.3.3;

– IEC 61204-7 for a transformer used in a low-voltage power supply;

– 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 using the test voltage specified in 5.4.9.1;
  - the overload test according to G.5.3.3;

– IEC 61558-2-16 for transformers used in a switch mode power supply.

NOTE 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.

G.5.3.2 Insulation

G.5.3.2.1 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 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.5.3.2.2 Compliance criteria

Compliance is checked by inspection, measurement and where applicable by test.

G.5.3.3 Transformer overload tests

G.5.3.3.1 Test conditions

If the tests are carried out under simulated conditions on the bench, these conditions shall include any protective 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.5.3.3.2 Compliance criteria

Maximum temperatures of windings shall not exceed the values in Table G.3 when measured as specified in B.1.6, 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 protective device showing the trip time versus the current characteristics;*
– *with an automatic reset **thermal cut-off**: as shown in Table G.3 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.1.6, 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 **mains**, 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.3 – 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 EIS 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.

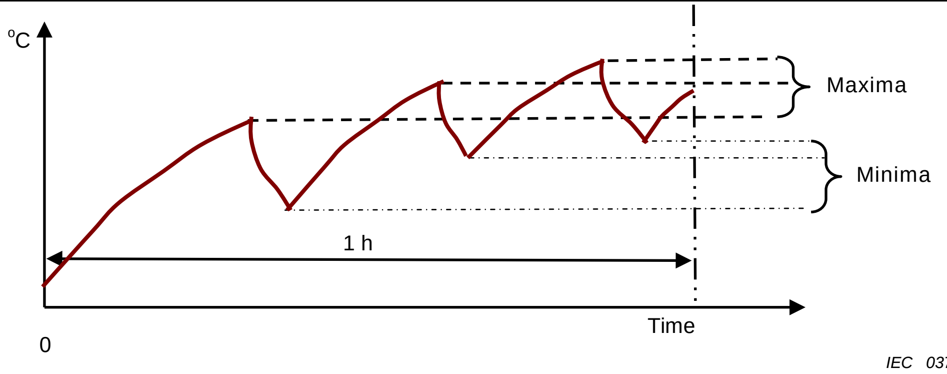


Figure G.1 – Determination of arithmetic average temperature

G.5.3.3.3 Alternative test method

The transformer is covered with a single layer of ***cheesecloth*** *and is placed on a wooden board that is covered with a single layer of* ***wrapping tissue****. The transformer is then gradually loaded until one of the following situations occurs:*

– *the overload protective device operates,*

– *the winding becomes an open circuit,*

– *the load cannot be increased any further without reaching a short-circuit or foldback condition,*

The transformer is then loaded to a point just before the above applicable situation occurs and is operated for 7 h.

During the test the transformer shall not emit flames or molten metal. The ***cheesecloth*** *shall not char or catch fire.*

If the transformer voltage exceeds ES1, the ***basic safeguard*** *or* ***reinforced safeguard*** *provided in the transformer shall withstand the electric strength test in 5.4.9.1 as applicable after it has cooled to room temperature.*

G.5.4 Motors

G.5.4.1 General requirements

DC motors supplied from PS2 or PS3 circuits isolated from the a.c. **mains** shall comply with the tests of G.5.4.5, G.5.4.6 and G.5.4.9. 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.5.4.5.

All other motors supplied from PS2 or PS3 circuits shall comply with the overload tests of G.5.4.3 and G.5.4.4 and, where applicable, G.5.4.7, G.5.4.8 and G.5.4.9.

However, the following motors are exempt from the test of G.5.4.3:

– 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.

G.5.4.2 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 protective 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.1.6. 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 protective 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.5.4.3 Running overload test and compliance criteria

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.5.4.4), until the overload protective device operates.*

Compliance is checked by measuring the motor winding temperatures during each steady period. The measured temperatures shall not exceed the values in Table G.4.

Table G.4 – 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 EIS in accordance with IEC 60085. The assigned letter designations are given in parentheses.							

G.5.4.4 Locked-rotor overload

G.5.4.4.1 Test method

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, provided that the constant temperature is not more than that specified in Table 10 for the insulation system used;*

– *a motor with an automatic reset protective device is cycled on locked-rotor for 18 days;*

– *a motor with a manual reset protective device is cycled on locked-rotor for 60 cycles, the protective 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 protective device is operated until the device operates.*

G.5.4.4.2 Compliance criteria

Compliance is checked by measuring temperatures at regular intervals during the first three days for a motor with inherent or external impedance protection or with an automatic reset protective device, or during the first 10 cycles for a motor with a manual reset protective device, or at the time of operation of a non-resettable protective device. The measured temperatures shall not exceed the values in Table 3.

During the test, protective 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.

After the period specified for temperature measurement, the motor shall withstand the electric strength test of 5.4.9.1 after the insulation has cooled to room temperature and with test voltages reduced to 0,6 times of the specified values.

NOTE Continuation of the test of an automatic reset protective device beyond 72 h, and of a manual reset protective 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.5.4.5 Running overload for d.c. motors

G.5.4.5.1 Requirement

The test of G.5.4.5.2 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.

If difficulty is experienced in obtaining accurate temperature measurements, due to the small size or unconventional design of the motor, the method of G.5.4.5.3 can be used instead.

G.5.4.5.2 Test method and compliance criteria

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. The measured temperatures shall not exceed the values in Table G.4.

Following the test, if the motor voltage exceeds ES1, the ***basic safeguard*** *or* ***reinforced safeguard*** *provided in the motor shall withstand the electric strength test in 5.4.9.1 after it has cooled to room temperature, but with test voltages reduced to 0,6 times the specified values.*

G.5.4.5.3 Alternative method

The motor is covered with a single layer of ***cheesecloth*** *and placed on a wooden board that is covered with a single layer of* ***wrapping tissue****. The motor is then gradually loaded until one of the following situations occur:*

- *the overload protective device operates;*
- *the winding becomes an open circuit;*

– *the load cannot be increased any further without reaching a locked rotor condition.*

The motor is then loaded to a point just before the above applicable situation occurs and is operated for 7 h.

During the test, the motor shall not emit flames or molten metal. The ***cheesecloth*** *shall not char or catch fire.*

Following the test, if the motor voltage exceeds ES1, the ***basic safeguard*** *or* ***reinforced safeguard*** *provided in the motor shall withstand the electric strength test in 5.4.9.1 after it has cooled to room temperature, but with test voltages reduced to 0,6 times the specified values.*

G.5.4.6 Locked-rotor overload for d.c. motors

G.5.4.6.1 Requirement

Motors shall pass the test in G.5.4.6.2.

Where difficulty is experienced in obtaining accurate temperature measurements because of the small size or unconventional design of the motor, the method of G.5.4.6.3 can be used instead.

G.5.4.6.2 Test method and compliance criteria

The motor is operated at the voltage used in its application and with its rotor locked for 7 h or until steady state conditions are established, whichever is longer. However, if the motor winding opens, or the motor otherwise becomes permanently de-energized, the test is discontinued.

Compliance is checked by measuring the motor winding temperatures during the test. The measured temperatures shall not exceed the values in Table G.3.

Following the test, if the motor voltage exceeds ES1, and after it has cooled to room temperature, the motor shall withstand the electric strength test in 5.4.9.1 but with test voltages reduced to 0,6 times the specified values.

G.5.4.6.3 Alternative method

The motor is covered with a single layer of ***cheesecloth*** *and placed on a wooden board that is covered with a single layer of* ***wrapping tissue****.*

The motor is then operated at the voltage used in its application and with its rotor locked for 7 h or until steady state conditions are established, whichever is the longer. However, if the motor winding opens, or the motor otherwise becomes permanently de-energized, the test is discontinued.

During the test, the motor shall not emit flames or molten metal. The ***cheesecloth*** *shall not char or catch fire.*

Following the test, if the motor voltage exceeds ES1, and after it has cooled to room temperature, the motor shall withstand the electric strength test in 5.4.9.1 but with test voltages reduced to 0,6 times the specified values.

G.5.4.7 Test method and compliance criteria 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.

Compliance is checked by measuring the motor winding temperatures during the test. The measured temperatures shall not exceed the values in Table G.3.

G.5.4.8 Test method and compliance criteria 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.

Compliance is checked by measuring the motor winding temperatures during the test. The measured temperatures shall not exceed the values in Table G.3.

G.5.4.9 Test method and compliance critieria 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.6 Wire insulation

G.6.1 General

The following requirements apply to all wires, including wires in wound components (see also Clause G.5), lead-out wires and the like, whose insulation provides **basic insulation**, **supplementary insulation** or **reinforced insulation**.

NOTE 1 For insulation provided in addition to insulation on winding wire, see 5.4.4.

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 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 This exception 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 J.3.2.

G.6.2 Solvent-based enamel winding insulation

Solvent-based enamel is not considered to provide **supplementary insulation** or **reinforced insulation**, under any circumstances.

Solvent-based enamel is considered **basic insulation** where all the following conditions are met:

– the insulation provides **basic insulation** in a wound component between an **external circuit** and an 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 26 and Table 27;

– the finished component is subjected to a **type test** for electric strength (between windings and between windings and the core, see G.5.3.2.1), in accordance with 5.4.9.1;

– the finished component is subjected to **routine tests** for electric strength (between windings and between windings and the core, see G.5.3.2.1), in accordance with 5.4.9.2.

Except as given in 4.3.2.3, the core of the above wound component shall not be **accessible** to an **ordinary person**.

G.7 Mains supply cords

G.7.1 General

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),

  NOTE 1 There is no limit on the mass of the equipment if the equipment is intended for use with a detachable power supply cord.

  • for equipment provided with a detachable power supply cord, be not lighter than light PVC sheathed flexible cord according to IEC 60227-1 (designation 60227 IEC 52),

- for screened cords of **moveable equipment**, the flexing test of 3.1 of IEC 60227-2:2003;

  NOTE 2 Although screened cords are not covered in the scope of IEC 60227-2, the relevant flexing tests of IEC 60227-2 are used.

– other types of cords may be used if they have similar electro-mechanical and fire safety properties as above.

NOTE 3 Where national or regional standards exist, they can be used to show compliance with the above paragraph.

For **pluggable equipment type A** or **pluggable equipment type B** that has protective earthing, a **protective earthing conductor** shall be included in the **mains** supply cord. For all other equipment, if a **mains** cord is supplied without a **protective earthing conductor**, a **protective earthing conductor** cable shall be supplied as well.

Equipment intended to be used by musicians while performing (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).

Compliance is checked by inspection. For screened cords, damage to the screen is acceptable provided that:

– *during the flexing test the screen does not make contact with any conductor; and*

– *after the flexing test, the sample withstands the appropriate electric strength test between the screen and all other conductors.*

G.7.2 Cross sectional area

Mains supply cords shall have conductors with cross-sectional areas not less than those specified in Table G.5 (see also 5.6.3).

Table G.5 – Sizes of conductors

Rated current of the equipment [a] A **up to and including**	**Minimum conductor sizes**	
	Cross-sectional area mm^2	**AWG or Kcmil** [cross-sectional area in mm^2] [e]
3	0,5 [b]	20 [0,5]
6	0,75	18 [0,8]
10	1,00 (0,75) [c]	16 [1,3]
16	1,50 (1,0) [d]	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] [e]
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 footnotes [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 footnotes [b], [c] and [d].

NOTE 2 For higher currents see the IEC 60364 series.

[a] The **rated current** includes currents that can be drawn from a socket outlet providing **mains** power for other equipment.

[b] For **rated current** up to 3 A, a nominal cross-sectional area of 0,5 mm^2 may be used in some countries 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 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.

[e] AWG and kcmil sizes are provided for information only. The associated cross-sectional areas, in square brackets, have been rounded to show significant figures only. AWG refers to the American Wire Gage and the term "cmil" refers to circular mils where 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.

Compliance is checked by inspection.

G.7.3 Cord anchorages and strain relief for non-detachable power supply cords

G.7.3.1 General

Safeguards against strain being transmitted to the equipment terminations of the conductors of cords or interconnecting cables connected to ES2 circuits, ES3 circuits or PS3 circuits are specified below.

G.7.3.2 Cord strain relief

G.7.3.2.1 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 unless the cord anchorage, including the screw, is made of insulating material and the screw is of comparable size to the diameter of the cord being clamped.

When a linear force and a torque are applied to a **non-detachable power supply cord** or cable, a **basic safeguard** shall minimize strain from being transmitted to the cord or cable terminations.

The linear force applied to the cord or cable is specified in Table G.6. The force is applied in the most unfavourable direction for 1 s and repeated 25 times.

Table G.6– 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 specified force and torque, by measurement, and visual inspection. There shall be no damage to the cord or conductors and the displacement of the conductors shall not exceed 2 mm. Stretching of the cord outer jacket without displacement of the conductors is not considered displacement.

G.7.3.2.2 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.6.*

G.7.3.2.3 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.7.3.2.4 Strain relief and cord anchorage material

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

If the **basic safeguard** (strain relief mechanism) is made of polymeric material, the **basic safeguard** shall retain its structural properties following the mould stress relief according to Clause T.8.

Compliance is determined by inspection and by applying the force and torque tests of G.7.3.2.1 after the ***basic safeguard*** *has come to room temperature.*

G.7.4 Cord entry

Safeguards against electric shock and electrically-caused fire from cords or cables connected to ES2 circuits, ES3 circuits or PS3 circuits are specified below.

The entry of a cord or cable into the equipment shall be provided with **safeguards** against electric shock as specified in Clause 5. If the cord jacket passes the electric strength test of 5.4.9.1 for **supplementary insulation**, the cord jacket may be considered a **supplementary safeguard**.

The cord or cable entry shall be provided with a **supplementary safeguard** to:

– prevent abrasion of the cord or cable outer surface; and

– prevent the cord or cable from being pushed into the equipment to such an extent that the cord or its conductors, or both, could be damaged or internal parts of the equipment could be displaced.

Compliance is determined by an electric strength test between the cord or cable conductors and ***accessible*** *conductive parts following the tests of G.7.3.2.1. The test voltage shall be for* ***reinforced insulation*** *in accordance with 5.4.9.1.*

G.7.5 Non-detachable cord bend protection

G.7.5.1 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; and

– be of insulating material; and

– 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.7.5.2 Test method and compliance criteria

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 °C ± 2 °C.

Flat cords are bent in the plane of least resistance.

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

Compliance is checked by inspection, by measurement and, where necessary, by test with the cord as delivered with the equipment.

G.7.6 Supply wiring space

G.7.6.1 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 connected to a **protective conductor**' 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 **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.7.6.2 Stranded wire

G.7.6.2.1 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.7.6.2.2 Test method and compliance criteria

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.8 Varistors

G.8.1 General

A varistor shall comply with:

– the **safeguards** against electric shock of G.8.2; and
– the **safeguards** against fire of G.8.3 if the method “reduce the likelihood of ignition” of 6.4.1 is chosen.

The **safeguards** against fire of G.8.3 are not applicable to a varistor used in a suppression circuit whose clamping voltage (see IEC 61051-1) is above a.c. **mains transient voltage**.

NOTE 1 A varistor is sometimes referred to as an MOV or a VDR.

NOTE 2 Such connections described above make the varistor a **PIS**.

G.8.2 Safeguards against electric shock

A varistor shall comply with IEC 61051-2, whether a **fire enclosure** is provided or not, taking into account all of the following:

– Preferred climatic categories (see 2.1.1 of IEC 61051-2:1991):
  - lower category temperature: – 10 °C
  - upper category temperature: + 85 °C
  - duration of damp heat, steady state test: 21 days.
– Maximum continuous voltage:
  - at least 1,25 times the **rated voltage** of the equipment or
  - at least 1,25 times the upper voltage of the **rated voltage range**.

  NOTE The maximum continuous voltages are not limited to values specified in 2.1.2 of IEC 61051-2:1991, other voltages can be used.
– Combination pulse (Table I group 1 of IEC 61051-2:1991, Amendment 1:2009).

For the test, a combination pulse is selected from subclause 2.3.6 in IEC 61051-2:1991, Amendment 1:2009. The test consists of 10 positive pulses or 10 negative pulses, each having a shape of 1,2/50 μs for voltage and 8/20 μs for current.

For the selection, a.c. **mains** voltage and overvoltage category, see Table 13.

Mains under 300 V is considered to be 300 V.

For overvoltage category IV of Table 13, a combination pulse 6kV/3kA is used except for 600 V, for which a combination pulse of 8 kV/4 kA is used. As an alternative, the combination pulse test of IEC 61051-2:1991, Amendment 1:2009 (2.3.6, Table I group 1 and Annex A), including consideration of the nominal **mains** voltage and overvoltage category, is acceptable.

In addition to the performance requirements of Table I group 1 of IEC 61051-2:1991 and Amendment 1:2009, the varistor voltage at the manufacturer's specified current after the test shall not have changed by more than 10 % when compared to the value before the test.

The body of surge suppression varistor shall comply with the needle flame according to IEC 60695-11-5, with the following test severities:

– Duration of application of the test flame: 10 s
– After flame time: 5 s

If the body of surge suppression varistor complies with **V-1 class material**, the needle flame test does not need to be performed.

G.8.3 Safeguards against fire

G.8.3.1 General

Supplementary safeguards to be provided against fire resulting from the failure of the varistor if the method “reduce the likelihood of ignition” of 6.4.1 is chosen are specified below.

A varistor shall be regarded as a **PIS**. In case the method “reduce the likelihood of ignition” is chosen, the varistor overload test of G.8.3.2; and **temporary overvoltage** test of G.8.3.3 shall be performed depending on the maximum continuous a.c. voltage of the varistor according to Table G.7.

Table G.7 – Varistor overload and temporary overvoltage test

Maximum continuous a.c. voltage of a varistor	Connection Between		
	L to N or L to L	L to PE	N to PE
1,25 × V_r to 2 × V_r	G.8.3.2	G.8.3.2 and G.8.3.3	G.8.3.2 and G.8.3.3
Over 2 × V_r to 1 200 + 1,1 × V_r	No test	G.8.3.3	G.8.3.3
Over 1 200 + 1,1 × V_r	No test	No test	No test
V_r is the **rated voltage** or the upper voltage of the **rated voltage range** of the equipment.			

G.8.3.2 Varistor overload test

The following test is simulated as required by Table G.7 to either a varistor or a surge suppression circuit containing varistors connected across the ***mains*** *(L to L or L to N), line to protective earth (L to PE), or neutral to protective earth (N to PE).*

The following test simulation circuit shall be used:

- *Voltage is the a.c source of* $2 \times V_r$.
- *Current is the current resulted from a test resistor* R_x *connected in series with the a.c source.*
- V_r *is the* ***rated voltage*** *or the upper voltage of the* ***rated voltage range*** *of the equipment.*

For line to neutral, if a fuse not exceeding 10 A is located in the equipment before and in series with the varistor, either an initial test resistor (R_1) *may be used resulting in the same current as the fuse, or a short-circuit may be applied. If no fuse is connected in series, the test shall be performed with an initial test resistor* $R_1 = 16 \times V_r$.

For line to protective earth and neutral to protective earth, the test shall be performed with an initial test resistor $R_1 = 16 \times V_r$.

If the circuit does not open immediately during the initial application of test current, the test shall be continued until temperature stability (see B.1.6).

Subsequently, the test shall be repeated with new values of R_x (R_2, R_3, R_4, *etc.) until the circuit opens.*

- $R_2 = 8 \times V_r\ \Omega$
- $R_3 = 4 \times V_r\ \Omega$
- $R_4 = 2 \times V_r\ \Omega$
- $R_x = 0{,}5 \times (R_{x-1})\ \Omega$

During the test, the circuit may open due to the operation of a protective device such as a fuse, a thermal fuse or a GDT.

Components in parallel with the varistor that may be affected by this test shall be disconnected.

During and following the test, there shall be no risk of fire and ***equipment safeguards****, other than the varistor under test, shall remain effective.*

G.8.3.3 Temporary overvoltage test

The ***temporary overvoltage*** *test is simulated by the following test methods where applicable:*

A varistor or a surge suppression circuit containing varistors connected between the ***mains*** *conductors and the earth, "Line to Protective Earth" and "Neutral to Protective Earth", the* ***temporary overvoltage*** *described below is applied. The test method and compliance criteria are described in 8.3.8.1 and 8.3.8.2 of IEC 61643-11.*

- *Line to Protective Earth:*
  - *withstand* $1{,}71 \times U_0$ *for 5 s.*
  - *withstand* $1\,200 + 1{,}1 \times U_0$ *V ac for 5 s or fail safely.*
- *Neutral to Protective Earth:*

- *withstand 1 200 V a.c. for 200 ms.*

NOTE 1 U_0 is the nominal a.c. voltage of the system as defined in IEC 61643-11, which is the nominal line to neutral voltage (r.m.s. value of the a.c. voltage) of the system to which the EUT is intended to be connected.

If a surge suppression circuit is used, the combination pulse specified in G.8.2 is applied before this test.

During the test, the circuit may open due to the operation of a protective device such as a thermal fuse or a GDT.

NOTE 2 For different power distribution systems, the **temporary overvoltages** are defined in Annex B of IEC 61643-1.

Components in parallel with the varistor that may be affected by this test shall be disconnected.

G.9 Integrated circuit (IC) current limiters

G.9.1 Requirements

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:

– 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;

– the IC current limiters are supplied by a source whose output does not exceed 250 VA;

– the IC current limiters output current is limited to 5 A or less;

– the IC current limiters limit the current or voltage to the required value with the manufacturer's defined drift, as applicable, taken into account after each of the conditioning tests.

At the choice of the manufacturer, the conditioning tests shall be conducted in accordance with G.9.2, G.9.3 or G.9.4. IC current limiters that meet the test program of either G.9.2, G.9.3 or G.9.4 are considered to comply with the above requirements.

A different sample may be used for each test.

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.

G.9.2 Test program 1

Test program 1 consists of the following:

– *10 000 cycles of turning enable on and off with a 100 $\Omega \pm 5$ Ω resistor and a 425 μF $\pm$ 10 μF capacitor in parallel with the output;*

– *10 000 cycles of turning enable on and off with a ferrite-core inductor having 0,35 mH $\pm$ 0,1 mH inductance at 1 kHz and a d.c. resistance not exceeding 1 Ω;*

– *10 000 cycles of turning enable on and off with the input connected to a capacitor rated 425 μF $\pm$ 1 μF and shorting the output;*

– *10 000 cycles of turning the input pin on and off with a capacitor rated 425 μF $\pm$ 1 μF connected to the input supply while keeping enable active and shorting the output;*

– *10 000 cycles of turning the input pin on and off with a ferrite-core inductor having 0,35 mH ± 0,1 mH inductance at 1 kHz and a d.c. resistance not exceeding 1 Ω connected to the input supply and return while keeping enable active and shorting the output;*

– *50 cycles with the enable pin held active with the output open-circuited, each cycle consisting of shorting the output and then opening the output;*

– *50 cycles with the enable pin held active while applying a short to the output, each cycle consisting of turning the power on and off;*

– *50 cycles with the enable pin held active while power is applied, each cycle consisting of shorting the output, removing power, reapplying power, removing the short, followed by removal of power.*

G.9.3 Test program 2

Test program 2 consists of the following:

– *50 cycles with the enable pin held active with the output open-circuited; each cycle consisting of shorting the output and then opening the output;*

– *50 cycles with the enable pin held active while applying a short to the output; each cycle consisting of turning the power on and off;*

– *50 cycles with the enable pin held active with the output loaded to maximum power, each cycle consisting of turning the power on and off;*

– *50 cycles with the enable pin held active while power is applied, each cycle consisting of shorting the output, removing power, reapplying power, removing the short, followed by removal of power;*

– *3 cycles of exposing the device (not energized) to 70 °C ± 2 °C for 24 h; followed by at least 1 h at room ambient; followed by at least 3 h at – 30 °C ± 2 °C; followed by 3 h at room ambient;*

– *10 cycles of exposing the device (while energized) to 50 °C ± 2 °C for 10 min; followed by 10 min at 0 °C ± 2 °C with a 5 min period of transition from one state to the other;*

– *7 days with the output short-circuited and the device wrapped in a double layer of* ***cheesecloth****. A quick acting 5 A fuse kept in series with the output shall not open and a current meter shall not show a current of more than 5 A.*

G.9.4 Test program 3

Test program 3 consists of the following:

– *Subclause H.17.1.4.2 of IEC 60730-1:2010;*

– *10 000 cycles of turning enable on and off with a 100 Ω resistor and 425 μF capacitor in parallel with the output;*

– *10 000 cycles of turning enable on and off with a ferrite-core inductor having 0,35 mH ± 0,1 mH inductance at 1 kHz and a d.c. resistance not exceeding 1 Ω connected in the output circuit;*

– *10 000 cycles of turning enable on and off while input connected to a capacitor rated 425 μF and shorting the output;*

– *10 000 cycles of turning input pin on and off while a capacitor rated 425 μF to the input supply keeping enable active and shorting the output;*

– *10 000 cycles of turning input pin on and off with a ferrite-core inductor having 0,35 mH ± 0,1 mH inductance at 1 kHz and a d.c. resistance not exceeding 1 Ω connected to the input supply keeping enable active and shorting the output;*

– *50 cycles with enable pin held active and applying short to output with power on and off;*

– *50 cycles with enable pin held active and output loaded to maximum power with power on and off;*
– *50 cycles with enable pin held active and applying power, apply short to output; remove power, apply power, remove short, remove power;*
– *3 cycles of exposing the device (not energized) 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 energized) 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.*

G.9.5 Compliance criteria

After each of the tests above, the device shall limit the current in accordance with its specification as applicable or the device shall become open circuit. The open circuited device is replaced with a new sample and tests continued as applicable.

G.10 Resistors

G.10.1 General

When required by 5.5.6, ten samples are tested for the resistor test of G.10.2. A sample is a single resistor if used alone, or a group of resistors in series.

G.10.2 Resistor test

Before the test, the resistance of ten samples is measured.

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

– temperature: (40 ± 2) °C;
– humidity: (93 ± 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.10.3 applies.

G.10.3 Resistors serving as safeguards between the mains and an external circuit consisting of a coaxial cable

G.10.3.1 General

Test requirements for resistors bridging insulation between the **mains** and an **external circuit** consisting of a coaxial cable and that ensure that they do not significantly change in value over a long period of time are given below.

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.10.2 and followed by the test of G.10.3.2 or G.10.3.3 as applicable.

G.10.3.2 Voltage surge test

Each sample is 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 14).*

G.10.3.3 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 14).*

G.10.3.4 Compliance criteria

After the tests of G.10.3.2 or G.10.3.3, the resistance of each sample shall not have changed by more than 20 %. No failure is allowed.

G.11 Capacitors and RC units

G.11.1 General

The requirements below specify conditioning criteria when testing capacitors and RC units or discrete components forming an RC unit and serving as **safeguards** and provides selection criteria for capacitors and RC units that comply with IEC 60384-14.

G.11.2 Conditioning of capacitors and RC units

When required by 5.5.2.1, 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 ± 2) °C and a relative humidity of (93 ± 3) %.

Capacitors subjected to a duration that is longer than 21 days during the above test are considered acceptable.

G.11.3 Rules for selecting capacitors

The appropriate capacitor subclass shall be selected from those listed in Table G.8, according to the rules of application in the table.

Table G.8 – 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 test 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.

1 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 5.4.1.8.2.

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 test voltage shall be at least equal to the **required withstand voltage**.

3 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.

4 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.

5 If two or more capacitors are used in series they shall comply with 5.5.2.1 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.11.4 Examples of the application of capacitors

Table G.9 gives examples for the number of Y capacitors required bridging **basic insulation**, **supplementary insulation** or **reinforced insulation** based on the **required withstand voltage**. Table G.10 gives the maximum voltage that can appear across a Y capacitor based on the **peak working voltage**.

Table G.11 gives examples for the number of Y capacitors required bridging **basic insulation** and **reinforced insulation** based on the **temporary overvoltages**. Table G.12 gives examples of the application of X capacitors selected in accordance with Table G.8.

Table G.9 – Examples of the application of Y capacitors based on the test voltages of Table 26

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.10 – Examples of the application of Y capacitors based on the test voltages of Table 27

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 5.4.9.1
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 5.5.2.1.

[b] For application of Y capacitor located in circuits connected to the **mains**, see Table G.9 and Table G.11.

B **basic insulation** D **double insulation**

S **supplementary insulation** R **reinforced insulation**

Table G.11 – Examples of the application of Y capacitors based on the test voltages of Table 28

Nominal mains voltage V r.m.s. **up to and including**	**Bridged insulation**	**Capacitor type**	**Number of capacitors**
250	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.12 – 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.12 Optocouplers

Optocouplers shall comply with the requirements of IEC 60747-5-5:2007. In the application of IEC 60747-5-5:2007,

– the **type testing** as specified in 7.4.3 of IEC 60747-5-5:2007 shall be performed with a voltage $V_{\mathrm{ini,a}}$ that is at least equal to the appropriate test voltage in 5.4.9.1 of this standard, and

– the **routine testing** as specified in 7.4.1 of IEC 60747-5-5:2007 shall be performed with a voltage $V_{\mathrm{ini,b}}$ that is at least equal to the appropriate test voltage in 5.4.9.2 of this standard.

G.13 Printed boards

G.13.1 General

The requirements for **basic insulation**, **supplementary insulation**, **reinforced insulation** and **double insulation** on printed boards are specified below.

These requirements also apply to the windings of a planar transformer.

G.13.2 Uncoated printed 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.13.3 Coated printed boards

The requirements for separation distances before the boards are coated are specified below.

An alternative method to qualify coated printed boards is given in IEC 60664-3.

For printed boards whose outer surfaces are to be coated with a suitable coating material, the minimum separation distances of Table G.13 apply to conductive parts before they are coated.

Double insulation and **reinforced insulation** shall pass **routine tests** for electric strength of 5.4.9.2.

Either one or both conductive parts and the entire distances over the surface between the conductive parts shall be coated.

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.13.6.

Table G.13 – 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.13.6 is not required.

G.13.4 Insulation between conductors on the same inner surface

The requirements for insulation on the same inner layer of a multilayer board are specified below.

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.13.5 Insulation between conductors on different surfaces

The requirements for insulation on the different layers of a multilayer board are specified below.

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.14.

Table G.14 – Insulation in printed boards

Specification of insulation	Type tests [a]	Routine tests for electric strength [c]
Two layers of sheet insulating material including pre-preg [b]	No	Yes
Three or more layers of sheet insulating material including pre-preg [b]	No	No
An insulation system with ceramic coating over a metallic substrate, cured at ≥ 500 °C	No	Yes
An insulation system, with two or more coatings other than ceramic over a metallic substrate, cured at < 500 °C	Yes	Yes

NOTE 1 Pre-preg is the term used for a layer of glass cloth impregnated with a partially cured resin.

NOTE 2 For definition of ceramic, see IEC 60050-212:2010, 212-15-25.

[a] Thermal conditioning of G.13.6.2 followed by the electric strength test of 5.4.9.1.

[b] Layers are counted before curing.

[c] Electric strength testing is carried out on the finished printed board.

G.13.6 Tests on coated printed boards

G.13.6.1 Sample preparation and preliminary inspection

Three sample printed boards (or, for coated components in Clause G.14, 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.13.6.2 Test method and compliance criteria

Sample 1 is subjected to the thermal cycling sequence of 5.4.1.5.3.

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 ± 2 °C. The temperature used to determine the temperature index line is the highest temperature on the board where safety is involved.

When using Figure G.2, interpolation may be used between the nearest two temperature index lines.

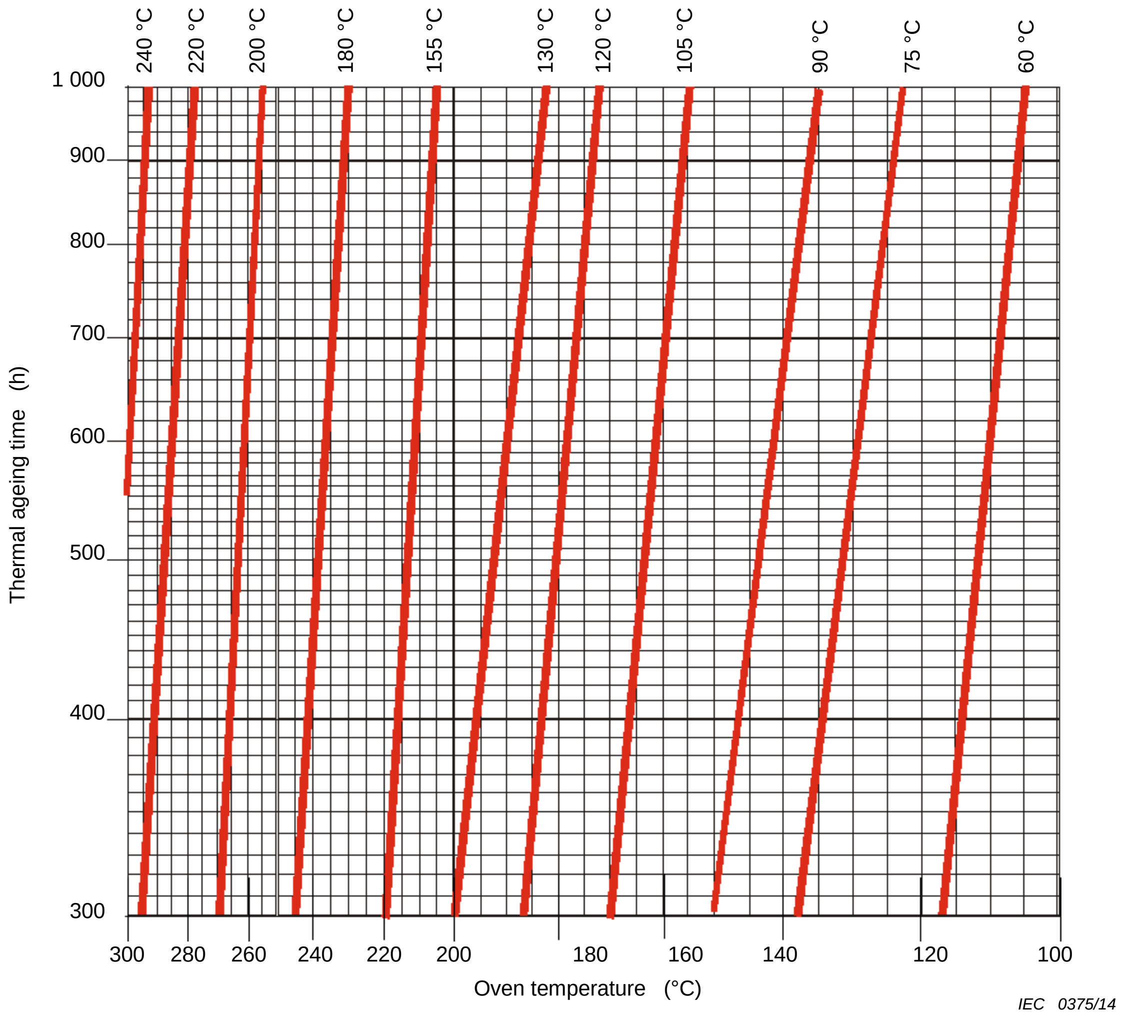


Figure G.2 – Thermal ageing time

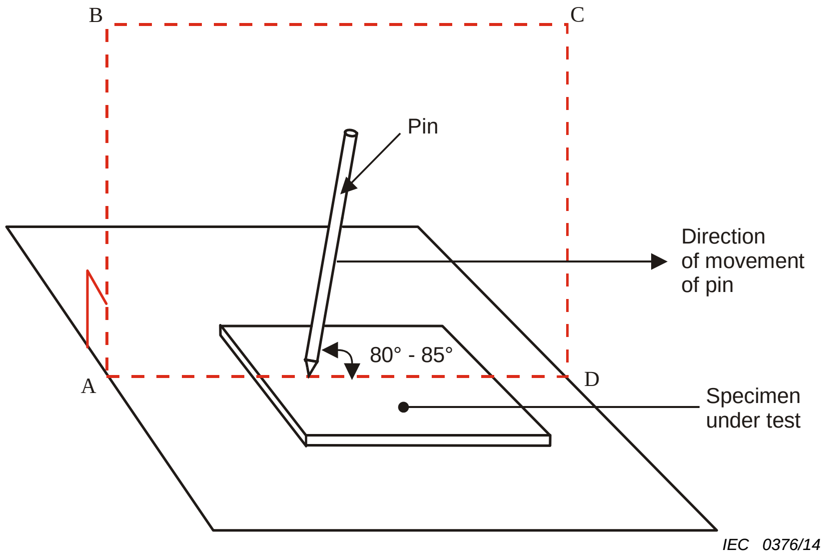
Samples 1 and 2 are then subjected to the humidity conditioning of 5.4.8 and shall withstand the electric strength test of 5.4.9.1 between conductors.

Sample board 3 is subjected to the following abrasion resistance 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 N ± 0,5 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 5.4.9.1 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.14 Coatings on component terminals

G.14.1 Requirements

The requirements for coatings on component terminals and the like, where the coating is used to reduce **clearances** and **creepage distances** are specified below.

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.13 apply to the component before coating, and the coating shall meet all the requirements of G.13.3. 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.13 (see G.13.3).

G.14.2 Test method and compliance criteria

Compliance is checked by inspection taking into account Figure O.11 and by applying the sequence of tests covered by G.13.6. These tests are carried out on a completed assembly including the component(s).

The abrasion resistance test of G.13.6.2 is carried out on a specially prepared sample printed board as described for sample 3 in G.13.6.1, except that the separation between the conductive parts shall be representative of the minimum separations and maximum potential gradients used in the assembly.

G.15 Pressurized liquid filled components

G.15.1 General

Construction and test requirements for pressurized LFCs used inside the equipment where an injury can occur within the meaning of this standard due to leaks of the liquid in the LFC are specified below.

This subclause does not apply to the following:

– an LFC that is sealed but open to the atmosphere in the equipment; or

– components containing small amounts of liquids not likely to cause any injury (for example, liquid crystal displays, electrolytic capacitors, liquid cooling heat pipes, etc.); or

– wet **cell batteries** (for wet **cell batteries**, see Annex M).

– an LFC and its associated parts that comply with P.3.3.

G.15.2 Requirements

An LFC located internal to the equipment shall comply with all of the following requirements:

– flammable or conductive liquid shall be stored in a container, and the LFC shall comply with the tests of G.15.3.3, G.15.3.4, G.15.3.5 and G.15.3.6;

– the liquid shall be provided with protection in accordance with Clause 7 (hazardous substances);

– non-metallic parts of the container system shall withstand the tests of G.15.3.1 and G.15.3.2;

– 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.15.3.2, the test of G.15.3.1 is conducted.

G.15.3 Test methods and compliance criteria

G.15.3.1 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 or is non-pressurised (for example, an ink cartridge) 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 specified by the manufacturer at the maximum temperature measured during* ***normal operating conditions****; and*

– *three times the maximum measured working pressure at the maximum temperature measured during application of the* ***abnormal operating conditions*** *of Clause B.3 and* ***single fault conditions*** *of Clause B.4.*

G.15.3.2 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 ^{o}C and placed in a full draft air-circulating oven. Following the conditioning, the system shall comply with the test of G.15.3.1 and non-metallic parts shall show no sign of deterioration such as cracking and embrittlement.

G.15.3.3 Tubing and fittings compatibility test

Ten samples of the test specimens made of the material used for the 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. Five specimens shall be tested in the as received condition and the remaining five specimens after a conditioning test for 40 days at 38 °C in a full draft air-circulating oven or in a water bath filled with the intended liquid and 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 tests.

G.15.3.4 Vibration test

One sample of the LFC, or the equipment containing the LFC, shall be 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 severities are:

– *duration: 30 min;*
– *amplitude: 0,35 mm;*
– *frequency range: 10 Hz, 55 Hz, 10 Hz;*
– *sweep rate: approximately one octave per minute.*

G.15.3.5 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.15.3.6 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.15.4 Compliance criteria

Compliance is checked by inspection and evaluation of the available data or by the tests of G.15.3. During and after these tests, there shall be no rupture, no leaks and no loosening of any connection or part.

G.16 IC including capacitor discharge function (ICX)

G.16.1 Requirements

An ICX and any associated components critical to the discharge function of a capacitor to an **accessible** part (such as the **mains** capacitor) are not fault tested if one of the following conditions is met:

– the ICX with the associated circuitry as provided in the equipment complies with the tests of G.16.2. Any impulse attenuating components (such as varistors and GDTs) that attenuate the impulse to the ICX and the associated circuitry are disconnected. If discharge components external to the ICX are necessary, they shall not fail during the tests; or
– the ICX tested separately complies with the requirements of G.16.2. If discharge components external to the ICX are necessary:

- they shall be included in the test of G.16.2, and
- they shall not fail during the tests, and
- the discharge components used in the equipment shall be within the range tested.

G.16.2 Tests

Where the ICX is tested by itself, the test set up shall be as recommended by the ICX manufacturer.

- *humidity treatment of 5.4.8 for 120 h.*
- *100 positive impulses and 100 negative impulses between line and neutral using a capacitor with the largest capacitance and a resistor with the smallest resistance specified by the manufacturer of the ICX; and repeated with a capacitor with the smallest capacitance and the resistor with the largest resistance. The time between any two impulses shall not be less than 1 s. The impulse shall be as specified in circuit 2 of Table D.1 with* U_c *equal to the transient voltage.*
- *Application of an a.c. voltage that is 110 % of the* ***rated voltage*** *for 2,5 min.*
- *10 000 cycles of power on and off using a capacitor with the smallest capacitance and a resistor with the largest resistance as specified by the manufacturer of ICX. The power on and off cycles time shall not be less than 1 s.*

If any of the associated circuitry components other than those critical for the discharge function fails, it may be replaced with a new component.

G.16.3 Compliance criteria

Compliance is checked by evaluation of the available data or by conducting the above tests. The capacitor discharge test is conducted after the above tests, ensuring the ICX or the EUT provided with the ICX continues to provide the ***safeguard*** *function.*

NOTE Evaluation of available data should include information of failure of any associated circuitry components keeps the discharge mode in the on/stay mode

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

$$I_{TS1} = \frac{I_p}{\sqrt{2}} \qquad \textit{for} \quad (t_1 \leq 600\ \text{ms})$$

$$I_{TS1} = \frac{t_1 - 600}{600} \times \frac{I_{pp}}{2\sqrt{2}} + \frac{1200 - t_1}{600} \times \frac{I_p}{\sqrt{2}} \qquad \textit{for} \quad (600\ \text{ms} < t_1 < 1200\ \text{ms})$$

$$I_{TS1} = \frac{I_{pp}}{2\sqrt{2}} \qquad \textit{for} \quad (t_1 \geq 1200\ \text{ms})$$

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);*

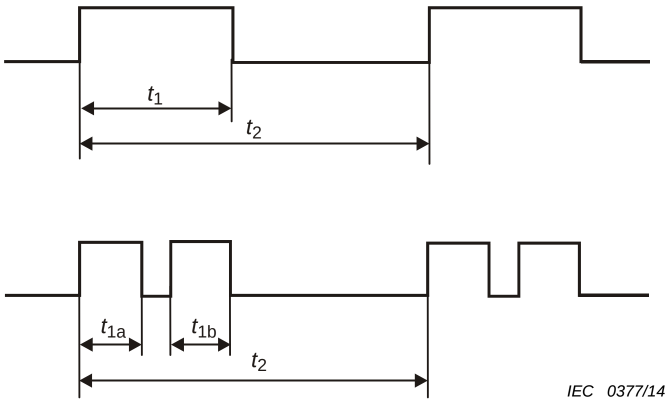
I_{dc} *is the d.c. current in mA flowing through the 5 000 Ω resistor during the non-active period of the cadence cycle;*

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.*



Key

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

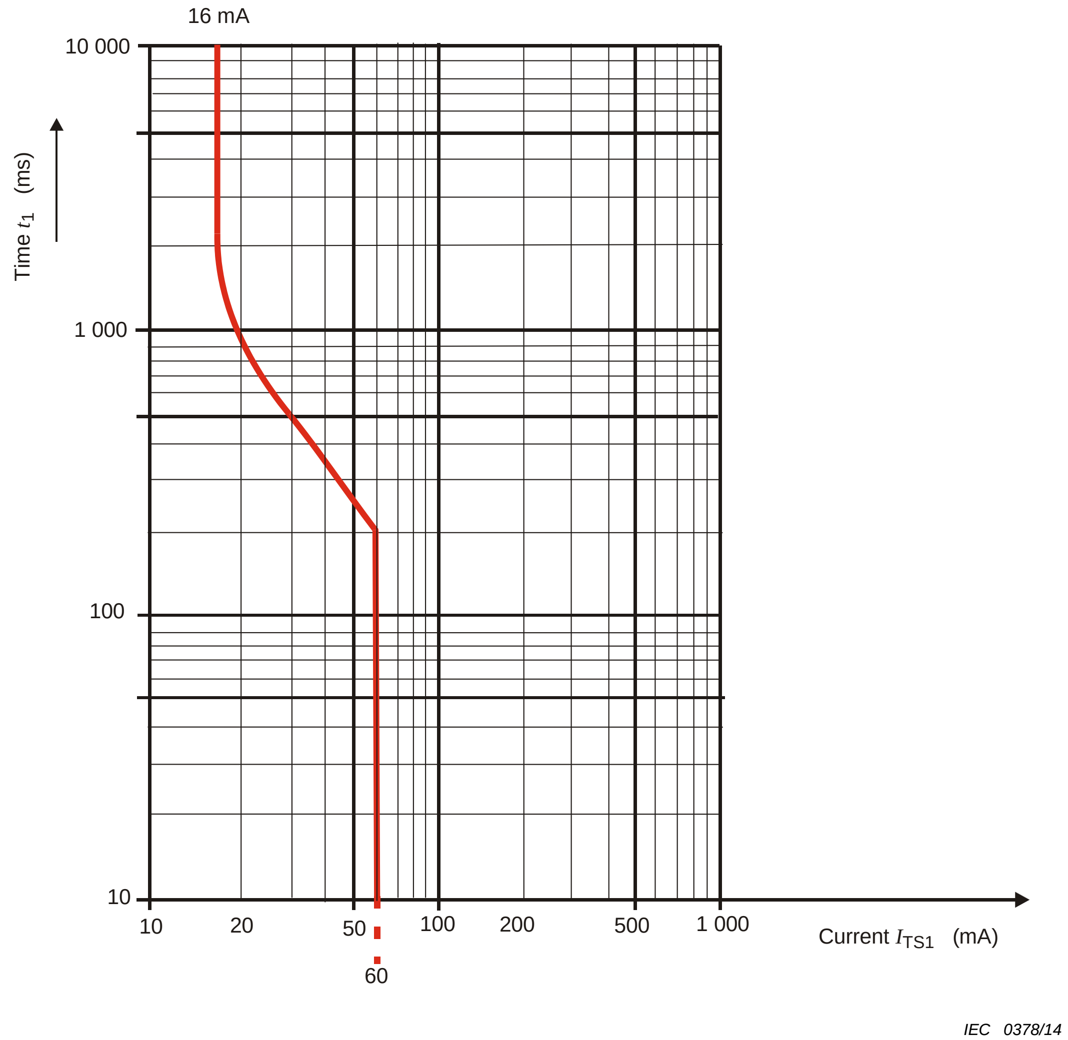


Figure H.2 – I_{TS1} limit curve for cadenced ringing signal

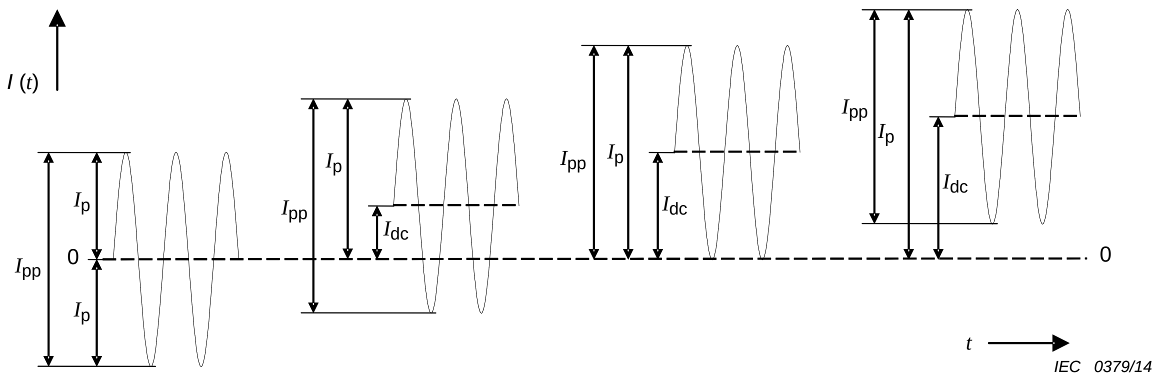


Figure H.3 – Peak and peak-to-peak currents

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 MΩ.

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;

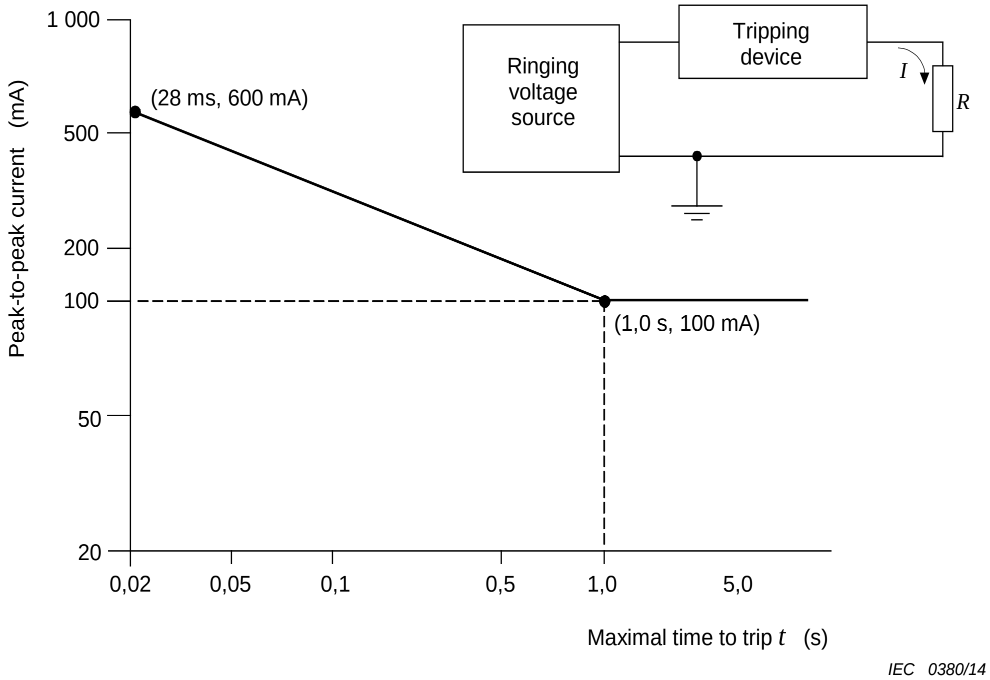
– if the current through a 1 500 Ω or greater resistor exceeds 100 mA peak-to-peak, a tripping device shall be included. If the tripping device meets the trip criteria specified in Figure H.4 with $R \geq 500\ \Omega$, no monitoring voltage is required. If, however, the tripping device only meets the 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 is normally 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.4.

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 concept of overvoltage categories is used for equipment energized directly from the a.c. **mains**.

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 determined from the **mains** voltage and the overvoltage category, I to IV (see Table 13 of this standard).

The overvoltage category therefore shall be identified for each equipment intended to be connected to the **mains** (see Table I.1).

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

Requirements for winding wires whose insulation may be used to provide **basic insulation**, **supplementary insulation**, **double insulation** or **reinforced insulation** in wound components without interleaved insulation are specified below.

This annex applies to:

– solid round winding wires having diameters between 0,01 mm and 5,0 mm, and stranded winding wires with equivalent cross-sectional areas, and

– solid square and solid rectangular (flatwise bending) winding wires with cross-sectional areas of 0,000 079 mm^2 to 19,6 mm^2.

NOTE See G.6.1 for the minimum number of overlapping layers.

J.2 Type tests

J.2.1 General

*The winding wire shall pass the following **type tests**, carried out at a temperature between 15 °C and 35 °C and a relative humidity between 45 % and 75 %, unless otherwise specified.*

J.2.2 Electric strength

J.2.2.1 Solid round winding wires and stranded winding wires

J.2.2.1.1 Wires with a nominal conductor diameter up to and including 0,1 mm

The test specimen is prepared according to 4.3 of IEC 60851-5:2008. The specimen is then subjected to the electric strength test of 5.4.9.1, between the conductor of the wire and the cylinder, with a minimum test voltage of

– *3 kV r.m.s. or 4,2 kV peak for **reinforced insulation**, or*

– *1,5 kV r.m.s. or 2,1 kV peak for **basic insulation** or **supplementary insulation**.*

J.2.2.1.2 Wires with a nominal conductor diameter over 0,1 mm up to and including 2,5 mm

The test specimen is prepared according to 4.4.1 of IEC 60851-5:(twisted pair). The specimen is then subjected to the electric strength test of 5.4.9.1 with a test voltage that is not less than twice the appropriate voltage of 5.4.9.1, 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.2.2.1.3 Wires with a nominal conductor diameter over 2,5 mm

The test specimen is prepared according to 4.5.1 of IEC 60851-5:2008. The specimen is then subjected to the electric strength test of 5.4.9.1 between the conductor of the wire and the shot, with a minimum test voltage of

– *3 kV r.m.s. or 4,2 kV peak for **reinforced insulation**, or*

– *1,5 kV r.m.s. or 2,1 kV peak for **basic insulation** or **supplementary insulation**.*

J.2.2.2 Square or rectangular wires

The test specimen is prepared according to 4.7.1 of IEC 60851-5:2008 (single conductor surrounded by metal shots). The specimen is then subjected to the electric strength test of 5.4.9.1, with a minimum test voltage of

– *3 kV r.m.s. or 4,2 kV peak for **reinforced insulation**, or*

– *1,5 kV r.m.s. or 2,1 kV peak for **basic insulation** or **supplementary insulation**.*

J.2.3 Flexibility and adherence

Clause 5.1 (in Test 8) of IEC 60851-3:2009 shall be used, using the mandrel diameters of Table J.1.

The test specimen is then examined in accordance with 5.1.1.4 of IEC 60851-3:2009, followed by the electric strength test of 5.4.9.1 in this standard, with minimum test voltage of

– *3 kV r.m.s. or 4,2 kV peak for **reinforced insulation**, or*

– *1,5 kV r.m.s. or 2,1 kV peak for **basic insulation** or **supplementary insulation**.*

The test voltage is applied between the wire and the mandrel.

Table J.1 – Mandrel diameter

Nominal conductor diameter or thickness mm	Mandrel diameter mm
less than 0,35	4,0 ± 0,2
less than 0,50	6,0 ± 0,2
less than 0,75	8,0 ± 0,2
less than 2,50	10,0 ± 0,2
less than 5,00	Four times the conductor diameter or thickness [a]

[a] In accordance with IEC 60317-43.

The tension to be applied to the wire during winding on the mandrel is calculated from the wire diameter to be equivalent to 118 MPa ± 10 % (118 N/mm^2 ± 10 %).

Edgewise bending on the smaller dimension side (width) is not required for rectangular wire.

For mandrel winding test of the square and rectangular wire, two adjacent turns do not need to contact each other.

J.2.4 Heat shock

The test specimen shall be prepared in accordance with 3.1.1 (in Test 9) of IEC 60851-6:1996, followed by the electric strength test of 5.4.9.1 in this standard, with a minimum test voltage of

– *3 kV r.m.s. or 4,2 kV peak for **reinforced insulation**, or*

– *1,5 kV r.m.s or 2,1 kV peak for **basic insulation** or **supplementary insulation**.*

The test voltage is applied between the wire and the mandrel. The oven temperature is the relevant temperature of the thermal class of insulation in Table 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 ± 5° of the specified temperature. The classes are related to the classification of electrical insulating materials and EISs in accordance with IEC 60085. The assigned letter designations are given in parentheses.								

Edgewise bending on the smaller dimension side (width) is not required for rectangular wire.

NOTE Subclause 3.1.2 in Test 9 of IEC 60851-6:1996 is not used for solid square and solid rectangular winding wires.

J.2.5 Retention of electric strength after bending

Five specimens are prepared as in J.2.3 and tested as follows. Each specimen is removed from the mandrel, placed in a container and positioned so that it can be surrounded by at least 5 mm of metal shot. The ends of the conductor in the specimen shall be sufficiently long to avoid flash over. The shot shall be not more than 2 mm in diameter and shall consist of balls of stainless steel, nickel or nickel plated iron. The shot is gently poured into the container until the specimen under test is covered by at least 5 mm of shot. The shot shall be cleaned periodically with a suitable solvent.

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 specimen shall be subjected to the electric strength test of 5.4.9.1, with a minimum test voltage of

– *3 kV r.m.s. or 4,2 kV peak for **reinforced insulation**, or*

– *1,5 kV r.m.s. or 2,1 kV peak for **basic insulation** or **supplementary insulation**.*

The mandrel diameter and tension applied to the wire during winding on the mandrel are as in Table J.1.

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 in accordance with the electric strength test of 5.4.9.1, 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

*The **sampling test** shall be conducted according to the suitable test specified in J.2.2.*

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-energization 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**.

If reduction of the energy source class takes longer than 2 s, then an **instructional safeguard** shall be provided in accordance with Clause F.5, except that:

– element 1a shall be placed on the door, cover or other part that initiates the interlock action and is opened or removed to gain access; and

– element 3 is optional.

The elements of the **instructional safeguard** shall be as follows:

– element 1a: , IEC 60417-6057 (2011-05) for moving parts or

, IEC 60417-5041 (2002-10) for hot parts

– element 2: not specified

– element 3: not specified

– element 4: the time when the energy source will be reduced to the required class

K.1.2 Test method and compliance criteria

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 Figure V.1 or Figure V.2, as applicable 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 Test method and compliance criteria

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 Test method and compliance criteria

*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 using **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 5.4.9.1 at a test voltage required for **basic insulation** or **reinforced insulation**, as applicable. 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** shall comply with the applicable distance from Table 15, provided the switch or relay complies with K.7.2, K.7.3 and K.7.4.

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 5.4.9.1 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****.*

Annex L
(normative)

Disconnect devices

L.1 General requirements

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; or
– an appliance coupler; or
– an isolating switch; or
– a circuit breaker; or
– any equivalent means for disconnection.

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, IEC 60947-1 shall apply. 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.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.3 Parts that remain energized

Parts on the supply side of a **disconnect device** in the equipment, that remain energized 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.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.

EXAMPLE 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.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.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.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.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 **instructional safeguard** in accordance with Clause F.5 at each **disconnect device** giving adequate instructions for the removal of all power from the unit.

The elements of the **instructional safeguard** shall be as follows:

– element 1a: , IEC 60417-6042 (2010-11); and

, IEC 60417-6172 (2012-09)

– element 2: “Caution” or equivalent word or text, and “Shock hazard” or equivalent text

– element 3: optional

– element 4: “Disconnect all power sources” or equivalent text

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.9 Compliance criteria

Compliance is checked by inspection.

Annex M
(normative)

Equipment containing batteries and their protection circuits

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**.

Where a **battery** safety standard contains equivalent requirements to the requirements in this annex, a **battery** in compliance with that **battery** standard is considered to fulfil the corresponding requirements of this annex, and tests that are part of the **battery** safety standard need not be repeated under this annex.

For equipment containing a **battery** that is replaceable by an **ordinary person**, an **instructional safeguard** shall be provided in accordance with Clause F.5, except that the complete **instructional safeguard** may be provided in the instructions.

The elements of the **instructional safeguard** shall be as follows:

– element 1a: not available
– element 2: “CAUTION” or equivalent word or text
– element 3: “Risk of explosion if the battery is replaced by an incorrect type” or equivalent text
– element 4: optional

M.2 Safety of batteries and their cells

M.2.1 Requirements

Batteries and their **cells** shall comply with the relevant IEC standards for **batteries** as listed below.

IEC 60086-4, IEC 60086-5, 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 62133, IEC 62281, and IEC 62485-2.

NOTE Other **battery** safety standards are under development, and are intended to be included in future.

M.2.2 Compliance criteria

Compliance is checked by inspection or evaluation based on data provided by the manufacturer.

M.3 Protection circuits for batteries provided within the equipment

M.3.1 Requirements

Protection circuits for **batteries** provided within the equipment and that are not an integral part of the **battery** shall be so designed that:

– **safeguards** are effective during **normal operating conditions**, **abnormal operating conditions**, **single fault conditions**, installation conditions and transportation conditions; and

– 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 be inherently protected to avoid creating a class 2 energy source or a class 3 energy source.

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

*Protection circuits for **batteries** 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 the equipment, or recommended by the manufacturer for use with the equipment. The test for **battery** protection circuits in the equipment may be performed using a **battery** simulator replacing the **battery** itself. The temperature test is conducted in a temperature controlled chamber. A control signal simulating the actual signal from the temperature sensor in the **battery** may be used in order to perform the test.*

– *Overcharging of a rechargeable **battery**. The **battery** is charged while briefly subjected to the simulation of any **single fault condition** that is likely to occur in the charging circuit and that results in overcharging of the **battery**. To minimize testing time, the failure is chosen that causes the worst-case overcharging condition. The **battery** is then charged for a single period of 7h with the simulated failure in place.*

– *Excessive discharging. 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**, all **cells** shall be tested as a unit.*

NOTE Some of the tests specified can be hazardous to the persons performing the tests. Use appropriate measures to protect such persons against possible chemical or **explosion** hazards.

*For equipment where the **battery** can be removed from the equipment by an **ordinary person**, the following additional tests apply:*

– *Reverse charging of a rechargeable* ***battery****. Check whether the equipment containing a* ***battery*** *has such construction design that the* ***battery*** *may be placed into the equipment in the manner causing reverse charging. Also it will be checked if the electrical connection is made. If a reverse charging is judged possible by the inspection, the following test is applied. However, when relevant IEC* ***battery*** *standards cover this requirement in the Annex, the test is considered to be performed.*

  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.*

– *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.*

M.3.3 Compliance criteria

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 a* ***safeguard****; 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 a* ***safeguard*** *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****.*

Throughout the tests:

– *the* ***battery*** *temperature shall not exceed the allowable temperature of the* ***battery*** *as specified by the* ***battery*** *manufacturer; and*

– *the maximum current drawn from the* ***battery*** *shall be within the range of the specification of the* ***battery****.*

M.4 Additional safeguards for equipment containing a secondary lithium battery

M.4.1 General

Equipment designed to be operated while incorporating one or more portable sealed **secondary lithium batteries** are subject to the requirements in this clause.

M.4.2 Charging safeguards

M.4.2.1 Requirements

Under **normal operating conditions**, **abnormal operating conditions** or **single fault conditions** the charging voltage per **secondary lithium battery** and the charging current per **secondary lithium battery** shall not exceed the **maximum specified charging voltage** and **maximum specified charging current**.

The **battery** charging circuit shall stop charging when the temperature of the **battery** exceeds the **highest specified charging temperature**. The **battery** charging circuit shall limit the current to the value specified by the **battery** manufacturer when the **battery** temperature is lower than the **lowest specified charging temperature**.

M.4.2.2 Compliance criteria

*Compliance is checked by measuring the charging voltage, the charging current and the temperature of each individual **cell** of the **secondary lithium battery** under **normal operating conditions**, **abnormal operating conditions** and **single fault conditions**. The **cell** temperature shall be measured at the points specified by the **battery** manufacturer. **Single fault conditions** that may affect the charging voltage or charging current or the temperature shall be applied in accordance with Clause B.4.*

NOTE 1 For potted assemblies, thermocouples could be attached to the **cell** surface before potting.

*A higher charging voltage than the **maximum specified charging voltage** or a higher charging current than the **maximum specified charging current**, that occurs just after the introduction of an **abnormal operating condition** or a **single fault condition**, may be ignored if the operation of a protective device or circuitry, provided in addition to the normal regulating circuitry, prevents an unsafe condition of the **battery**.*

*Where appropriate, for the purpose of the measurement, the **battery** may be replaced by a circuit simulating the **battery** load.*

*The charging voltage shall be measured when the **secondary lithium battery** becomes fully charged. The charging current shall be measured during the entire charging cycle up to the **maximum specified charging voltage**.*

*During and after the test, no fire or **explosion** (other than venting) of **secondary lithium battery** shall occur. The charging voltage shall not exceed **maximum specified charging voltage**. The charging current shall not exceed **maximum specified charging current**. The charging of the **battery** shall be stopped when the temperature of the **battery** exceeds the **highest specified charging temperature**. The **battery** charging circuit shall limit the current to the value specified by the **battery** manufacturer when the **battery** temperature is lower than the **lowest specified charging temperature**.*

NOTE 2 Venting without flame, fire or expulsion of solid materials is a **safeguard** of a **secondary lithium battery**.

*In addition, for equipment where the **battery** can be removed from the equipment by an **ordinary person**, compliance is checked by measuring the charging voltage and the charging current, and by evaluating the temperature control function of the equipment under **normal operating conditions**, **abnormal operating conditions** and **single fault conditions**.*

*All parameters controlled by the protection circuit for the **battery** shall be within those specified in the relevant IEC **battery** standard, and shall cover the following:*

– *the maximum current drawn from the **battery** shall be within the range of the specification of the **battery**; and*

– *throughout the tests, the **battery** temperature shall not exceed the allowable temperature of the **battery** as specified by the **battery** manufacturer.*

NOTE 3 The controlling elements are voltage, current, and temperature.

M.4.3 Fire enclosure

Secondary lithium battery shall be provided with a **fire enclosure** according to 6.4.8. The **fire enclosure** may be that of the **secondary lithium battery** itself or that of the equipment containing the **secondary lithium battery**.

Equipment with **batteries** are exempted from the above requirement, provided that:

– the **battery** complies with PS1 circuit limits; or

– the equipment with the **battery** complies with the **supplementary safeguard** requirements of 6.4.5.2.

Compliance is checked by inspection of the relevant material or by evaluation of the ***secondary lithium battery*** *datasheet.*

M.4.4 Drop test of equipment containing a secondary lithium battery

M.4.4.1 General

The tests for **direct plug-in equipment**, **hand-held equipment** and **transportable equipment** that contain a **secondary lithium battery** are specified below. These test are specified to verify that mechanical shock will not compromise a **safeguard** within the **battery** or the equipment.

M.4.4.2 Preparation and procedure for the drop test

The drop test is conducted in the following order:

- *Step 1: drop of the equipment containing a* ***battery*** *as specified in M.4.4.3*
- *Step 2: check the charge and discharge function of the dropped equipment as specified in M.4.4.4*
- *Step 3: conduct a charge and discharge cycle test of the dropped* ***battery*** *as specified in M.4.4.5*

As a preparation of the drop test, two ***batteries*** *are fully charged at the same time under the same charging conditions. The open circuit voltages of both* ***batteries*** *are measured to confirm the initial voltages are the same. One* ***battery*** *is used for the drop test and the other is used as a reference.*

M.4.4.3 Drop

The equipment with a fully charged ***battery*** *installed shall be subjected to the drop test of Clause T.7.*

After the drop test, the ***battery*** *is removed from the equipment. The open circuit voltages of the dropped* ***battery*** *and the reference (undropped)* ***battery*** *are periodically monitored during the following 24 hour period. The voltage difference shall not exceed 5%.*

M.4.4.4 Check of the charge/discharge function

The charging/discharging circuit functions (charging- control voltage, charging control current, and temperature control) are checked to determine that they continue to operate and that all ***safeguards*** *are effective. A dummy* ***battery*** *or appropriate measurement tool that represents the* ***battery*** *characteristics may be used for this examination in order to differentiate between* ***battery*** *damage and equipment malfunctions.*

If the charge/discharge function does not operate, the test is terminated, continuation with step 3 is not necessary and compliance is determined by M.4.4.6.

M.4.4.5 Charge / discharge cycle test

If the dropped equipment is still functioning, the dropped equipment with the dropped ***battery*** *installed is subject to three complete discharge and charge cycles under* ***normal operating conditions****.*

M.4.4.6 Compliance criteria

*During the tests, fire or **explosion** of the **battery** shall not occur unless an appropriate **safeguard** is provided that contains the **explosion** or fire. If venting occurs, any electrolyte leakage shall not defeat a **safeguard**.*

*When a protection circuitry for charging or discharging in the equipment or the **battery** detects an abnormality in the **battery** and stops charging or discharging, the result is considered to be acceptable.*

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 Test method and compliance criteria

*If the **battery** is designed to be carried with bare conductive terminals, the **battery** shall comply with the test of P.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 a sufficient overcurrent protective device to prevent any accidental short-circuit inducing conditions as mentioned above; or

– the **battery** connections up to the first overcurrent protective 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 1 Where terminals and conductors are not insulated, by design or for maintenance purposes, only insulated **tools** are to be used in that area.

Unless internal fault testing has been conducted on the **battery** as part of compliance with an IEC **battery** standard in M.2.1, the internal fault testing as described below is required.

NOTE 2 Not all **battery** standards in M.2.1 contain a similar internal fault test.

Each **cell** in a **battery** shall be faulted to ensure that each **cell** vents safely without introducing an **explosion** or fire. Where a **cell** is incorporated into a **battery** or the equipment, sufficient spacing shall be allowed for the proper vent operation of each **cell**.

M.6.1.2 Compliance criteria

For external faults, compliance may be checked by inspection.

The sample shall not explode or emit molten material at any time during any of the tests.

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.

The **battery** system should be isolated from the fixed installation before this measurement is carried out.

NOTE Before carrying out any test, consider the presence of ES2 or ES3 voltages between the **battery** and the associated rack or **enclosure**.

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.*

M.7 Risk of explosion from lead acid and NiCd batteries

M.7.1 Ventilation preventing an 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.

Clause M.7 is applied for open type **batteries** and valve regulated type **batteries**. Sealed type **batteries** with a mechanism of reducing gas are considered to comply with this requirement.

M.7.2 Test method and compliance criteria

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 K, P = 1 013 hPa:

- *1 Ah decomposes H_2O into 0,42 l H_2 + 0,21 l O_2,*
- *decomposition of 1 cm^3 (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:*

$$Q = v \times q \times s \times n \times I_{\mathrm{gas}} \times C_{\mathrm{rt}} \times 10^{-3} \quad \left[\mathrm{m^3/h}\right]$$

where

Q *is the ventilation air flow in m³/h;*

v *is the necessary dilution of hydrogen:*

$\frac{(100-4)\ \%}{4\ \%} = 24$;

q $= 0{,}42 \times 10^{-3}\ \left[\mathrm{m^3/Ah}\right]$ *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 2 C_{10} is the 10 h rate with current I_{10} for lead acid **cells**: (Ah) to U_{final} = 1,80 V/**cell** at 20 °C

C_5 is the 5h rate with current I_5 for NiCd **cells**: (Ah) to U_{final} = 1,00 V/**cell** at 20 °C

with $v \times q \times s = 0{,}05\ \left[\mathrm{m^3/Ah}\right]$ *the ventilation air flow calculation formula is:*

$$Q = 0{,}05 \times n \times I_{gas} \times C_{rt} \times 10^{-3}\ \left[\mathrm{m^3/h}\right]$$

The current I_{gas} *in mA producing gas is determined by one of the following formulas:*

$$I_{gas} = I_{float} \times f_g \times f_s\ \left[\mathrm{mA/Ah}\right] \text{ or}$$

$$I_{gas} = I_{boost} \times f_g \times f_s\ \left[\mathrm{mA/Ah}\right]$$

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*** *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

For outdoor equipment, Clause 11 of IEC 60950-22:2005 applies.

M.8 Protection against internal ignition from external spark sources of batteries with aqueous electrolyte

M.8.1 General

The requirements specified below apply to rechargeable **batteries** providing a venting system.

NOTE For example, a **battery** used in a 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**.

Clause M.8 is applied for open type **batteries** and valve regulated type **batteries**. Sealed type **batteries** with a mechanism of reducing gas are considered to comply with this requirement.

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. During this test, use proper precautions to **safeguard** persons and equipment from **explosion** and burns.

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.*

$$d = 28{,}8 \times \sqrt[3]{I_{\text{gas}}} \times \sqrt[3]{C_{\text{rt}}} \qquad [\text{mm}]$$

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.

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.***

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:

$$\left(\frac{dV}{dt}\right)_{\text{min}} = \frac{(dG/dt)_{\text{max}}}{k \times \text{LEL}} \times \frac{T}{293}$$

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 $\%_{\text{vol}}$ 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:

$$V_z = \left(\frac{dV}{dt}\right)_{\text{min}} / \ c$$

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.

$$V_z = f \times \left(\frac{dV}{dt}\right)_{\text{min}} / \ c$$

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 $\left(\frac{dV}{dt}\right)_{\text{min}}$

including all factors corresponds with the hourly ventilation air flow Q (in m^3/h) for secondary **batteries** calculated under

$$Q = f \times \left(\frac{dV}{dt}\right)$$

$$Q = 0{,}05 \times (N) \times I_{gas} \times C_{rt} \times 10^{-3} \quad [m^3/h]$$

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 c = 1 air change per hour within the hemisphere:

$$d^3 = \frac{3}{2\pi} \times 0{,}05 \times 10^6 \times (N) \times I_{gas} \times C_{rt} \quad \left[mm^3\right]$$

$$d = 28{,}8 \times \left(\sqrt[3]{N}\right) \times \sqrt[3]{I_{gas}} \times \sqrt[3]{C_{rt}} \quad [mm]$$

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 $\sqrt[3]{1/N}$).

The distance d as a function of the rated capacity for various charge currents I (mA/Ah) is shown in Figure M.1.

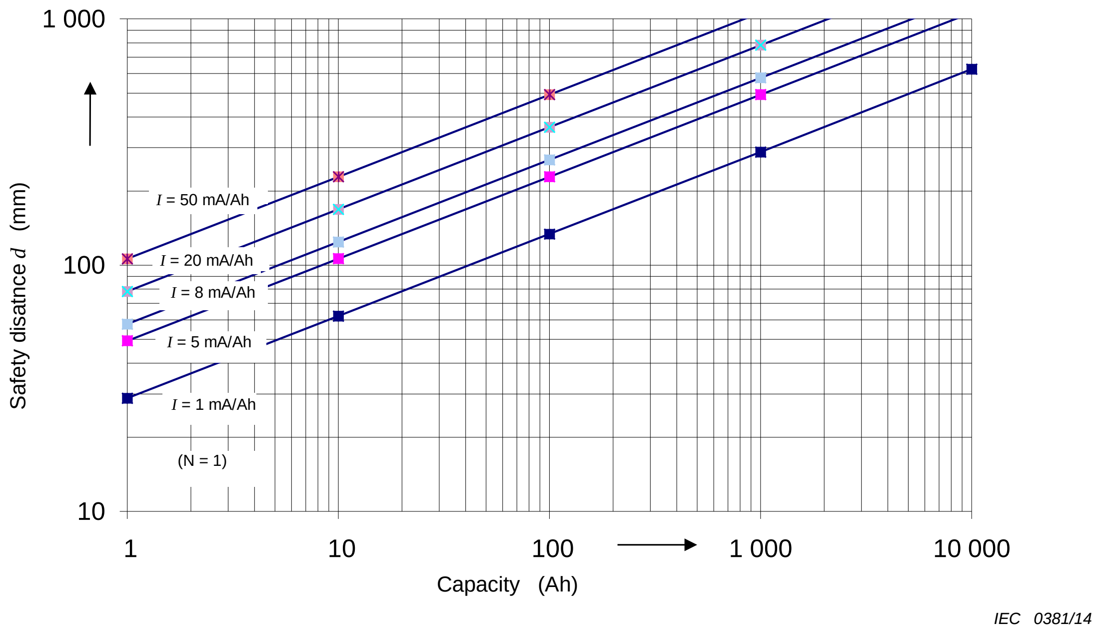


Figure M.1 – Distance d as a function of the rated capacity for various charge currents *I* (mA/Ah)

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** and refilling of consumed material.

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 **cells** 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 reasonably 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**, **instructional safeguards** in accordance with Clause F.5 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 B.3.6 considering all possible installation, transportation and use conditions.*

Annex N
(normative)

Electrochemical potentials (V)

Magnesium, magnesium alloys	Zinc, zinc alloys	80 tin/20 zinc on steel, zinc on iron or steel l	Aluminium	Cadmium on steel	Aluminium/magnesium alloy	Mild steel	Duralumin	Lead	Chromium on steel, soft solder	Cr on Ni on steel, tin on steel, 12 % Cr stainless steel	High chromium stainless steel	Copper, copper alloys	Silver solder, austenitic stainless steel	Nickel on steel	Silver	Rhodium on silver on copper, silver/gold alloy	Carbon	Gold, platinum	
0	0,5	0,55	0,7	0,8	0,85	0,9	1,0	1,05	1,1	1,15	1,25	1,35	1,4	1,45	1,6	1,65	1,7	1,75	Magnesium, magnesium alloys
	0	0,05	0,2	0,3	0,35	0,4	0,5	0,55	0,6	0,65	0,75	0,85	0,9	0,95	1,1	1,15	1,2	1,25	Zinc, zinc alloys
		0	0,15	0,25	0,3	0,35	0,45	0,5	0,55	0,6	0,7	0,8	0,85	0,9	1,05	1,1	1,15	1,2	80 tin/20 zinc on steel, zinc on iron or steel
			0	0,1	0,15	0,2	0,3	0,35	0,4	0,45	0,55	0,65	0,7	0,75	0,9	0,95	1,0	1,05	Aluminium
				0	0,05	0,1	0,2	0,25	0,3	0,35	0,45	0,55	0,6	0,65	0,8	0,85	0,9	0,95	Cadmium on steel
					0	0,05	0,15	0,2	0,25	0,3	0,4	0,5	0,55	0,6	0,75	0,8	0,85	0,9	Aluminium/magnesium alloy
						0	0,1	0,15	0,2	0,25	0,35	0,45	0,5	0,55	0,7	0,75	0,8	0,85	Mild steel
							0	0,05	0,1	0,15	0,25	0,35	0,4	0,45	0,6	0,65	0,7	0,75	Duralumin
								0	0,05	0,1	0,2	0,3	0,35	0,4	0,55	0,6	0,66	0,7	Lead
									0	0,05	0,15	0,25	0,3	0,35	0,5	0,55	0,6	0,65	Chromium on steel, soft solder
										0	0,1	0,2	0,25	0,3	0,45	0,5	0,55	0,6	Cr on Ni on steel, tin on steel, 12 % Cr stainless steel
											0	0,1	0,15	0,2	0,35	0,4	0,45	0,5	High chromium stainless steel
												0	0,05	0,1	0,25	0,3	0,35	0,4	Copper, copper alloys
													0	0,05	0,2	0,25	0,3	0,35	Silver solder, austenitic stainless steel
														0	0,15	0,2	0,25	0,3	Nickel on steel
															0	0,05	0,1	0,15	Silver
																0	0,05	0,1	Rhodium on silver on copper, silver/gold alloy
																	0	0,05	Carbon
																		0	Gold, platinum

Cr = Chromium

Ni = Nickel

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 O.1 to O.20, 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**.

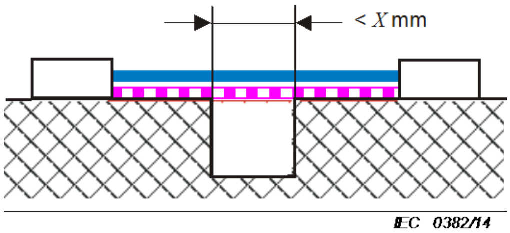
Table O.1 – Value of X

Pollution degree (see 5.4.1.5)	X mm
1	0,25
2	1,00
3	1,50

NOTE Throughout this annex, the following convention is used:

clearance

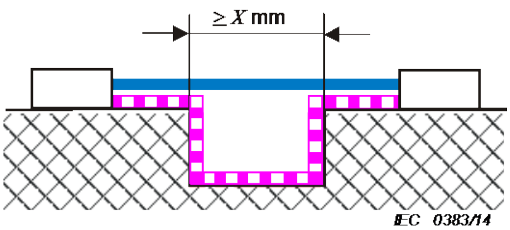
creepage distance path



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.

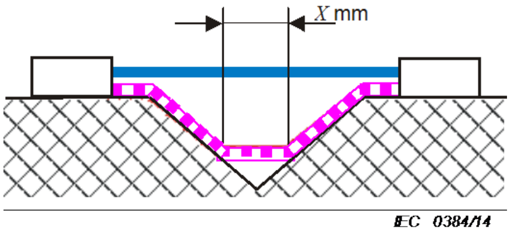
Figure O.1 – Narrow groove



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.

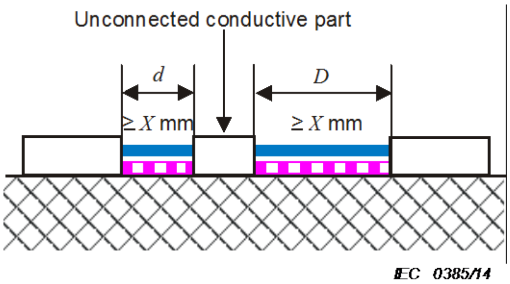
Figure O.2 – Wide groove



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.

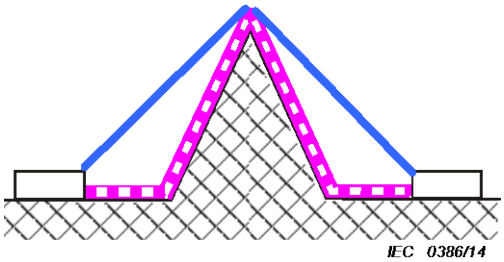
Figure O.3 – V-shaped groove



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.

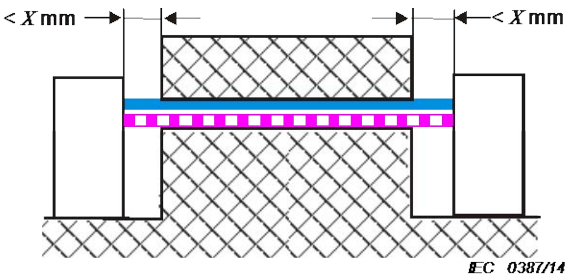
Figure O.4 – Intervening unconnected conductive part



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.

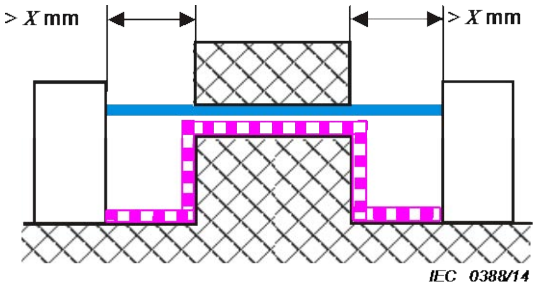
Figure O.5 – Rib



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.

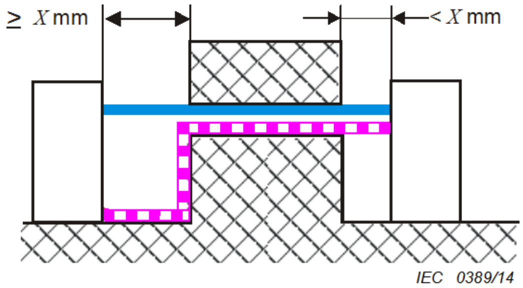
Figure O.6 – Uncemented joint with narrow groove



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.

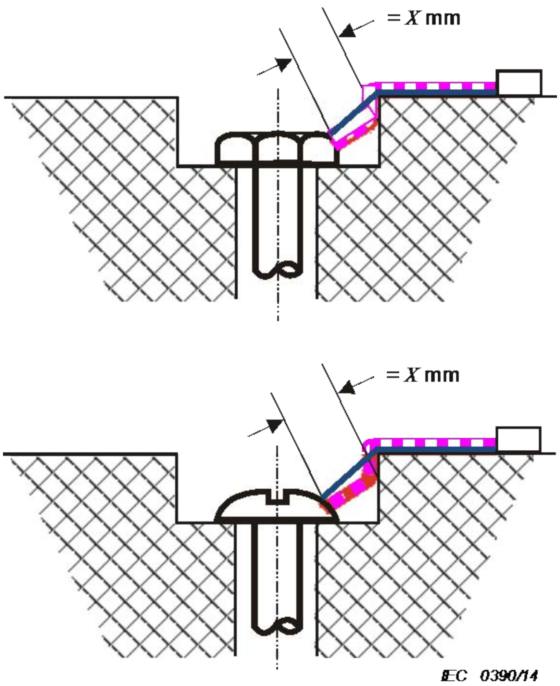
Figure O.7 – Uncemented joint with wide groove



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.

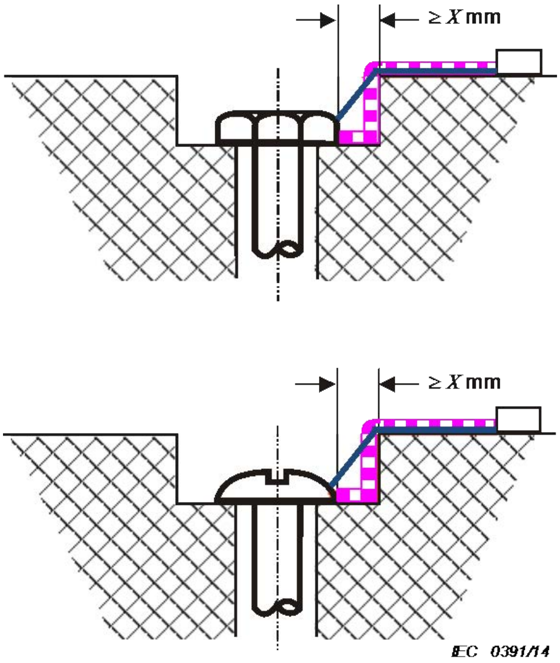
Figure O.8 – Uncemented joint with narrow and wide grooves



Gap between head of screw and wall of recess too narrow to be taken into account.

Where the gap between the head of the screw and the wall of recess is smaller than X mm, the measurement of **creepage distance** is made from the screw to the wall at the place where 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 O.10 – Wide recess

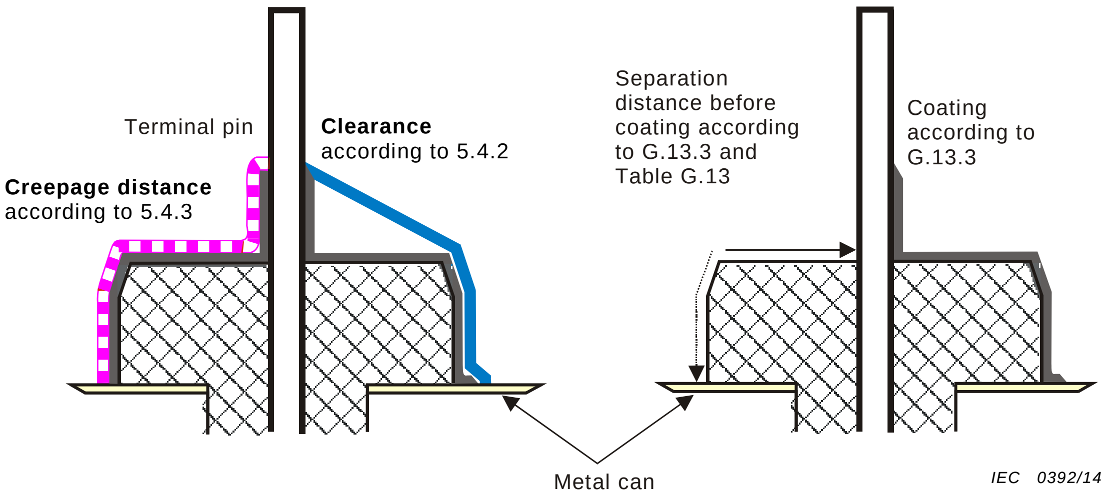


Figure O.11– Coating around terminals

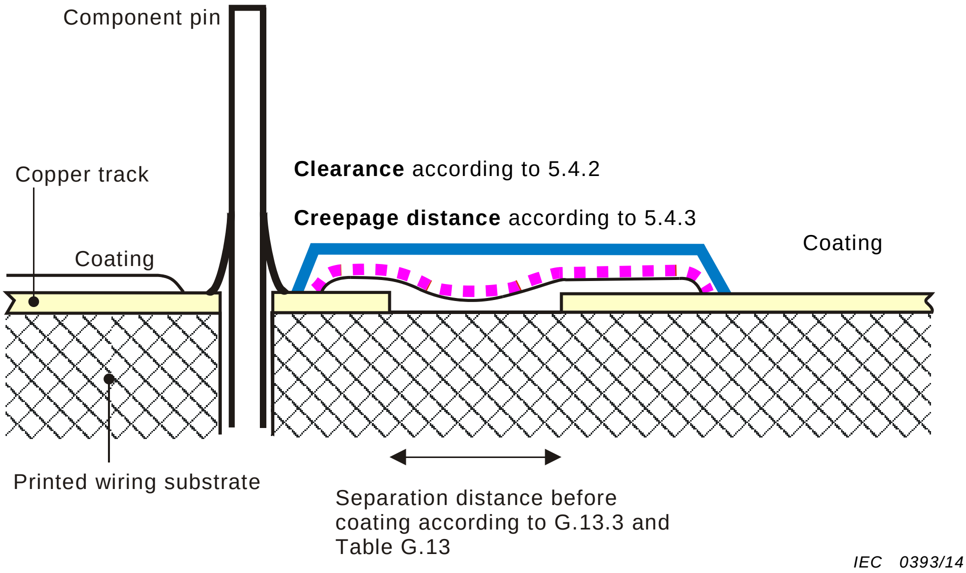


Figure O.12 – Coating over printed wiring

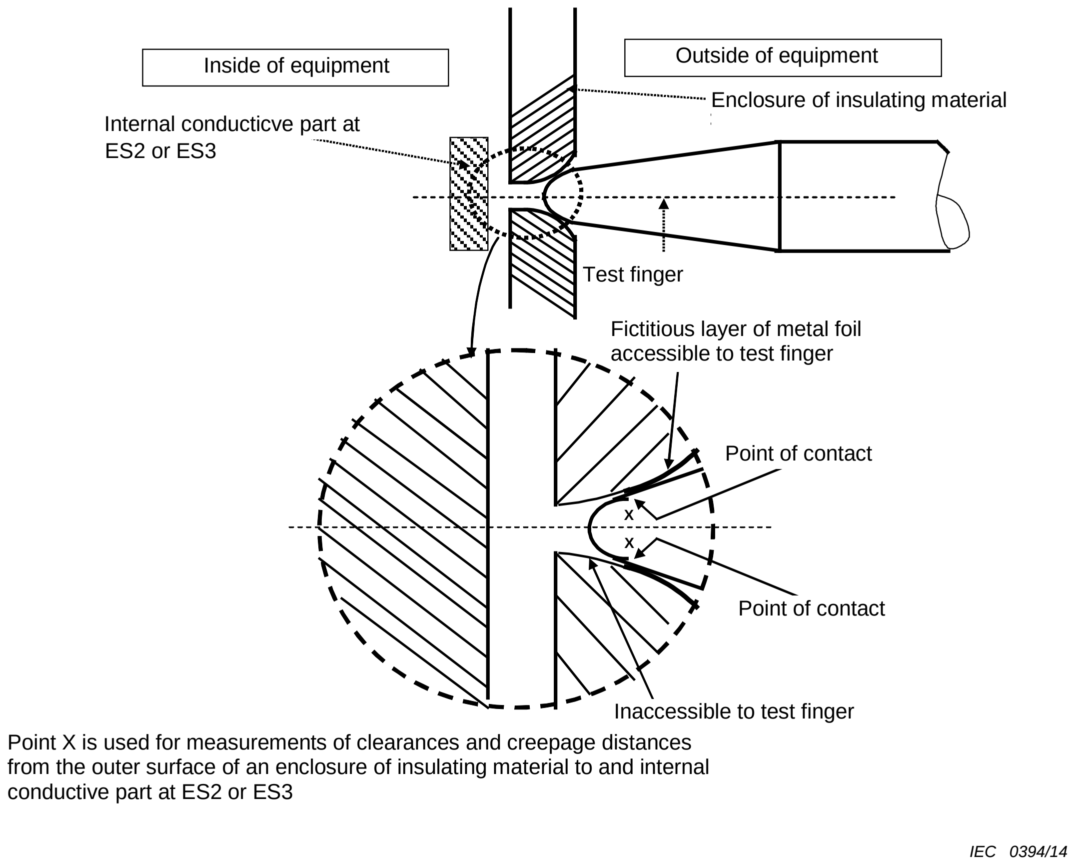


Figure O.13 – Example of measurements in an enclosure of insulating material

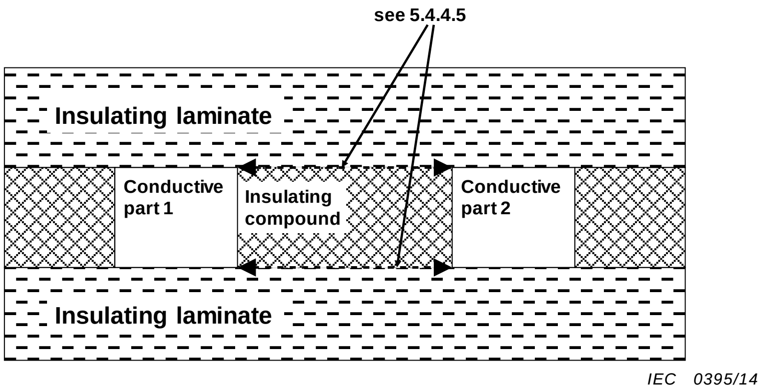


Figure O.14 – Cemented joints in multi-layer printed boards

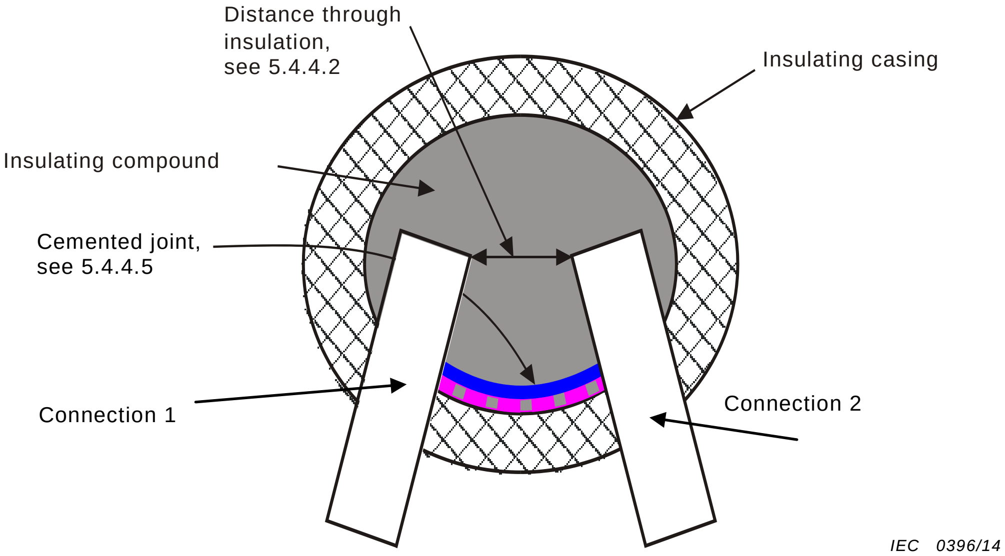


Figure O.15 – Device filled with insulating compound

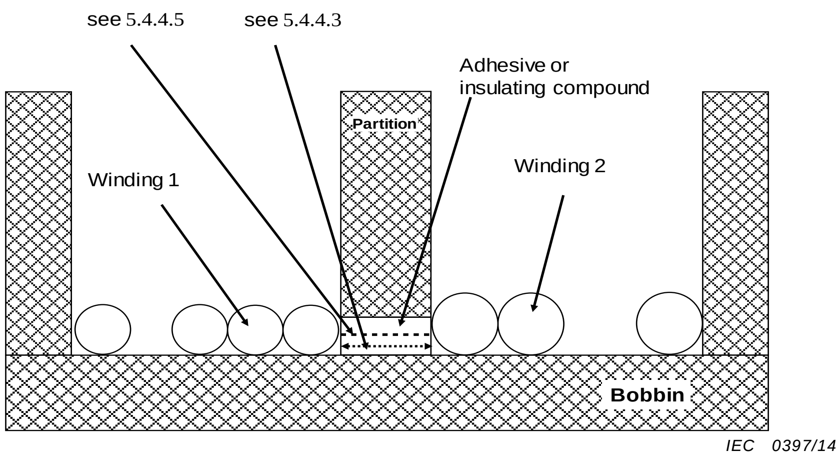
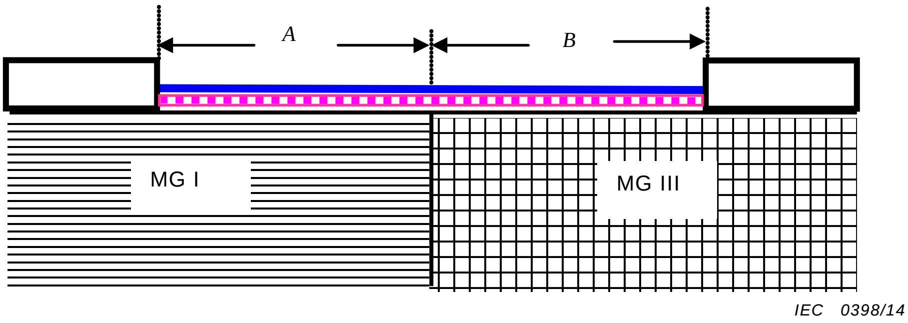


Figure O.16 – Partitioned bobbin

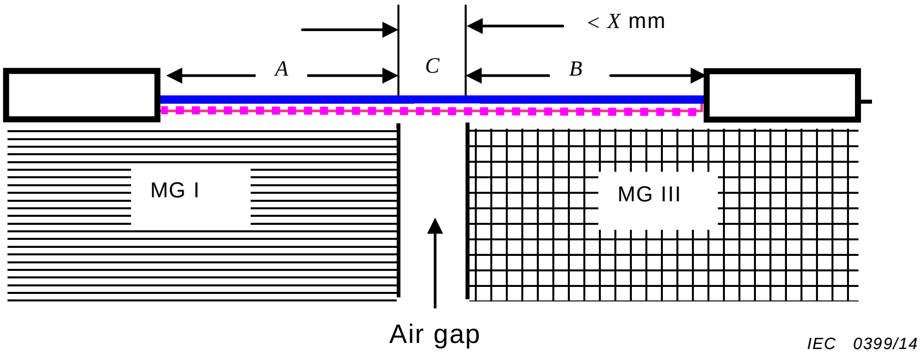


Condition: Path under consideration is along two materials having different CTI values.

Rule: **Creepage distance** is calculated as follows:

$$\frac{A}{\text{Required } \textbf{creepage} \text{ for MG I}} + \frac{B}{\text{Required } \textbf{creepage} \text{ for MG III}} \geq 1$$

Figure O.17 – Materials with different CTI values

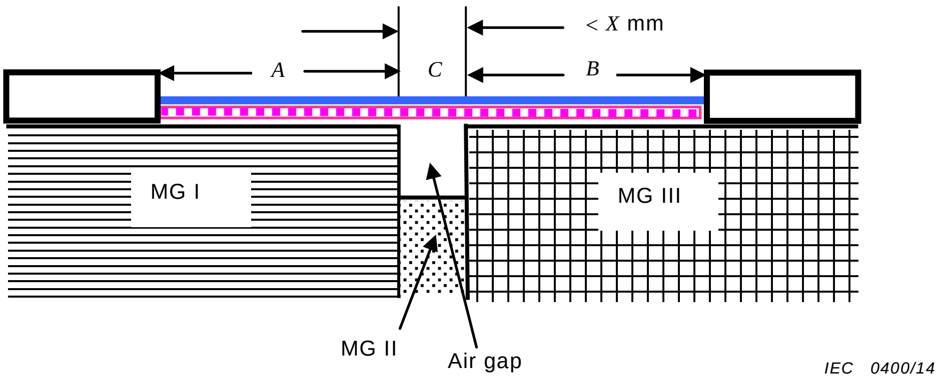


Condition: Path under consideration includes a parallel or converging-sided air gap having a width of less than *X* mm and two different materials on each side.

Rule: **Creepage distance** is calculated as follows:

$$\frac{A}{\text{Required } \textbf{creepage} \text{ for MG I}} + \frac{B + C}{\text{Required } \textbf{creepage} \text{ for MG III}} \geq 1$$

Figure O.18 – Materials with different CTI values having an air gap of less than *X* mm

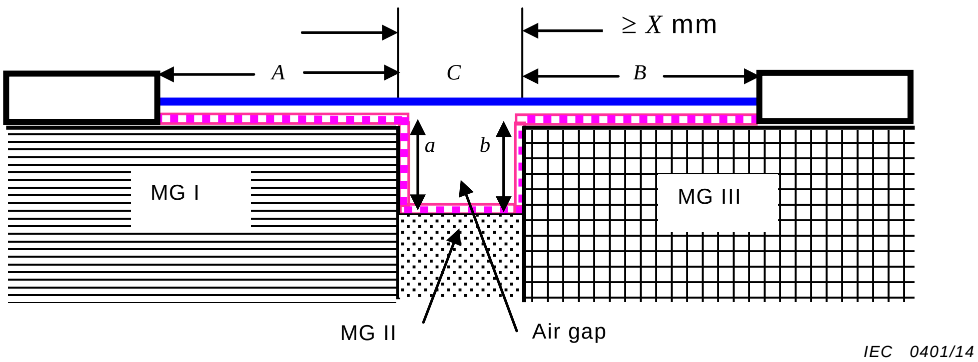


Condition: Path under consideration includes a parallel or converging-sided groove having a width of less than X mm and two different materials on each side and a different material below the groove.

Rule: **Creepage distance** is calculated as follows:

$$\frac{A}{\text{Required } \textbf{creepage} \text{ for MG I}} + \frac{B + C}{\text{Required } \textbf{creepage} \text{ for MG III}} \geq 1$$

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:

$$\frac{A + a}{\text{Required } \textbf{creepage} \text{ for MG I}} + \frac{C}{\text{Required } \textbf{creepage} \text{ for MG II}} + \frac{B + b}{\text{Required } \textbf{creepage} \text{ for MG III}} \geq 1$$

Figure O.20 – Materials with different CTI values having an air groove not smaller than X mm

Annex P
(normative)

Safeguards against conductive objects

P.1 General

This annex specifies **safeguards** to reduce the likelihood of fire, electric shock and adverse chemical reaction due to the entry of objects through top or side openings in the equipment, or due to spillage of internal liquids, or the failure of metalized coatings and adhesives securing conductive parts inside the equipment.

The **basic safeguard** against entry of a foreign object is that persons are not expected to insert a foreign object into the equipment. The **safeguards** specified in this annex are **supplementary safeguards**.

This annex does not apply to openings that are parts of connectors.

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.

For **transportable equipment**, the **safeguards** shall be effective for all orientations.

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.

P.2 Safeguards against entry or consequences of entry of a foreign object

P.2.1 General

Equipment shall comply with the requirements of P.2.2 or with the requirements of P.2.3.

P.2.2 Safeguards against entry of a foreign object

Openings in the top and sides of an **accessible enclosure** shall be so located or constructed to reduce the likelihood that a foreign object will enter the openings.

Equipment openings shall comply with the requirements specified below when the doors, panels, and covers, etc., are closed or in place. These requirements do not apply to openings located behind doors, panels, covers, etc., even if they can be opened or removed by an **ordinary person**.

The following constructions are considered to comply:

– openings that do not exceed 5 mm in any dimension;

– openings that do not exceed 1 mm in width regardless of length;

– openings that meet the requirements of IP3X or IP4X;

– top openings in which vertical entry is prevented (see Figure P.1 for examples);

– side openings provided with louvres that are shaped to deflect outwards an external vertically falling object (see Figure P.2 for examples);

– side openings without louvres where the **enclosure** thickness at the opening is not less than the vertical dimension of the opening.

Compliance is checked by inspection or measurement.

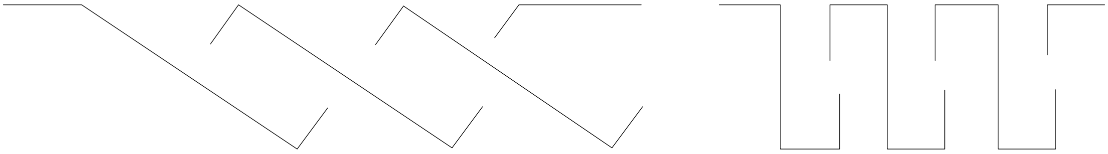


Figure P.1 – Examples of cross-sections of designs of top openings which prevent vertical entry

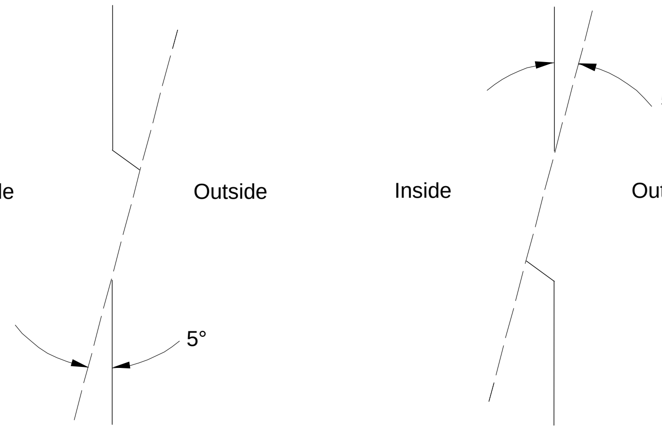


Figure P.2 – Examples of cross-sections of designs of side opening louvres which prevent vertical entry

P.2.3 Safeguards against the consequences of entry of a foreign object

P.2.3.1 Safeguard requirements

The entry of a foreign object shall not defeat an **equipment supplementary safeguard** or an **equipment reinforced safeguard**. Furthermore, the object shall not create a **PIS**.

Safeguards against the consequences of entry of foreign objects include the following:

– an internal barrier that prevents a foreign object from defeating an **equipment safeguard** or creating a **PIS**;

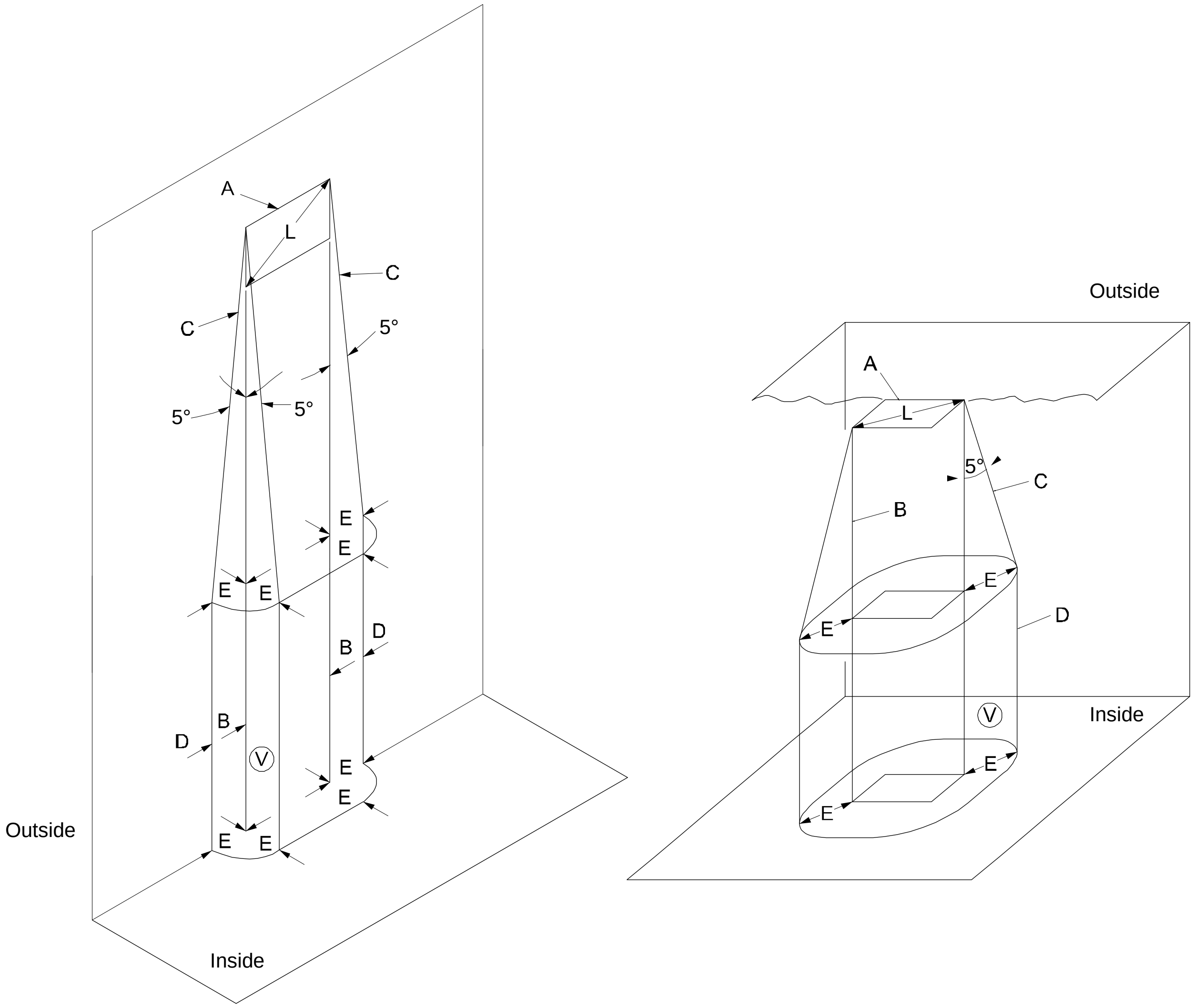
– within the projected volume as depicted in Figure P.3 there are

- no bare conductive parts of a **safeguard**; or
- no **PIS**; or
- no bare conductive parts of ES3 or PS3 circuits; or
- only conductive parts covered with conformal or other similar coatings.

NOTE 1 Conductive parts covered with conformal or other similar coatings are not considered to be bare conductive parts. A conformal coating is a dielectric material deposited on a printed circuit board and components in order to protect them against moisture, dust, corrosion and other environmental stresses.

– within the projected volume as depicted in Figure P.3, bare conductive parts at ES3 or PS3 subjected to the tests of P.2.3.2.

Other constructions shall be subject to the test of P.2.3.2.



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 projected (keep-out) volume for **supplementary** or **reinforced safeguards**

Figure P.3 – Internal volume locus for foreign object entry

For **transportable equipment**, if the design does not prevent the entry of a foreign object, the object is considered to move to any place within the equipment. The ES3 and PS3 keep-out volume in Figure P.3 is not applicable to **transportable equipment**.

For **transportable equipment** with metallized plastic parts and the like, if the design does not prevent the entry of a foreign object, the distance between the metallized parts and all bare conductive parts of ES3 or PS3 shall be at least 13 mm. Alternatively, the metallized parts and the bare conductive parts shall be tested by shorting.

NOTE 2 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 by inspection, measurement, and where necessary by the test of P.2.3.2.

P.2.3.2 Consequence of entry test

An attempt shall be made to short all bare conductive parts of ES3 or PS3 within volume V, Figure P.3, along a direct straight path to all other bare conductive parts and to all metallized parts within a 13 mm radius. The attempt of shorting is made by means of a straight metal object, 1 mm in diameter and having any length up to 13 mm, applied without appreciable force.

*For **transportable equipment**, the attempt of shorting shall be at all places where the foreign object could lodge.*

*During and after the tests, all **supplementary safeguards** and **reinforced safeguards** shall be effective, and no part shall become a **PIS**.*

P.3 Safeguards against spillage of internal liquids

P.3.1 General

The requirements specified below apply to equipment with internal liquids where that liquid may defeat any **equipment safeguard**.

These requirements do not apply to:

– liquids that are non-conductive, non-flammable, non-toxic, and non-corrosive, and are not in a pressurized container;

– electrolytic capacitors;

– liquids with viscosity of 1 Pa s or more;

– **batteries** (see Annex M).

NOTE Viscosity of 1 Pa s 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.

P.3.3 Spillage safeguards

If the spillage may result in a **single fault condition** not covered by Clause B.4, then:

– the vessel serving as a **basic safeguard** shall allow no spillage under **normal operating conditions**, and the **supplementary safeguard** (for example, a barrier or drip pan or supplementary containment vessel, etc.) shall effectively limit the spread of the spillage; 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:

– the liquid shall be contained in a **double safeguard** or a **reinforced safeguard**; or

– following the spillage:

- a toxic liquid shall not be **accessible** to **ordinary persons** or **instructed persons**, and
- a conductive liquid shall not bridge a **basic insulation**, a **supplementary insulation** or a **reinforced insulation**, and
- a flammable liquid (or its vapour) shall not contact any **PIS** or parts at a temperature that may ignite the liquid, and
- a corrosive liquid shall not contact any connection of a **protective conductor**.

A vessel that meets the relevant test requirements of Clause G.15 is considered to comprise a **reinforced safeguard**.

NOTE The following liquids are generally considered non-flammable:

– Oil or equivalent liquids used for lubrication or in a hydraulic system having a flash point of 149 °C or higher; or

– Replenishable liquids such as printing inks having a flash point of 60 °C or higher.

P.3.4 Compliance criteria

Compliance is checked by inspection or available data, and where necessary, by the relevant tests.

*During and after the tests, all **supplementary safeguards** and **reinforced safeguards** shall be effective, and no part shall become a **PIS**.*

P.4 Metallized coatings and adhesives securing parts

P.4.1 General

The metalized coating and adhesive shall have adequate bonding properties throughout the life of the equipment.

Compliance is checked by examination of the construction and of the available data. If such data is not available, compliance is checked by the tests of P.4.2.

P.5 **For metalized coatings,** clearances **and** creepage distances **for** pollution degree **3 shall be maintained instead of the tests of P.4.2.**

P.5.1 Tests

A sample of the equipment or a subassembly of the equipment containing parts having metalized coating and the parts joined by adhesive is evaluated with the sample placed with the part secured by adhesive on the underside.

Condition the sample in an oven at a temperature T_C for the specified duration (eight weeks, three weeks or one week) as follows:

$$T_C = T_R + (T_A + 10 - T_S)$$

In case the value for $T_A + 10 - T_S$ is negative, the value will be replaced by zero.

where

T_C *is the conditioning temperature;*

T_R *is the rated conditioning temperature value of (82 ± 2) °C for eight weeks; (90 ± 2) °C for three weeks; or (100 ± 2) °C (for one week) as applicable;*

T_A *is the temperature of the coating or the part under* ***normal operating conditions*** *(see B.2.6.1);*

T_S *= 82.*

NOTE 1 For example for eight week conditioning, if the actual temperature is 70 °C, then the T_A + 10 – T_S = 70 + 10 – 82 = -2, then this -2 is ignored. The minimum conditioning temperature remains 82 °C. Also, for three week conditioning, if the actual temperature is 70 °C, then the T_A + 10 – T_S = 70 + 10 – 82 = -2, then this -2 is ignored. The minimum conditioning temperature remains 90 °C. Also, for one week conditioning, if the actual temperature is 70 °C, then the T_A + 10 – T_S = 70 + 10 -82 = -2, then this -2 is ignored. The minimum conditioning temperature remains 100 °C.

NOTE 2 For example for eight week conditioning, if the actual temperature is 75 °C, then the T_A + 10 – T_S = 75 + 10 – 82 = + 3, the minimum conditioning temperature becomes 82 + 3 = 85 °C. Also, for three week conditioning, if the actual temperature is 75 °C, then the T_A + 10 – T_S = 75 + 10 – 82 = +3, then the minimum conditioning temperature remains 90 + 3 = 93 °C. Also, for one week conditioning, if the actual temperature is 75 °C, then the T_A + 10 – T_S = 75 + 10 – 82 = + 3, then the minimum conditioning temperature remains 100 + 3 = 103 °C.

NOTE 3 The table below gives the summary of the results in NOTE 1 and NOTE 2:

T_A	T_R	T_S	T_A + 10 – T_S	T_C = T_R + T_A + 10 – T_S
70	82 (8 weeks)	82	70+10-82= –2	82 + 0 = 82
70	90 (3 weeks)	82	70+10-82= –2	90 + 0 = 90
70	100 (1 week)	82	70+10-82= –2	100 + 0 = 100
75	82 (8 weeks)	82	75+10-82= +3	82 + 3 = 85
75	90 (3 weeks)	82	75+10-82= +3	90 + 3 = 93
75	100 (1 week)	82	75+10-82= +3	100 + 3 = 103

Upon completion of the temperature conditioning, subject the sample to the following:

– *remove the sample from oven and leave it at any convenient temperature between 20 °C and 30 °C for a minimum of 1 h;*

– *place the sample in a freezer at –40 °C ± 2 °C for a minimum of 4 h;*

– *remove and allow the sample to come to any convenient temperature between 20 °C and 30 °C for a minimum of 8 h;*

– *place the sample in a cabinet at 91 % to 95 % relative humidity for 72 h at any convenient temperature between 20 °C and 30 °C;*

– *remove the sample and leave it at any convenient temperature between 20 °C and 30 °C for a minimum of 1 h;*

– *place the sample in an oven at the temperature used for the temperature conditioning (*T_C*) for a minimum of 4 h;*

– *remove the sample and allow it to reach any convenient temperature between 20 °C; and 30 °C for a minimum of 8 h.*

The sample is then immediately subjected to the tests of Annex T according to 4.4.4.

With the concurrence of the manufacturer, the above time durations may be extended.

After the above tests:

- *a metalized coating or a part secured by adhesive shall not fall off or partly dislodge;*
- *a metalized coating shall be subjected to the abrasion resistance test of G.13.6.2. After the abrasion resistance test, the coating shall have not loosened and no particles shall become loose from the coating;*
- ***enclosure** parts serving as **safeguards** shall comply with all the applicable requirements for **enclosures**.*

Annex Q
(normative)

Circuits intended for interconnection with building wiring

Q.1 Limited power source

Q.1.1 Requirements

A limited power source shall comply with one of the following:

a) the output is inherently limited in compliance with Table Q.1; or

b) linear or non-linear impedance limits the output in compliance with Table Q.1. If a PTC device is used, it shall:

   1) pass the tests specified in Clauses 15, 17, J.15 and J.17 of IEC 60730-1:2010; or

   2) meet the requirements of IEC 60730-1 for a device providing Type 2.AL action;

   3) 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

c) an overcurrent protective device is used and the output is limited in compliance with Table Q.2; or

d) an IC current limiter complying with Clause G.9 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.1.2 Test method and compliance criteria

*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 maximum power shall be considered, such as from a **battery** and from a **mains** circuit.*

*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 fault conditions** are applied in a regulating network according to Clause Q.1.1, item b) 3) 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
$U_{oc} \leq 30$	$U_{oc} \leq 30$	≤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 and 60 s in case of a PTC device or 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			≤5,0
$20 < U_{oc} \leq 30$	$20 < U_{oc} \leq 30$	≤1 000/U_{oc}	≤250	≤100/U_{oc}
–	$30 < U_{oc} \leq 60$			≤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.2 Test for external circuits – paired conductor cable

Equipment supplying power to an ***external circuit*** *paired conductor cable intended to be connected to the building wire 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 B.2.3 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 B.2.3 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. This test demonstrates that a **protective bonding conductor**, used in circuits protected by a device having a rating not exceeding 25 A, is suitable for the fault current permitted by the overcurrent protective device, and in doing so, tests the integrity of a **supplementary safeguard**.

R.2 Test setup

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****.*

If the overcurrent protective device is provided in the equipment, then this is used for the test.

For a.c. sources where only one overcurrent protective 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 protective device is by-passed. The manufacturer shall specify the device used for the test in the equipment safety instructions.

Where there is no protective device present in the equipment, a suitable overcurrent protective device shall be chosen. This overcurrent protective device shall be such that it does not interrupt the fault current before half a cycle has passed. The overcurrent protective device in the building installation for a.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.

R.3 Test method

The source shall be applied to the EUT via the ***mains*** *cord supplied or specified by the equipment manufacturer. Where there is no* ***mains*** *cord supplied or specified, a 1 m length of 2,5 mm^2 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 a short-circuit in the equipment to the earth connection of the equipment shall be introduced. The point at which this is done is depending on the equipment. After consideration of the equipment construction and circuit diagrams, the short-circuit shall be introduced between the phase conductor, at the point nearest to the input (the point of lowest impedance), and the protective bonding path under consideration. There may be more than one point at which this short-circuit may be applied to determine the worst case.

The ***protective bonding conductor*** *is connected to a source capable of supplying an a.c. or d.c. current, as appropriate to the EUT, 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, shall remain connected 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 criteria

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 **clearances**, **creepage distances** and distances through insulation,*

– *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 are usually 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.*

The following additional requirements apply to the specified clauses of IEC 60695-11-5:2004.

Clause 6 of IEC 60695-11-5:2004 – 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 of IEC 60695-11-5:2004 – 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 of IEC 60695-11-5:2004 – 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 5.4.1.4 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 of IEC 60695-11-5:2004 – 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 of IEC 60695-11-5:2004 – 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.*

For the purpose of this standard, the following additional requirements apply to the stated clauses of IEC 60695-11-5:2004.

Clause 6 of IEC 60695-11-5:2004 – 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 of IEC 60695-11-5:2004 – Severities

The value of duration of application of the test flame is as follows:

– *the test flame is applied for 60 s.*

Clause 8 of IEC 60695-11-5:2004 – 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 5.4.1.4 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 of IEC 60695-11-5:2004 – 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 of IEC 60695-11-5:2004 – 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. A* ***cheesecloth*** *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.*

Use of a metal screen or a wired-glass ***enclosure*** *surrounding the test area is recommended.*

S.3.2 Test method and compliance criteria

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 diesel fuel oil. 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.

NOTE “Diesel fuel oil” is regarded to be similar to a medium volatile distillate fuel oil having a mass per unit volume between 0,845 g/ml and 0,865 g/ml, a flash point between 43,5 °C and 93,5 °C and an average calorific value of 38 MJ/l

The 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.

The hierarchies of the **material flammability classes** are given in Table S.1, Table S.2 and Table S.3.

Table S.1 – Foamed materials

Material flammability class	ISO standard
HF-1 regarded better than **HF-2**	ISO 9772
HF-2 regarded better than **HBF**	ISO 9772
HBF	ISO 9772

Table S.2 – Rigid materials

Material flammability class	IEC standard
5VA regarded better than **5VB**	IEC 60695-11-20
5VB regarded better than **V-0**	IEC 60695-11-20
V-0 regarded better than **V-1**	IEC 60695-11-10
V-1 regarded better than **V-2**	IEC 60695-11-10
V-2 regarded better than **HB40**	IEC 60695-11-10
HB40 regarded better than **HB75**	IEC 60695-11-10
HB75	IEC 60695-11-10

Table S.3 – Very thin materials

Material flammability class	ISO standard
VTM-0 regarded better than **VTM-1**	ISO 9773
VTM-1 regarded better than **VTM-2**	ISO 9773
VTM-2	ISO 9773

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.

EXAMPLE Wood-based materials 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 of IEC 60695-11-20:1999, 8.3.*

For the purpose of this standard, the following additional requirements apply to the specified clauses of IEC 60695-11-20:1999.

Clause 7 of IEC 60695-11-20:1999 – 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 of IEC 60695-11-20:1999 – 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 5.4.1.4 or 70 °C, whichever is the higher, and then cooled to room temperature.*

Subclause 8.3 of IEC 60695-11-20:1999 – Plate procedure

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 of IEC 60695-11-20:1999 – 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.*

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 this standard. 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 N ± 1 N is applied to the component or part under consideration for a short time duration of approximately 5 s.

T.3 Steady force test, 30 N

The test is conducted by means of the straight unjointed version of the applicable test probe of Figure V.1 or Figure V.2, applied with a force of 30 N ± 3 N for a short time duration of approximately 5 s.

T.4 Steady force test, 100 N

The test is conducted by subjecting the external ***enclosure*** *to a steady force of 100 N ± 10 N over a circular plane surface 30 mm in diameter for a short time duration of approximately 5 s, applied in turn to the top, bottom, and sides.*

T.5 Steady force test, 250 N

The test is conducted by subjecting the external ***enclosures*** *to a steady force of 250 N ± 10 N over a circular plane surface 30 mm in diameter for a short time period of approximately 5 s, applied in turn to the top, bottom and sides.*

T.6 Enclosure impact test

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 of 50 mm ± 1 mm in diameter and with a mass of 500 g ± 25 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 ± 10 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 ± 10 mm onto the sample (see Figure T.1).*

For evaluating a part that acts as a ***fire enclosure*** *only, the test is done as above, but the vertical distance is 410 mm ± 10 mm.*

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.

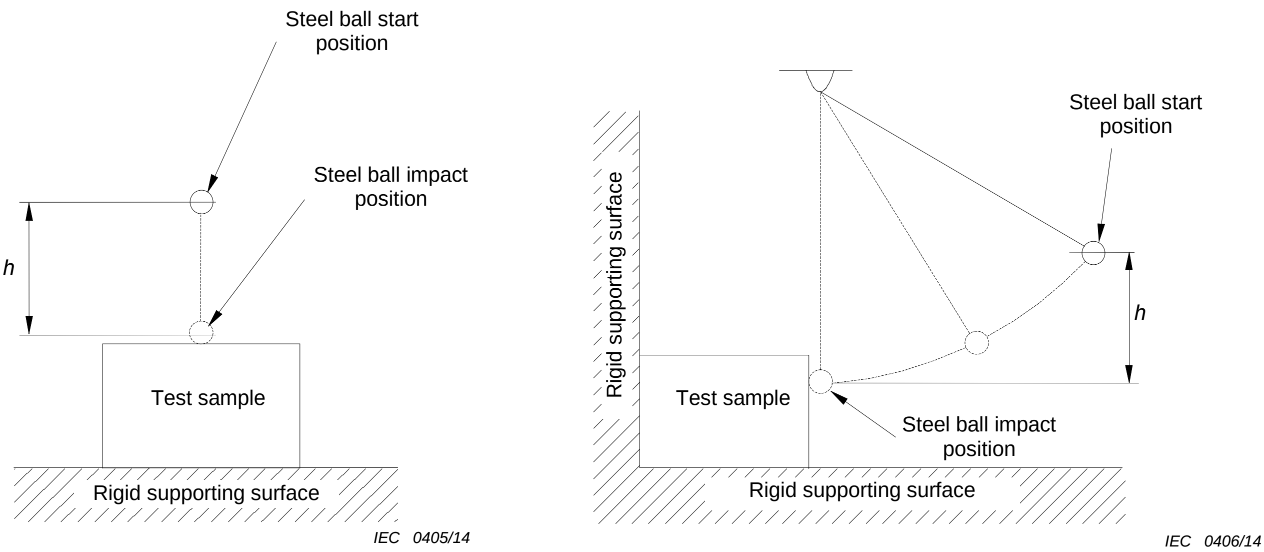


Figure T.1 – Impact test using sphere

T.7 Drop test

A sample of the complete equipment is subjected to three impacts that result from being dropped onto a horizontal surface in positions likely to produce the most adverse results.

The height of the drop shall be:

- *750 mm ± 10 mm for desk-top or table-top equipment and **moveable equipment**;*
- *1 000 mm ± 10 mm for **hand-held equipment**, **direct plug-in equipment** and **transportable equipment**.*
- *500 mm ± 10 mm for a part acting as a **fire enclosure** only of desk-top equipment and **moveable equipment;***
- *350 mm ± 10 mm for a part acting as a **fire enclosure** only of **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 ± 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 5.4.1.4.2, 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 Impact test

The test sample is supported over its whole area and shall be subjected to a single impact, specified in Table T.1. If the sample is made of glass, the impact shall be applied in a location representing the centre of the glass.

The impact specified shall be caused by allowing a solid, smooth, steel ball of 50 mm ± 1 mm in diameter and with the mass of 500 g ± 25 g to fall freely from rest through a vertical distance not less than specified in Table T.1, as shown in Figure T.1, and strike the sample with the specified impact in a direction perpendicular to the surface of the sample.

Table T.1 – Impact force

Part	**Result**	**Impact** J	**Height** mm
Unles otherwise specified below, any glass used as a **safeguard** against class 3 energy sources	Class 3 energy sources	3,5	714
Glass on floor standing equipment	Skin-lacerations	3,5	714
Glass on portable equipment, table-top equipment and on fixed mounted equipment	Skin-lacerations	2	408
Glass serving only as a **fire enclosure**	PS energy source	1	204
Glass lenses that are provided for the attenuation of UV radiation	Exposure to UV radiation	0,5	102
To apply the required impact, the height is calculated by $H = E / (g \times m)$ where H is the vertical distance in metres with a tolerance of ± 10 mm; E is the impact energy in Joules; g is the gravitational acceleration of 9,81 m/s^2; m is the mass of the steel ball in kilograms.			

T.10 Glass fragmentation test

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 with sides of 50 mm shall not be less than 45.

T.11 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
$\geq$ 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, an **instructional safeguard** shall be provided in accordance with Clause F.5:

- element 1a: not available
- element 2: “Warning” or equivalent word or text
- element 3: “Risk of injury” or equivalent text
- element 4: “The CRT in this equipment uses 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” or equivalent text

The **instructional safeguard** shall be provided in the instructions.

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 is requested to indicate the most vulnerable area on the CRTs to be tested.

U.2 Test method and compliance criteria 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.

A part is considered **accessible** if the instructions or markings intended to be followed require that a person physically contacts that part. This applies without test and irrespective of whether a **tool** is required to gain access.

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 1 Equipment intended for use in homes, schools, public and similar locations is equipment generally considered to be **accessible** to children, see also Clause F.4.

– *the test probe of Figure V.2 for equipment that is not likely to be **accessible** to children.*

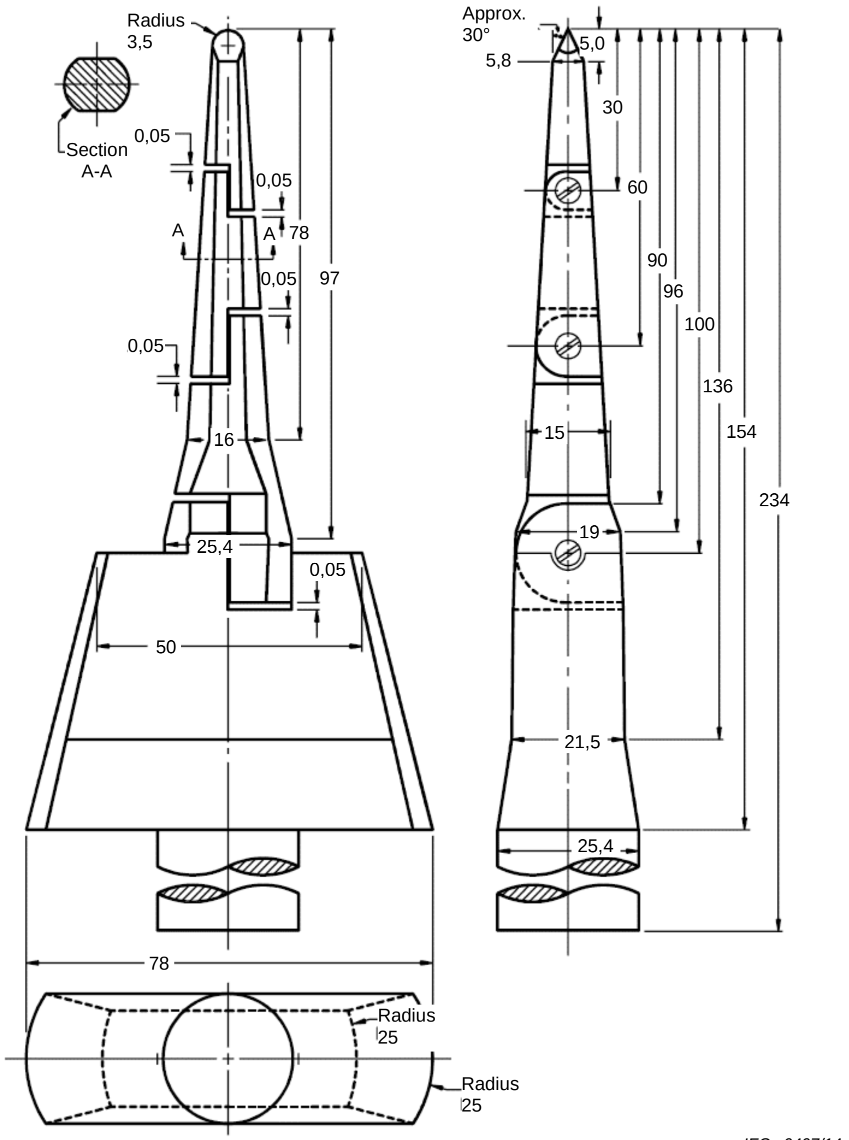
*Where entry behind a door, panel, removable cover, etc. is possible without the use of a **tool**, or entry is directed by manufacturer instructions or marking, with or without the use of a **tool**, the test probe is applied to surfaces and openings in those areas.*

*Where the entire probe passes through a large opening (allowing entry of an arm but not of a shoulder), the probe shall be applied to all parts within a hemisphere with radius of 762 mm. The probe handle shall point along a path towards the large opening to simulate the hand on the end of the arm extending through the large opening. The plane of the hemisphere shall be the outside plane of the opening. Any part outside the 762 mm radius hemisphere is deemed not **accessible**.*

NOTE 2 The equipment can be dismantled to perform this test.

V.1.3 Test method 2 – Openings tested with straight unjointed test probes

Openings preventing access to a part by the applicable jointed test probe of Figure V.1 or Figure V.2 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 applicable jointed version of the test probe is pushed through the opening using any necessary force up to 30 N.*



IEC 0407/14

Dimensions in millimetres

Tolerances on dimensions without specific tolerances:

angles: ± 15′

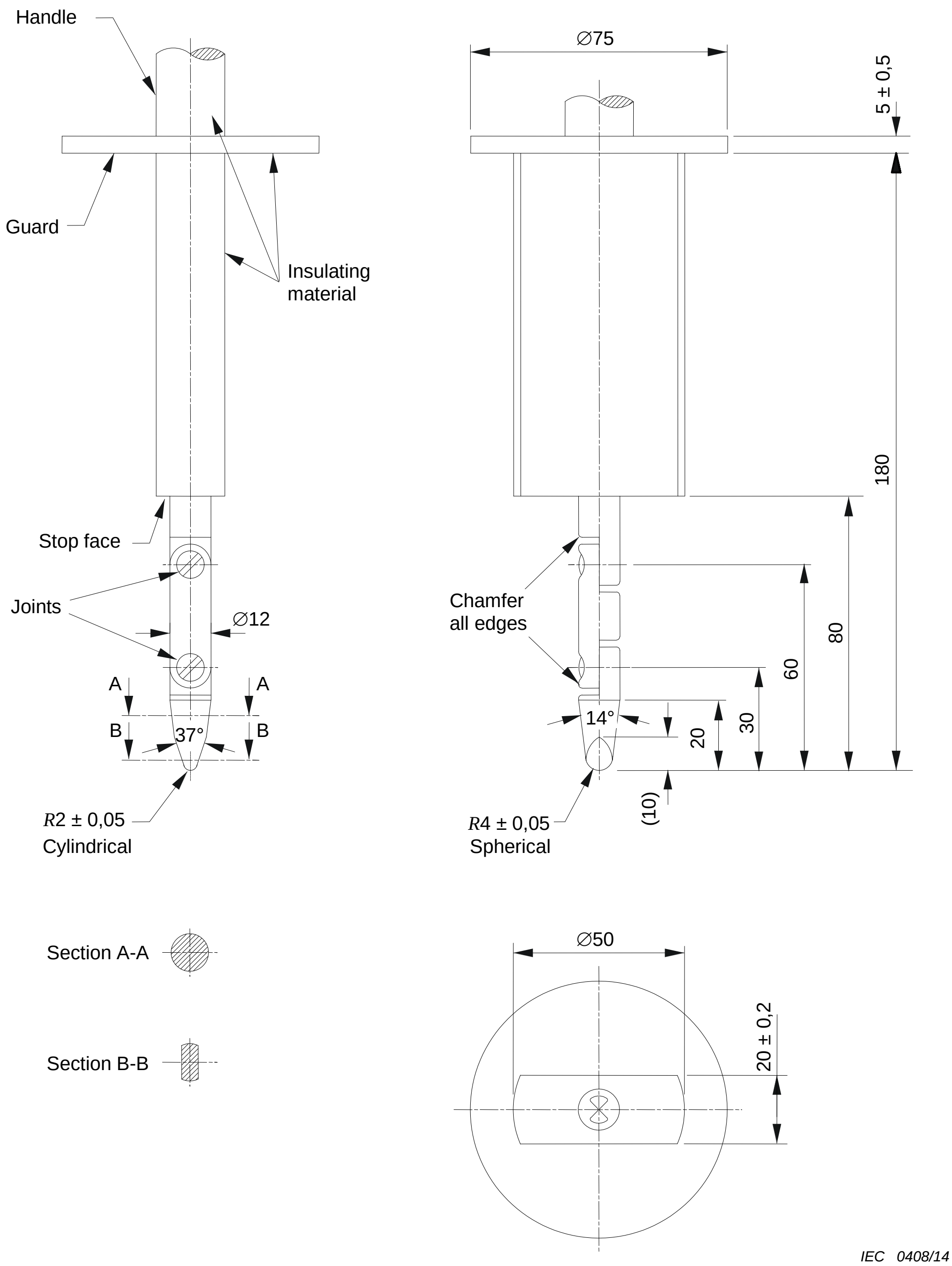
on radii: ± 0,1 mm

Tolerances on linear dimensions without specific tolerances:

≤ 15 mm:	$^{0}_{-0,1}$ mm
> 15 mm ≤ 25 mm:	± 0,1 mm
> 25 mm:	± 0,3 mm

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

Figure V.1 – Jointed test probe for equipment likely to be accessible to children



Linear dimensions in millimetres

Tolerances on dimensions without specific tolerances:

14° and 37° angles: ± 15′

on radii: ± 0,1 mm

on linear dimensions:

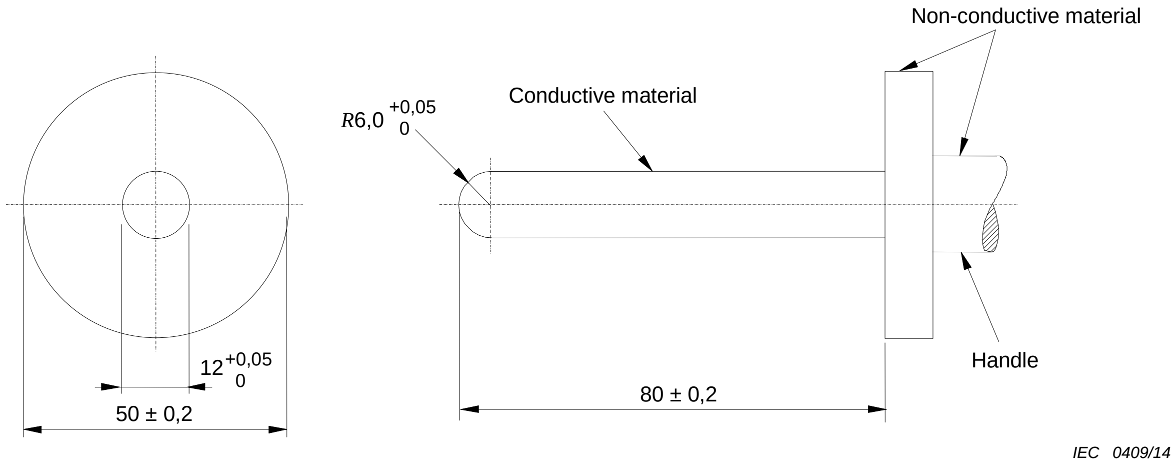
≤ 15 mm:	$^{0}_{-0,1}$ mm
> 15 mm ≤ 25 mm:	± 0,1 mm
> 25 mm:	± 0,3 mm

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

The blunt probe of Figure V.3 is applied without appreciable force and in any possible position to specified parts.

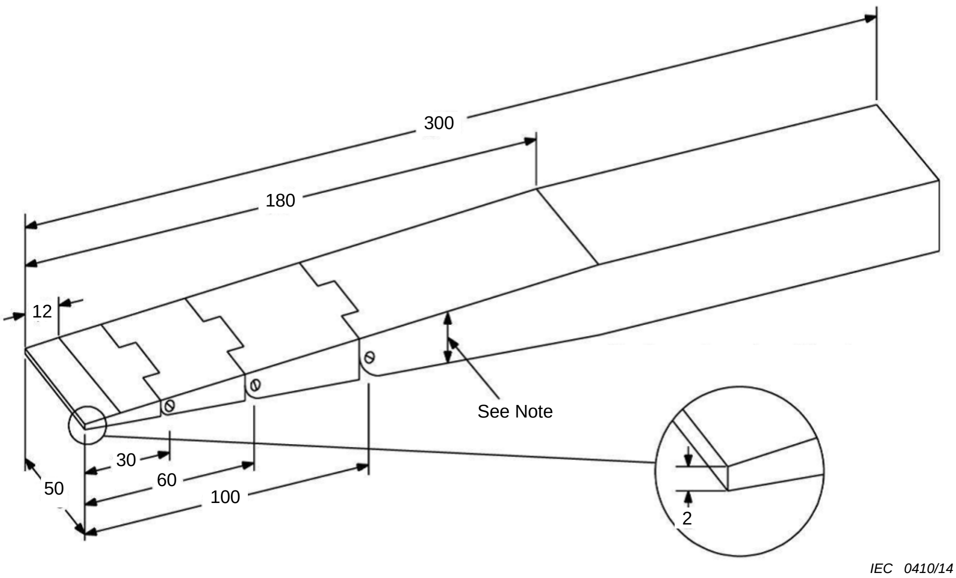


Dimensions in millimetres

Figure V.3 – Blunt probe

V.1.5 Test method 4 – Slot openings

The wedge probe of Figure V.4 is applied as specified.



Dimensions in millimetres

Tolerances on linear dimensions without specific tolerances:

≤ 25 mm: ± 0,13 mm

> 25 mm: ± 0,3 mm

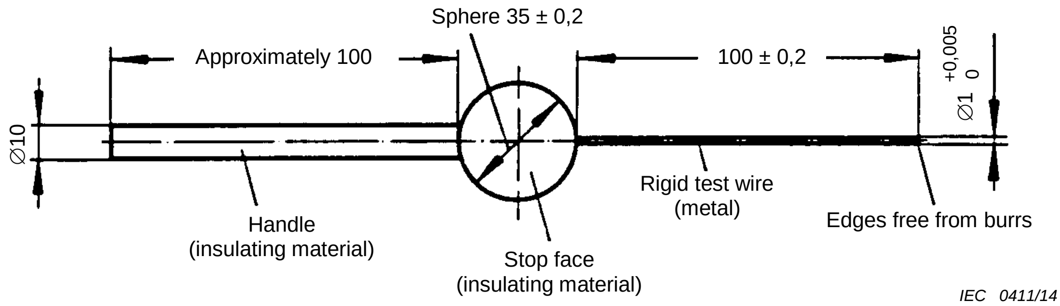
NOTE The thickness of the probe varies linearly, with slope changes at the following points along the probe:

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

The rigid test wire of the test probe of Figure V.5 is inserted into the applicable opening with a force up to 1 N ± 0,1 N and with the length limited to 20 mm ± 0,2 mm. While inserted, the probe is moved in any angle with minimal force.



Dimensions in millimetres

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 64 [5] basic safety publications and other relevant safety publications.

Terms not in the tables below are either the same or substantially the same as in other IEC standards.

W.2 Comparison of terms

In the tables 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 and definitions in IEC 60664-1:2007 and IEC 62368-1

IEC 60664-1:2007	IEC 62368-1
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 placed 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	3.3.14.9 **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

5 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	IEC 62368-1
3.13 **pollution degree** numeral characterizing the expected pollution of the micro-environment	**3.3.6.5** **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	**3.3.6.11** **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
3.9.2 **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	**3.3.6.7** **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	**3.3.6.8** **sampling test** test on a number of devices taken at random from a batch

Table W.2 – Comparison of terms and definitions in IEC 61140:2001 and IEC 62368-1

IEC 61140:2001 terms	IEC 62368-1 terms
3.1.1 basic protection protection against electric shock under fault-free conditions	*For consistency throughout the standard the term* "safeguard" *is used to describe the device or scheme that provides protection against an energy source.* **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	**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**
3.4 **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 NOTE 1 This concept does not necessarily imply a risk of electric shock. NOTE 2 For definitions of PEM and PEL see IEV 195-02-13 and 195-02-14.	*The term* **live part** *is not used.* *In accordance with the IEC 61140 definition, ES1, ES2 and ES3 are all live parts*
3.5 **hazardous-live-part** live part that, under certain conditions, can give a harmful electric shock 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.	*The term* **hazardous-live-part** *is not used.* *In accordance with the IEC 61140 definition, an ES3 source is a hazardous-live-part.*
3.26 **extra-low-voltage (ELV)** any voltage not exceeding the relevant voltage limit specified in IEC/TS 61201	*No equivalent term. See ES1.*
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** *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* – *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** *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* – *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.	*ES1 current limit is 0,5 mA a.c. and 2 mA d.c.* *ES2 current limit is 5 mA a.c., 25 mA d.c. (these values are taken from IEC/TS 60479-1)*
No equivalent term	**3.3.11.12** **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
No equivalent term. Based on double insulation	**3.3.11.2** **double safeguard** **safeguard** comprising both a **basic safeguard** and a **supplementary safeguard**
No equivalent term. Based on reinforced insulation	**3.3.11.11** **reinforced safeguard** single **safeguard** that is operational under – **normal operating conditions**, – **abnormal operating conditions**, and – **single fault conditions**.
No equivalent term. Roughly equivalent to a warning	**3.3.11.5** **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
No equivalent term	**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**
No equivalent term	**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
The term normal condition is used in IEC 61140, but not defined	**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
No equivalent term	**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
The term single fault is used in IEC 61140, but not defined	**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

Table W.3 – Comparison of terms and definitions in IEC 60950-1:2005 and IEC 62368-1

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 14, ID numbers 1, 2 and 3 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 14, ID numbers 1, 2 and 3 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: – an integrated Services Digital Network (ISDN); – 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 14

<table>
<tr><th>IEC 60950-1:2005 terms</th><th>IEC 62368-1 terms</th></tr>
<tr><td>None</td><td>3.3.8.1
instructed person
a person instructed or supervised by a skilled person as energy sources and who can responsibly use equipment and precautionary safeguards with respect to those energy sources</td></tr>
<tr><td>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</td><td>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</td></tr>
<tr><td>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.</td><td>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 14.</td></tr>
</table>

Table W.4 – Comparison of terms and definitions in IEC 60728-11 and IEC 62368-1

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 14.

Table W.5 – Comparison of terms and definitions in IEC 62151 and IEC 62368-1

IEC 62151 terms	IEC 62368-1 terms
3.1.3 **telecommunication network** a metallically 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 14.
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.

Table W.6 – Comparison of terms and definitions in IEC 60065 and IEC 62368-1

IEC 60065 terms	IEC 62368-1 terms
2.2.12 **professional apparatus** apparatus for use in trades, professions or industries and which is not intended for sale to the general public NOTE The designation should be specified by the manufacturer	No equivalent term.
2.4.3 **directly connected to the mains** electrical connection with the mains in such a way that a connection to either pole of the mains causes in that connection a permanent current equal to or greater than 9 A, protective devices in the apparatus being not short-circuited NOTE A current of 9 A is chosen as the minimum breaking current of a 6 A fuse	No equivalent term. In accordance with the IEC 60065 definition, an ES3 source would be considered directly connected to the **mains**.
2.4.4 **conductively connected to the mains** electrical connection with the mains in such a way that a connection through a resistance of 2 000 Ω to either pole of the mains causes in that resistance a permanent current greater than 0,7 mA (peak), the apparatus not being connected to earth	No equivalent term. In accordance with the IEC 60065 definition, an ES3 or ES2 source could be considered conductively connected to the **mains**.

IEC 60065 terms	IEC 62368-1 terms
2.4.7 **telecommunication network** metallically-terminated transmission medium intended for communication between apparatus 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 either a TNV circuit. Only the circuits in the apparatus are so classified. NOTE 2 A telecommunication network may be: - publicly or privately owned: - subject to transient overvoltages due to atmospheric discharges and faults in power distribution systems: - subject to longitudinal (common mode) voltages induced from nearby power lines or electric traction lines. NOTE 3 Examples of telecommunication networks are: - a public switched telephone network; - a public data network; - an 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 14
2.6.10 **hazardous live** electrical condition of an object from which a hazardous touch current (electric shock) could be drawn (see 9.1.1)	The term hazardous-live is not used. In accordance with the IEC 60065 definition, an ES3 source is hazardous live.
2.8.6 **instructed person** person adequately advised or supervised by skilled persons to enable him or her to avoid dangers and to prevent risks which electricity may create	**3.3.8.1** **instructed person** person instructed or supervised by a skilled person as to energy sources and who can responsibly uses **equipment safeguards** 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.

IEC 60065 terms	IEC 62368-1 terms
2.8.11 **potential ignition source** possible fault which can start a fire if the open-circuit voltage measured across an interruption or faulty contact exceeds a value of 50 V (peak) a.c. or d.c. and the product of the peak value of this voltage and the measured r.m.s. current under normal operating conditions exceeds 15 VA. Such a faulty contact or interruption in an electrical connection includes those which may occur in conductive patterns on printed boards. NOTE An electronic protection circuit may be used to prevent such a fault from becoming a potential ignition source.	**3.3.9.2** **arcing PIS** location where an arc may occur due to the opening of a conductor or 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.

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SOMMAIRE

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

ÉQUIPEMENTS DES TECHNOLOGIES DE L'AUDIO/VIDÉO, DE L'INFORMATION ET DE LA COMMUNICATION –

Partie 1: Exigences de sécurité

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Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

– addition des exigences pour les LED;
– nouvelles exigences pour les dispositifs montés sur un mur et un plafond;

– addition des exigences relatives aux chocs acoustiques pour les lecteurs de musique individuels;
– révision des exigences relatives aux piles et batteries, avec de nouvelles exigences concernant les piles et accumulateurs boutons;
– révision des exigences relatives aux brûlures.

Le texte de cette norme est issu des documents suivants:

FDIS	Rapport de vote
108/521/FDIS	108/531/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à l'approbation de cette norme.

Cette publication a été rédigée selon les Directives ISO/CEI, Partie 2.

Une liste de toutes les parties de la série CEI 62368, publiées sous le titre général *Equipements des technologies de l'audio/vidéo, de l'information et de la communication*, peut être consultée sur le site web de la CEI.

Les notes "dans certains pays" concernant les différentes pratiques nationales figurent dans les paragraphes suivants:

0.2.1, 1, 4.1.15, 4.7.3, 5.2.2.2, 5.4.2.3.2.4, 5.4.2.5, 5.4.5.1, 5.5.2.1, 5.5.6, 5.6.4.2, 5.7.5, 5.7.6.1, 10.5.3, 10.6.2.1, F.3.3.6, Tableau 13, Tableau 14 et Tableau 39.

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**.

Dans les figures et les tableaux, si la couleur est disponible:

– la couleur verte indique une source d’énergie de classe 1;
– la couleur jaune indique une source d’énergie de classe 2;
– la couleur rouge indique une source d’énergie de classe 3.

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 est attirée sur le fait que les fabricants d'appareils et les organismes d'essai peuvent avoir besoin d'une période transitoire après la publication d'une nouvelle publication CEI, ou d'une publication amendée ou révisée, pour fabriquer leurs produits conformes aux nouvelles exigences et pour adapter leurs équipements aux nouveaux essais ou aux essais révisés. Le comité recommande que le contenu de cette publication soit entériné au niveau national au plus tôt cinq ans après la date de publication.

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 comité 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 transitoire recommandée.

NOTE 3 Les informations explicatives relatives à la CEI 62368-1 sont contenues dans la CEI/TR 62368-2. Celle-ci comporte les justifications, ainsi que les informations explicatives relatives à la présente norme.

IMPORTANT – Le logo *"colour inside"* qui se trouve sur la page de couverture de cette publication indique qu'elle contient des couleurs qui sont considérées comme utiles à une bonne compréhension de son contenu. Les utilisateurs devraient, par conséquent, imprimer cette publication en utilisant une imprimante couleur.

INTRODUCTION

0 Principes de la présente norme relative à la sécurité des produits

0.1 Objectif

La présente partie de la CEI 62368 est une norme relative à la sécurité des produits qui classifie les sources d'énergie, spécifie des **protections** contre ces sources d'énergie, et fournit des recommandations concernant leur application et leurs exigences.

Les **protections** spécifiées 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 pour les douleurs et les blessures

Une source d’énergie 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’énergie. 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 ou physiologique peut ne pas se manifester pendant des jours, des semaines, des mois ou des années.

0.4 Sources d’énergie

Les sources d’énergie sont traitées par la présente norme avec 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 lié à une brûlure	6
Réaction chimique (par exemple, électrolyte, poison)	Endommagement de la peau, 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

De nombreux produits utilisent systématiquement de l'énergie pouvant provoquer des douleurs ou des blessures. La conception du produit 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'énergie (diminuer la probabilité que l'énergie s'échappe), ou
– interposer une barrière entre une partie du corps et la source d'énergie.

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 par 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.

Généralement, l'ordre de préférence pour présenter des **protections** est le suivant:

– **protections de l'équipement**: sont toujours utiles dans la mesure où elles ne nécessitent aucune connaissance ou action de la part des personnes en contact avec l'équipement;
– **protections de l'installation**: sont utiles lorsqu'une caractéristique de sécurité ne peut être assurée qu'après l'installation (par exemple, l'équipement est à boulonner au sol pour des raisons de stabilité);
– **protections** de comportement: sont utiles lorsque l'équipement nécessite qu'une source d'énergie soit **accessible**.

En pratique, le choix d'une **protection** prend en compte la nature de la source d'énergie, 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 individuelle

Une **protection individuelle** peut être une **protection principale**, une **protection supplémentaire** ou une **protection renforcée**.

Les exigences relatives aux **protections individuelles** 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.

0.5.5 Protections de comportement

0.5.5.1 Introduction aux protections de comportement

En l'absence d'une **protection** de l'équipement, de l'installation ou **individuelle**, une personne peut adopter un comportement particulier comme **protection** pour éviter le transfert d'énergie et les blessures qui en résultent. Une **protection** de comportement est un comportement volontaire ou averti destiné à réduire la probabilité de transfert d'énergie à une partie du corps.

La présente norme spécifie trois types de protections de comportement. Chaque type de **protection** de comportement est associé à un type particulier de personne. Une **protection par instructions** concerne généralement une **personne ordinaire**, mais elle peut également concerner une **personne avertie** ou une **personne qualifiée**. Une **protection de précaution** est employée par une **personne avertie**. Une **protection mise en place grâce à l'expérience acquise** est utilisée par une **personne qualifiée**.

0.5.5.2 Protection par instructions

Une **protection par instructions** est un moyen de fournir des informations, 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 Annexe F).

Une **protection par instructions** peut être une indication visuelle (symboles, mots ou les deux) ou un message sonore, selon le cas applicable pour l'utilisation prévue du produit.

Une **protection par 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 ou de classe 3.

Si les **protections de l'équipement** nuisent ou empêchent son fonctionnement, une **protection par instructions** peut remplacer les **protections de l'équipement.**

Si l'exposition à une source d'énergie pouvant provoquer une douleur ou une blessure est essentielle au bon fonctionnement de l'équipement, une **protection par instructions** peut être utilisée pour assurer la protection des personnes plutôt que d'avoir recours à une autre

protection. Il convient de considérer le fait de savoir s'il convient d'utiliser ou non une **protection individuelle** pour la **protection par instructions**.

La mise à disposition d'une **protection par instructions** ne fait pas d'une **personne ordinaire** une **personne avertie** (voir 0.5.5.3).

0.5.5.3 Protection de précaution (utilisée par une personne avertie)

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 précisées 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** est sensée alors appliquer une précaution comme **protection** pour éviter les blessures.

0.5.5.4 Protection mise en place grâce à l'expérience acquise (utilisée par une personne qualifiée)

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 précisées 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** est sensée alors utiliser son expérience comme **protection** pour éviter les blessures.

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 par instructions**.

0.5.7 Protections 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** a 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 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** (contre le feu)	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 par 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 par instructions** permettant de déconnecter le câble de télécommunication avant de soulever le couvercle	Exemple: après l'ouverture d'une porte, **protection par instructions** contre les parties chaudes	Exemple: **protection par 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)

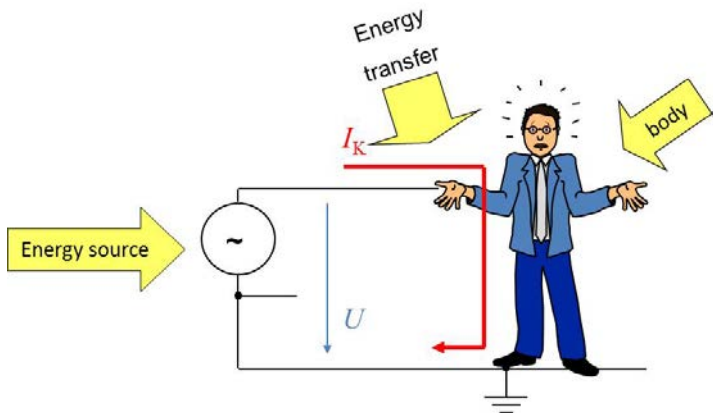
0.6.1 Modèles pour des douleurs ou blessures dues à l'électricité

Une douleur ou une blessure due à l'électricité peut survenir quand une énergie électrique susceptible de provoquer une douleur ou une blessure est transférée 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.



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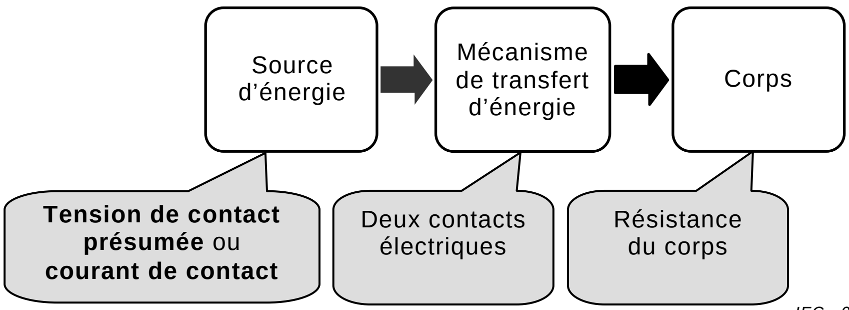


IEC 0325/14

Légende

Anglais	Français
Energy transfer	Transfert d'énergie
Body	Corps
Energy source	Source d'énergie

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.

0.6.2 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'énergie électrique pouvant provoquer une douleur ou une blessure et une partie du corps (voir la Figure 4).

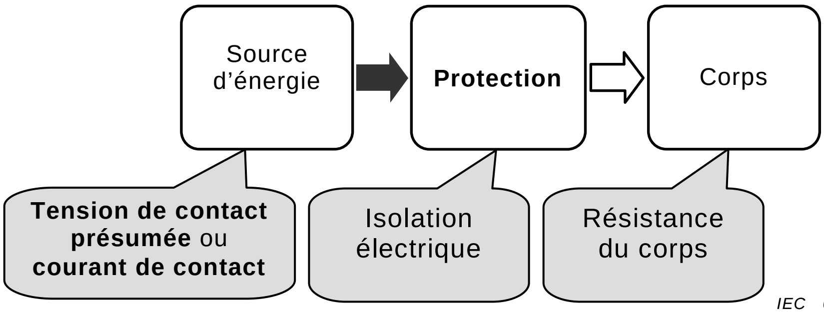


Figure 4 – Modèle pour se protéger contre les douleurs ou blessures dues à l'électricité

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'énergie 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'énergie 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'énergie 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'énergie électrique pouvant provoquer une blessure et une partie du corps.

0.7 Incendie d'origine électrique

0.7.1 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.

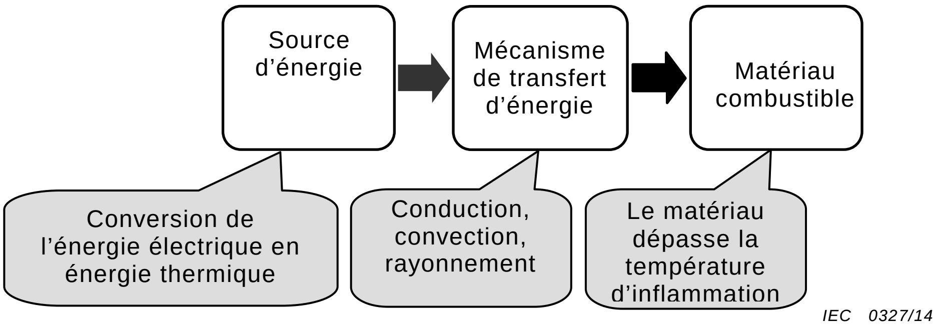


Figure 5 – Modèle pour les incendies d'origine électrique

L'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.

0.7.2 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.

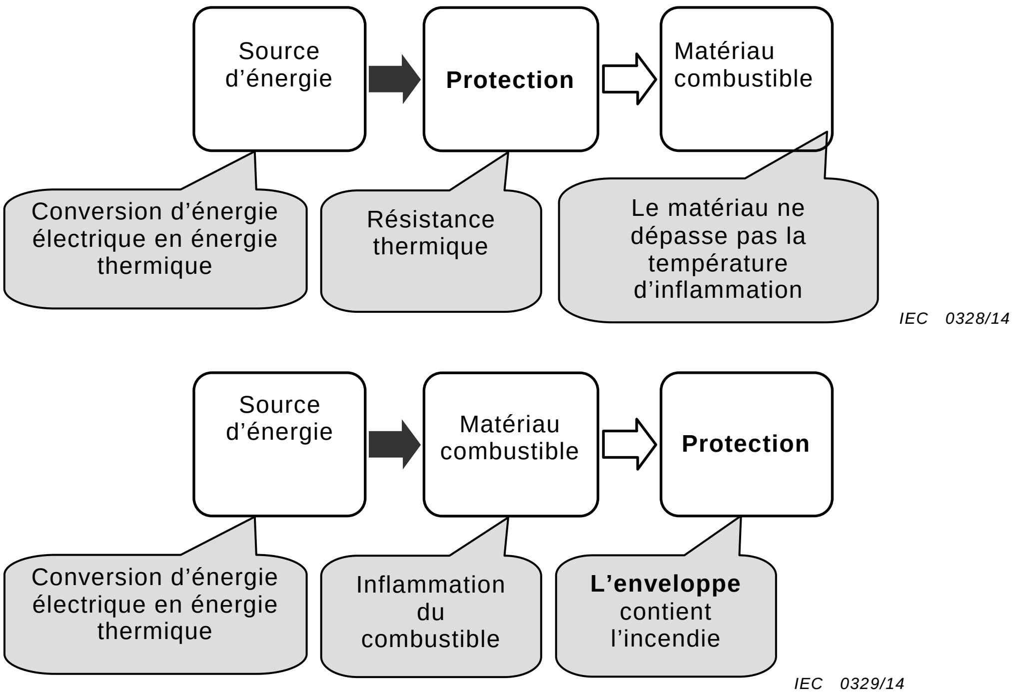


Figure 6 – Modèles pour se protéger contre les incendies

0.8 Blessures dues à des substances dangereuses

Les blessures dues à des **substances dangereuses** sont provoquées par une réaction chimique avec une partie du corps. L'étendue des blessures causées par une substance donnée 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 cette substance.

La **protection principale** contre les blessures dues à des **substances dangereuses** est le confinement du matériau.

Les **protections supplémentaires** contre les blessures dues à des **substances dangereuses** 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 par instructions**.

Les réglementations nationales et régionales régissent l'utilisation de et l'exposition à des **substances dangereuses** utilisées dans l'équipement. Ces réglementations ne permettent pas une classification pratique des **substances dangereuses** semblable à la classification des autres sources d'énergie dans la présente norme. Par conséquent, la classification des sources d'énergie ne s'applique pas dans l'Article 7.

0.9 Blessures dues à un choc mécanique

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 par 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 extraépais à l’avant d’un tube cathodique;

– des rails de glissière et des moyens de support;

– un **verrouillage de sécurité**.

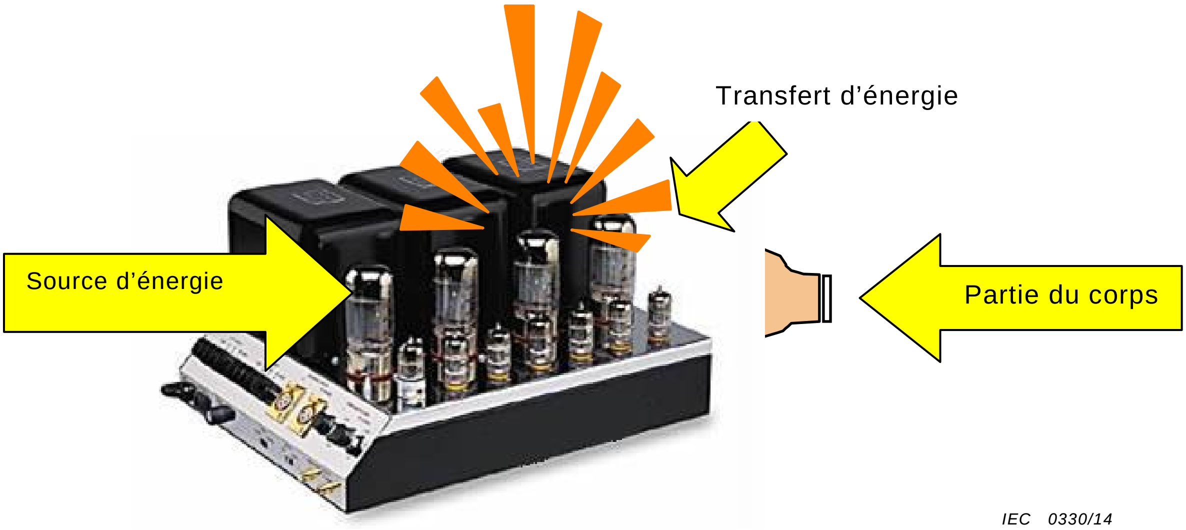
0.10 Blessures dues à la chaleur (brûlure de la peau)

0.10.1 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.



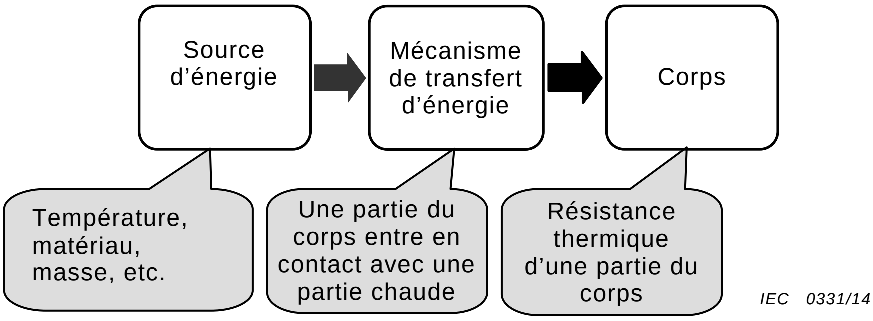


Figure 7 – Schéma et modèle pour les blessures dues à la chaleur

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).

0.10.2 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).

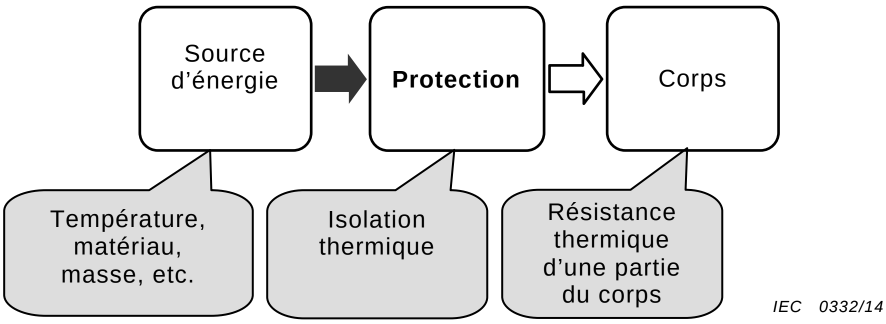


Figure 8 – Modèle pour se protéger contre les blessures dues à la chaleur

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 placée 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 par 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 placée 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 par instructions** identifiant les parties chaudes et le moyen de réduire la probabilité d'une blessure.

0.11 Blessures dues à des 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 surstimulation 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.

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.

La **protection principale** contre les blessures auditives consiste à limiter l'émission sonore des lecteurs de musique individuels et leurs casques et écouteurs associés.

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.

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.

NOTE 2 Une **tension assignée** de 600 V est considérée inclure les équipements ayant une **tension assignée** de 400/690V.

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 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.
– aux alimentations externes destinées à alimenter d'autres équipements entrant dans le domaine d'application de la présente partie de la CEI 62368;
– aux accessoires destinés à être utilisés avec des équipements entrant dans le domaine d'application de la présente partie de la CEI 62368.

La présente partie de la CEI 62368 ne s'applique pas aux systèmes d'alimentation électrique ne faisant pas partie intégrante de l'équipement, tels que les groupes convertisseurs, les systèmes de **batterie** de secours et les transformateurs de distribution.

La présente partie de la CEI 62368 spécifie des **protections** pour les **personnes ordinaires**, les **personnes averties** et les **personnes qualifiées**. Des exigences supplémentaires peuvent s'appliquer aux équipements clairement conçus ou destinés à être utilisés par des enfants ou particulièrement attrayants pour les enfants.

NOTE 3 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 partie de la CEI 62368 ne s'applique pas aux équipements destinés à être utilisés dans des régions humides. Des exigences supplémentaires peuvent s'appliquer.

Des exigences supplémentaires pour les équipements prévus pour une installation à l'extérieur sont données dans la CEI 60950-22.

La présente partie de la CEI 62368 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;
– des aspects environnementaux;
– des 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.

2 Références normatives

Les documents suivants sont cités en référence de manière normative, en intégralité ou en partie, dans le présent document et sont indispensables pour son application. 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/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 60086-5, *Piles électriques – Partie 5: Sécurité des piles à électrolyte aqueux*

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 60227-1, *Conducteurs et câbles isolés au polychlorure de vinyle, de tension nominale au plus égale à 450/750 V – Partie 1: Exigences générales*

CEI 60227-2:2003, *Conducteurs et câbles isolés au polychlorure de vinyle, de tension nominale au plus égale à 450/750 V – Partie 2: Méthodes d'essai*

CEI 60245-1, *Conducteurs et câbles isolés au caoutchouc – Tension assignée au plus égale à 450/750 V – Partie 1: Exigences générales*

CEI 60309 (toutes les parties), *Prises de courant pour usages industriels*

CEI 60317 (toutes les parties), *Spécifications pour types particuliers de fils de bobinage*

CEI 60317-43, *Spécifications pour types particuliers de fils de bobinage – Partie 43: Fil de section circulaire en cuivre recouvert d'un ruban de polyimide aromatique, classe 240*

CEI 60320 (toutes les parties), *Connecteurs pour usages domestiques et usages généraux analogues*

CEI 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 60332-2-2, *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*

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* (disponible en anglais seulement)

CEI 60417, *Symboles graphiques utilisables sur le matériel*, disponible à l'adresse suivante: <http://www.graphical-symbols.info/equipment>

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, *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 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*

IEC 60728-11:2005, *Cable networks for television signals, sound signals and interactive services – Part 11: Safety* (disponible en anglais seulement)

CEI 60730 (toutes les parties), *Dispositifs de commande électrique automatiques à usage domestique et analogue*

CEI 60730-1:2010, *Dispositifs de commande électrique automatiques à usage domestique et analogue – Partie 1: Règles générales*

IEC 60738-1:2009, *Thermistors – Directly heated positive temperature coefficient – Part 1: Generic specification* (disponible en anglais seulement)

CEI 60747-5-5: 2007, *Dispositifs à semiconducteurs – Dispositifs discrets – Partie 5-5: Dispositifs optoélectroniques – Photocoupleurs*

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, *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 60950-22:2005, *Matériels de traitement de l'information – Sécurité – Partie 22: Matériels destinés à être installés à l'extérieur*

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 mm^2 à 35 mm^2 (inclus)*

CEI 60999-2, *Dispositifs de connexion – Conducteurs électriques en cuivre – Prescriptions de sécurité pour organes de serrage à vis et sans vis – Partie 2: Prescriptions particulières pour les organes de serrage pour conducteurs au-dessus de 35 mm^2 et jusqu'à 300 mm^2 (inclus)*

CEI 61051-1, *Varistances utilisées dans les équipements électroniques – Partie 1: Spécification générique*

CEI 61051-2:1991, *Varistances utilisées dans les équipements électroniques – Partie 2: Spécification intermédiaire pour varistances pour limitations de surtensions transitoires*
Amendement 1:2009

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 61058-1:2008, *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*

CEI 61558-2-16, *Sécurité des transformateurs, alimentations, bobines d'inductance et produits analogues pour des tensions d'alimentation jusqu'à 1 100 V – Partie 2-16: Règles particulières et essais pour les blocs d'alimentation à découpage et les transformateurs pour blocs d'alimentation à découpage*[1]

CEI 61643-11, *Parafoudres basse tension – Partie 11: Parafoudres connectés aux systèmes basse tension – Exigences et méthodes d'essai*

CEI 61810-1:2008, *Relais électromécaniques élémentaires – Partie 1: Exigences générales*

CEI 61959, *Accumulateurs alcalins et autres accumulateurs à électrolyte non acide – Essais mécaniques pour accumulateurs portables étanches*

IEC 61965:2003, *Mechanical safety of cathode ray tubes* (disponible en anglais seulement)

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 62281, *Sécurité des piles et des accumulateurs au lithium pendant le transport*

CEI 62471:2006, *Sécurité photobiologique des lampes et des appareils utilisant des lampes*

IEC/TR 62471-2, *Photobiological safety of lamps and lamp systems – Part 2: Guidance on manufacturing requirements relating to non-laser optical radiation safety* (disponible en anglais seulement)

CEI 62485-2, *Exigences de sécurité pour les batteries d'accumulateurs et les installations de batteries – Partie 2: Batteries stationnaires*[2]

ISO 178, *Plastiques – Détermination des propriétés en flexion*

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1 A publier

2 A publier.

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*

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 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,* disponible à l'adresse: <http://www.graphical-symbols.info/equipment>

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*

EN 50332-1, *Équipement de systèmes acoustiques: casques et écouteurs associés avec un baladeur – Méthode de mesure de niveau maximal de pression acoustique et prise en compte d'une limite – Partie 1: Méthode générale pour "un équipement complet"*

EN 50332-2, *Équipement de systèmes acoustiques: casques et écouteurs associés avec un baladeur – Méthode de mesure de niveau maximal de pression acoustique et prise en compte d'une limite – Partie 2: Adaptation des équipements avec des écouteurs provenant de différents fabricants*

3 Termes, définitions et abréviations

3.1 Abréviations des sources d'énergie

Abréviation	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	
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 Autres abréviations

Abréviation	Description	
CD	compact disk	disque compact
CD ROM	compact disc read-only memory	disque optique compact
CRT	cathode raytube	tube cathodique
IRC	comparative tracking index	indice de résistance au cheminement
DVD	digital versatile disc	disque numérique polyvalent
EIS	electrical insulation system	système d'isolation électrique
EUT	equipment under test	équipement soumis à l'essai
GDT	gas discharge tube	tube à décharge dans un gaz
IC	integrated circuit	circuit intégré
ICX	integrated circuit with X- capacitor function	circuit intégré avec fonction X du condensateur
LED	light emitting diode	diode électroluminescente
LEL	lower explosion limit	limite inferieure d'explosivité
LFC	liquid filled component	composant a remplissage liquide
LPS	limited power source	source d'alimentation limitée

MOV	metal oxide varistor	varistances a oxyde métallique
NiCd	nickel cadmium	nickel-cadmium
PIS	potential ignition source	source potentielle d'incendie
PPE	personal protective equipment	équipement de protection individuelle
PTC	positive temperature coefficient	coefficient de température positif
RC	resistor-capacitor	résistance capacité
RG	risk group	groupe de risque
Sb	antimony	antimoine
SPD	surge protection device	dispositif de protection contre les surtensions – parafoudre
SRME	slide rail mounted equipment	équipement monté sur rail à glissières
UPS	uninterruptible power supply	alimentation sans interruption
VDR	voltage dependent resistor	varistance
VRLA	valve regulated lead acid	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.

Sauf spécification contraire, lorsque les mots «tension» et «courant» ou leurs abréviations sont utilisés, il s'agit de valeurs efficaces.

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 1 à l'article: 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 1 à l'article: 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

[SOURCE: CEI 60050-195:1998, 195-06-13, modifiée – le terme **protection** a été utilisé]

3.3.2.2
enveloppe
enceinte assurant le type et le degré de protection approprié pour l'application prévue

[SOURCE: CEI 60050-195:1998, 195-02-35]

3.3.2.3
enveloppe ignifuge (contre le feu)
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 douleurs et 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** est tenue d'exécuter selon son utilisation prévue

3.3.3.4
équipement relié en permanence
équipement pouvant uniquement être connecté électriquement au ou déconnecté électriquement du **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 ou par un connecteur non industriel ou les deux

Note 1 à l'article: Des exemples sont les fiches et socles de prise de courant couverts par les normes telles que la CEI/TR 60083 et la CEI 60320-1.

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 ou par un connecteur industriel ou les deux

Note 1 à l'article: Des exemples sont les fiches et socles de prise de courant couverts par les normes telles que la CEI 60309-1.

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 1 à l'article: 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 1 à l'article: 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 à l'article: Tous les matériaux thermoplastiques sont considérés comme susceptibles de subir une combustion, indépendamment de la **classe 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

Note 1 à l'article: 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

Note 1 à l'article: 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**

[SOURCE: CEI 60050-195, Amendement 1:2001, 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 placé entre deux parties conductrices ou entre une partie conductrice et une partie du corps

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

3.3.6 Divers

3.3.6.1
accessible
qui peut être touché par une partie du corps

Note 1 à l'article: 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/m^2

Note 1 à l'article: 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 l'isolation

3.3.6.4
mise à la terre pour des raisons fonctionnelles
mise à la terre d'un ou de plusieurs points d'un réseau, d'une installation ou d'un matériel pour des raisons autres que la sécurité électrique

[SOURCE: CEI 60050-195, Amendement 1:2001, 195-01-13]

3.3.6.5
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**

3.3.6.6
degré de pollution
chiffre caractérisant la pollution attendue du microenvironnement

[SOURCE: CEI 60050-581:2008, 581-21-07]

3.3.6.7
zone à accès limité
zone **accessible** uniquement aux **personnes qualifiées** et aux **personnes averties** munies de l'autorisation adéquate

3.3.6.8
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

[SOURCE: CEI 60664-1:2007, 3.19.2]

3.3.6.9
essai sur prélèvement
essai effectué sur un certain nombre de dispositifs prélevés au hasard dans un lot

[SOURCE: CEI 60664-1:2007, 3.19.3]

3.3.6.10
outil
objet pouvant être utilisé sur une vis, un verrou ou un moyen de fixation similaire

Note 1 à l'article: Les **outils** peuvent être par exemple des pièces de monnaie, de la vaisselle, un tournevis, une pince, etc.

3.3.6.11
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

3.3.6.12
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

3.3.6.13
papier mousseline
papier mousseline entre 12 g/m^2 et 30 g/m^2

Note 1 à l'article: Le **papier mousseline** est un papier doux, fin, généralement transparent utilisé pour emballer les articles délicats.

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 à l'article: Les **conditions anormales de fonctionnement** sont spécifiées en B.3.

Note 2 à l'article: Des **conditions anormales de fonctionnement** peuvent être induites par l'équipement ou par une personne.

Note 3 à l'article: 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'écrêtage 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 1 à l'article: Sauf spécification contraire, les conditions d'utilisation normale les plus rigoureuses sont les valeurs par défaut les plus défavorables telles que spécifiées en B.2.

Note 2 à l'article: Le mauvais usage n'est pas couvert par les **conditions normales de fonctionnement**. Il est en revanche couvert par les **conditions anormales de fonctionnement**.

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 1 à l'article: 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 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

Note 1 à l'article: Le **mauvais usage raisonnablement prévisible** est considéré être une forme de **conditions anormales de fonctionnement**.

[SOURCE: Guide ISO/CEI 51:1999, 3.14, modifiée – Note 1 à l'article a été ajoutée.]

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

Note 1 à l'article: Les **conditions de premier défaut** sont spécifiées en B.4.

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 les **protections de l'équipement** et les **protections de précaution** de manière responsable par rapport à ces sources d'énergie

Note 1 à l'article: Encadré, tel qu'utilisé dans la définition, signifie qui 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**

[SOURCE: CEI 60050-826:2004, 826-18-03]

3.3.8.3
personne qualifiée
personne ayant la formation ou l'expérience appropriée pour lui permettre d'identifier les dangers et de prendre les mesures appropriées pour réduire les risques de blessure pour elle-même et les autres

3.3.9 Sources potentielles d'incendie

3.3.9.1
source potentielle d'incendie
PIS
lieu où une énergie électrique peut provoquer une inflammation

Note 1 à l'article: L'abréviation "PIS" est dérivée du terme anglais correspondant "potential ignition source".

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 à l'article: 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 à l'article: 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 résistif
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

Note 1 à l'article: L'équipement peut présenter plus d'une valeur de **tension assignée** ou bien une **plage de tensions assignées**.

[SOURCE: CEI 60664-1:2007, 3.9]

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 du courant d'un dispositif de protection contre les surintensités qui est en place dans l'installation du bâtiment ou l'équipement 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 par instructions
instruction impliquant un comportement spécifié

3.3.11.6
protection individuelle
équipement de protection individuelle qui est porté sur le corps et qui réduit l'exposition à une source d'énergie

Note 1 à l'article: Un Equipement de Protection Personnel (EPI) est une forme de **protection individuelle**. Les exemples sont des écrans faciaux, des lunettes et des masques de protection, des gants, des tabliers, des appareils de protection respiratoires.

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, prévu pour réaliser une liaison équipotentielle de protection des parties devant être mises à la terre pour des raisons de sécurité

Note 1 à l'article: Un **conducteur de liaison de protection** est interne à l'équipement.

3.3.11.9
conducteur de protection
conducteur prévu à des fins de sécurité (par exemple, protection contre les chocs électriques)

Note 1 à l'article: Un **conducteur de protection** est soit un **conducteur de mise à la terre de protection**, soit un **conducteur de liaison de protection**.

[SOURCE: CEI 60050, Amendement 1:2001, 195-02-09]

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

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 1 à l'article: 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'énergie en une source d'énergie de classe inférieure préalablement à la possibilité de transfert de l'énergie supérieure vers une partie du corps

Note 1 à l'article: Un **verrouillage de sécurité** englobe le système des composants et circuits qui sont directement impliqués dans la fonction de **protection**, y compris les dispositifs électromécaniques, les conducteurs sur les cartes imprimées, le câblage et leurs extrémités, etc., selon le cas.

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 dans l'air
distance la plus courte dans l'air entre deux parties conductrices

[SOURCE: CEI 60664-1:2007, 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

[SOURCE: CEI 60664-1:2007, 3.3, modifiée — "solide" a été supprimé.]

3.3.13 Températures et commandes

3.3.13.1
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 1 à l'article: Un **limiteur de température** peut être à réenclenchement automatique ou réenclenchement manuel.

3.3.13.2
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

3.3.13.3
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
tension présentant une ondulation crête à crête ne dépassant pas 10 % de la valeur moyenne

Note 1 à l'article: 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 du **réseau d'alimentation** dans l'équipement, provenant de transitoires externes

3.3.14.3
valeur de crête de la tension de service
valeur crête de la **tension de service**, y compris toute composante en courant continu et les impulsions de crête répétitives générées dans l'équipement

3.3.14.4
tension de contact présumée
tension entre les parties conductrices **accessibles** simultanément lorsque ces parties conductrices ne sont pas touchées

3.3.14.5
courant dans le conducteur de protection
courant s'écoulant à travers le **conducteur de mise à la terre de protection** dans les **conditions normales de fonctionnement**

Note 1 à l'article: Le **courant du conducteur de protection** était auparavant compris dans le terme "courant de fuite".

3.3.14.6
tension de tenue requise
tension crête que l'isolation considérée est tenue de supporter

3.3.14.7
tension de service efficace
valeur efficace vraie de la **tension de service**

Note 1 à l'article: Une mesure efficace vraie comprend toute composante en courant continu de la forme d'onde.

Note 2 à l'article: 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:

$$\text{valeur efficace} = (A^2 + B^2)^{1/2}$$

3.3.14.8
surtension temporaire
surtension à fréquence industrielle de durée relativement longue

3.3.14.9
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**

Note 1 à l'article: 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

Note 1 à l'article: 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.

Note 2 à l'article: Les **équipements de classe I** peuvent être fournis avec une **construction de classe II**.

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**

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

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 1 à l'article: 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 ayant la capacité d'affecter de façon préjudiciable la santé humaine

Note 1 à l'article: Les critères permettant de déterminer si une substance est classifiée comme dangereuse sont généralement définis par voie juridique ou réglementaire.

3.3.17 Batteries

3.3.17.1
batterie
assemblage d'**éléments** prêt à être utilisé comme source d'énergie électrique caractérisé par sa tension, ses dimensions, l'assemblage de ses bornes, sa capacité et son débit

Note 1 à l'article: Le terme bloc de **batteries** est considéré comme étant équivalent à **batterie**.

3.3.17.2
élément
unité de base fabriquée pour fournir une source d'énergie électrique obtenue par transformation directe d'énergie chimique, qui se compose d'électrodes, de séparateurs, d'un électrolyte, d'un conteneur et de bornes

3.3.17.3
accumulateur bouton
accumulateur individuel de petite dimension dont le diamètre est supérieur à la hauteur

3.3.17.4
température de charge la plus élevée
température la plus élevée spécifiée par le fabricant à un site sur chaque pile individuelle comprenant la **batterie** pendant la charge d'un accumulateur

Note 1 à l'article: Il est généralement supposé que le fabricant du produit fini est en charge de spécifier la température sensible à la sécurité, la tension ou le courant de la **batterie**, sur la base des spécifications fournies par le fournisseur de la **batterie**.

3.3.17.5
température de charge la moins élevée
température la plus basse déclarée par le fabricant à un site sur chaque pile individuelle comprenant la **batterie** pendant la charge d'un accumulateur

3.3.17.6
courant de charge maximale
courant de charge le plus élevé déclaré par le fabricant pendant la charge d'un accumulateur

3.3.17.7
tension de charge maximale
tension de charge la plus élevée déclarée par le fabricant pendant la charge d'un accumulateur

3.3.17.8
batterie secondaire au lithium
batterie comprenant:

– une ou plusieurs piles au lithium; et

– un boîtier et des bornes, et

– peut avoir des dispositifs de commande électronique, et

– qui est prêt à être utilisé

Note 1 à l'article: Des exemples de **batterie secondaire au lithium** comprennent une **batterie** rechargeable au lithium, une **batterie** rechargeable polymère-lithium et une **batterie** rechargeable lithium-manganèse.

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 Le présent alinéa sera supprimé dans l'édition 3 de la présente norme. Il est ajouté ici pour favoriser la transition des dernières éditions de la CEI 60950-1 et de la CEI 60065 à la présente norme.

4.1.2 Utilisation de composants

Lorsque le composant ou une caractéristique d'un composant constitue une **protection** ou une partie d'une **protection**, les composants doivent être conformes soit aux exigences de la présente norme, soit lorsque cela est spécifié dans un article d'exigences, 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.

NOTE 2 L'essai applicable pour la conformité à une norme sur les composants est, en général, réalisé séparément.

Lorsqu'il est admis d'utiliser une norme CEI sur les composants, 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; et

– 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.

La conformité est vérifiée par examen et par les données ou essais appropriés.

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 l'Article B.2), les **conditions anormales de fonctionnement** (voir l'Article B.3) et les **conditions de premier défaut** (voir l'Article B.4), des **protections** soient prévues pour réduire la probabilité de blessure ou, en cas d'incendie, de dommage matériel.

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 supprimer 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 aux constructions et composants non traités spécifiquement

Lorsque l'équipement implique des technologies, des composants et 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.

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 Choix de critères

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.

Si une valeur efficace est mesurée, 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.1.6).

4.1.11 Conditions stables

Des conditions stables sont les conditions dans lesquelles l'équilibre thermique est considéré comme atteint (voir B.1.6).

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 38).

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, est tenu de

– porter des marquages, ou
– présenter des instructions, ou
– disposer de **protections par instructions**

doit répondre aux exigences appropriées de l'Annexe F.

La conformité est vérifiée par examen.

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'énergie

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
– les **conditions de premier défaut**.qui ne conduisent pas au dépassement des limites de classe 2.

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'énergie 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'énergie 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;

– une source d'énergie de classe 2 comme étant une source d'énergie de classe 3

Un conducteur neutre est déclaré comme une source d'énergie électrique de classe 3.

Un **conducteur de protection** est considéré comme une source d'énergie électrique de classe 1.

4.3 Protection contre les sources d'énergie

4.3.1 Généralités

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

Aucune **protection** n'est exigée 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**.

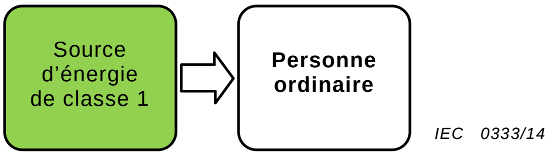


Figure 9 – Modèle pour protéger une personne ordinaire contre une source d'énergie de classe 1

4.3.2.2 Protections entre une source d'énergie de classe 2 et une personne ordinaire

Au moins une **protection principale** est exigée entre une source d'énergie de classe 2 et une **personne ordinaire** (voir la Figure 10).

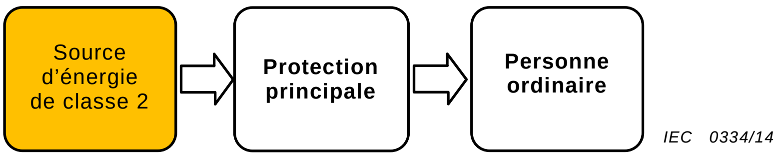


Figure 10 – Modèle pour protéger une personne ordinaire contre une source d'énergie de classe 2

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 supprimée une **protection par instructions** telle que décrite dans 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 par instructions** (voir 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 supprimée, et lorsque l'équipement est destiné à un usage domestique, une **protection par instructions** (voir F.5), à l'attention des adultes, doit constituer un avertissement contre le retrait ou la destruction de la **protection principale** par les enfants.

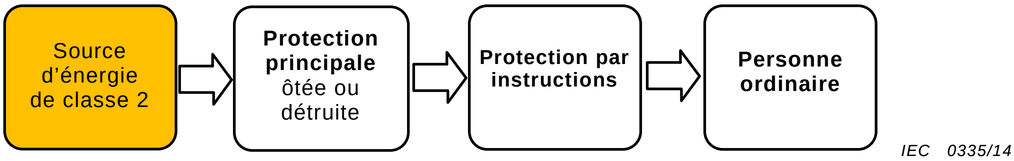


Figure 11 – Modèle pour protéger une personne ordinaire contre une source d'énergie de classe 2 dans les conditions d'entretien par une personne ordinaire

4.3.2.4 Protections entre une source d'énergie de classe 3 et une personne ordinaire

Sauf spécification contraire,

– une **protection principale d'équipement** et une **protection supplémentaire** (**double protection**) **d'équipement**; ou
– une **protection renforcée**

sont à interposer entre une source d'énergie de classe 3 et une **personne ordinaire** (voir la Figure 12).

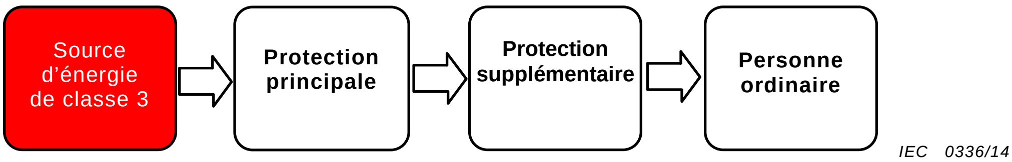


Figure 12 – Modèle pour protéger une personne ordinaire contre une source d'énergie de classe 3

4.3.3 Protections d'une personne avertie

4.3.3.1 Protections entre une source d'énergie de classe 1 et une personne avertie

Il n'est exigé aucune **protection** entre une source d'énergie de classe 1 et une **personne avertie** (voir la Figure 13).

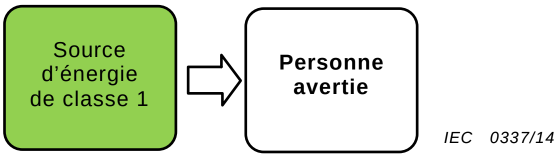


Figure 13 – Modèle pour protéger une personne avertie contre une source d'énergie de classe 1

4.3.3.2 Protections entre une source d'énergie de classe 2 et une personne avertie

Une **personne avertie** utilise une **protection de précaution** (voir la Figure 14). Aucune **protection supplémentaire** n'est exigée entre une source d'énergie de classe 2 et une **personne avertie**. Par conséquent, une source d'énergie de classe 2 peut être accessible à une **personne avertie**.

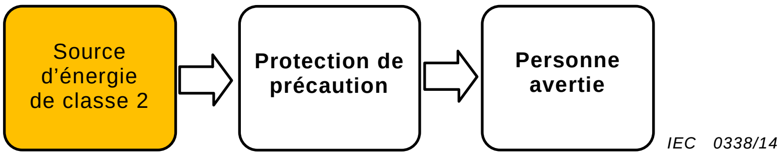


Figure 14 – Modèle pour protéger une personne avertie contre une source d'énergie de classe 2

4.3.3.3 Protections entre une source d'énergie de classe 3 et une personne avertie

Sauf spécification contraire,

– une **protection principale** et une **protection supplémentaire** (**double protection**) **d'équipement;** ou

– une **protection renforcée**

est exigée entre une source d'énergie de classe 3 et une **personne avertie** (voir la Figure 15).

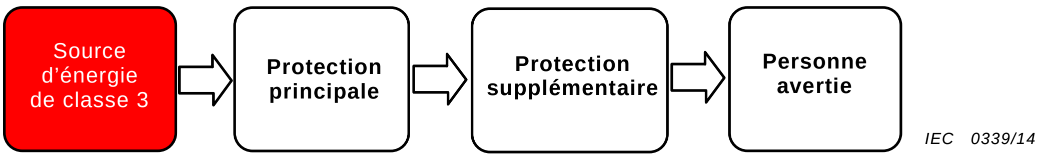


Figure 15 – Modèle pour protéger une personne avertie contre une source d'énergie de classe 3

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 exigé aucune **protection** entre une source d'énergie de classe 1 et une **personne qualifiée**. Ainsi, une source d'énergie de classe 1 peut être **accessible** à une **personne qualifiée** (voir la Figure 16).

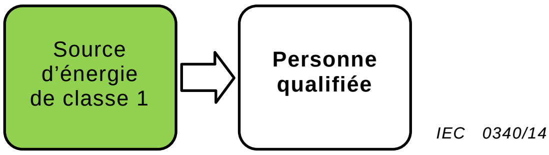


Figure 16 – Modèle pour protéger une personne qualifiée contre une source d'énergie de classe 1

4.3.4.2 Protections entre une source d'énergie de classe 2 et une personne qualifiée

Une **personne qualifiée** utilise une **protection mise en place grâce à l'expérience acquise** (voir la Figure 17). Il n'est exigé aucune **protection** supplémentaire entre une source d'énergie de classe 2 et une **personne qualifiée**. Par conséquent, il est admis qu'une source d'énergie de classe 2 soit accessible à une **personne qualifiée**.

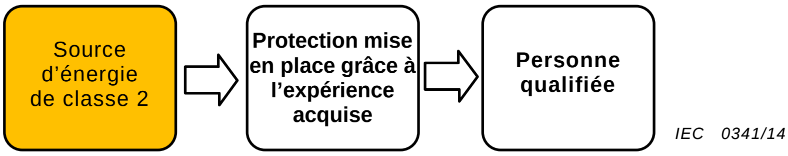


Figure 17 – Modèle pour protéger une personne qualifiée contre une source d'énergie de classe 2

4.3.4.3 Protections entre une source d'énergie de classe 3 et une personne qualifiée

Une **personne qualifiée** utilise une **protection mise en place grâce à l'expérience acquise** (voir la Figure 18). Sauf spécification contraire, il n'est exigé aucune **protection** supplémentaire entre une source d'énergie de classe 3 et une **personne qualifiée**. Par conséquent, il est admis qu'une source d'énergie de classe 3 soit accessible à une **personne qualifiée**

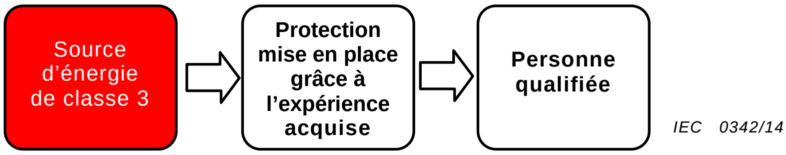


Figure 18 – Modèle pour protéger une personne qualifiée contre une source d'énergie de classe 3

Dans les conditions d'entretien de l'équipement sur une source d'énergie de classe 3, une **protection** prévue pour réduire la probabilité de blessure due à une réaction involontaire est exigée 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).

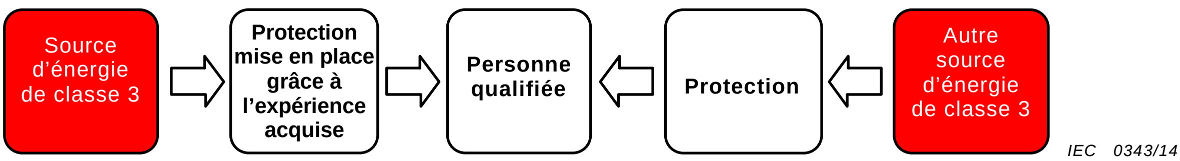


Figure 19 – Modèle pour protéger une personne qualifiée contre des sources d'énergie de classe 3 dans les conditions d'entretien de l'équipement

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 Matériaux ou composants équivalents

Lorsque la présente norme spécifie un paramètre particulier de **protection**, comme une classe thermique d'isolation ou une **classe d'inflammabilité du matériau**, une **protection** présentant un paramètre supérieur peut être utilisée.

NOTE Pour une hiérarchisation des **classes d'inflammabilité du matériau**, voir les Tableaux S.1, S.2 et S.3.

4.4.2 Composition d'une protection

Une **protection** peut être composée d'un ou de plusieurs éléments.

4.4.3 Parties accessibles d'une protection

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**.

4.4.4 Robustesse de la protection

4.4.4.1 Généralités

Lorsqu'une **protection** robuste (par exemple, une **enveloppe**, une barrière, une **isolation réalisée avec un isolant solide**, du métal mis à la terre, du verre, etc.) est **accessible** à une **personne ordinaire** ou à une **personne avertie**, la **protection** doit être conforme aux essais de résistance mécanique tels que spécifiés de 4.4.4.2 à 4.4.4.9.

Une **protection** robuste qui ne présente pas de parties **accessibles** doit être conforme à l'essai de relâchement des contraintes de l'Article T.8.

Pour une **protection accessible** après ouverture d'une **enveloppe** externe, voir 4.4.4.5.

Les exigences concernant:

– l'adhérence des revêtements métallisés; et
– les pièces de fixation adhésives servant de **protections;** et
– les parties susceptibles de supprimer une **protection** en cas de défaillance d'un adhésif

sont spécifiées dans l'Article P.4.

4.4.4.2 Essais de force constante

Une **enveloppe** ou barrière qui est **accessible** et qui est utilisée comme une **protection** des:

– **équipements transportables**; et
– **équipements portatifs**; et
– **équipements à enficher directement**;

doit être soumise à l'essai de force constante de l'Article T.4.

Pour tous les autres équipements, une **enveloppe** ou barrière qui est **accessible** et qui est utilisée comme une **protection** doit être soumise à l'essai de force constante de l'Article T.5.

Cette exigence ne s'applique pas au fond de l'équipement ayant une masse de plus de 18 kg à moins que les instructions utilisateur autorisent une orientation dans laquelle le fond de l'**enveloppe** devient le haut ou un côté de l'équipement.

Une **protection** qui est **accessible** et qui sert uniquement d'**enveloppe ignifuge (contre le feu)** ou de barrière contre le feu doit être soumise à l'essai de force constante de l'Article T.3.

Le verre est exempté des exigences ci-dessus. Les exigences applicables au verre sont données en 4.4.4.6.

4.4.4.3 Essais de chute

Les équipements suivants doivent être soumis à l'essai de chute de l'Article T.7:

– **équipement portatif**;

– **équipement à enficher directement**;

– **équipement transportable**;

– **équipement mobile** qui nécessite d'être soulevé ou manipulé par une **personne ordinaire** dans le cadre de son utilisation prévue, y compris le déplacement de routine;

  NOTE Un exemple d'un tel équipement est une déchiqueteuse à papier posée sur un bac à ordure et nécessitant son déplacement pour vider le bac.

– les équipements de bureau ou de table ayant une masse de 7 kg ou moins et qui sont conçus pour être utilisés avec un des éléments suivants:

  • un combiné de téléphone relié par un câble, ou

  • un autre accessoire avec une fonction acoustique, tenu dans la main lors de son utilisation et relié par un câble, ou

  • un casque.

4.4.4.4 Essais de choc

Tous les équipements, autres que ceux spécifiés en 4.4.4.3, doivent être soumis à l'essai de choc de l'Article T.6.

L'essai de choc de l'Article T.6 n'est pas appliqué à ce qui suit:

– le fond d'une **enveloppe**, sauf si les instructions utilisateur autorisent une orientation dans laquelle le fond de l'**enveloppe** devient le haut ou un côté de l'équipement;

– le verre;

  NOTE Les essais de choc sur le verre sont donnés en 4.4.4.6.

– la surface de l'**enveloppe** de **l'équipement stationnaire**, y compris l'équipement à encastrer, qui n'est pas **accessible** et protégé après l'installation;

4.4.4.5 Essais de protection accessible interne

Une **protection** interne solide **accessible** à une **personne ordinaire** après ouverture d'une **enveloppe** externe et dont la défaillance pourrait rendre les sources d'énergie de classe 2 ou 3 **accessibles,** doit être soumise à l'essai de force constante de l'Article T.3.

4.4.4.6 Essais de choc sur le verre

Les exigences ci-dessous sont applicables à toutes les parties en verre, à l'exception:

– d'une glace d'exposition utilisée sur les photocopieurs, scanneurs et dispositif analogue, pourvu que le verre soit conforme à 4.4.4.5 et soit couvert en utilisation normale; et

– des tubes cathodiques. Les exigences relatives aux tubes cathodiques sont données à l'Annexe U; et

– le verre qui est feuilleté ou a une construction telle que les particules de verre ne se séparent pas l'une de l'autre en cas de bris de glace; et

NOTE Le verre feuilleté inclut les constructions telles que le film plastique apposé sur un côté du verre.

– une **protection** qui est **accessible** et qui agit comme une **enveloppe ignifuge** seulement

Le verre qui est **accessible** à une **personne ordinaire** ou à une **personne avertie**:

– dont la surface dépasse 0,1 m^2; ou

– dont la dimension maximale dépasse 450 mm; ou

– empêchant l'accès aux sources d'énergie de classe 3 autres que PS3,

doit être soumis à l'essai de choc sur le verre de l'Article T.9.

4.4.4.7 Essais de matériau thermoplastique

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 au relâchement des contraintes internes ne doit pas altérer sa fonction de **protection**. Le matériau thermoplastique doit être soumis à l'essai de relâchement des contraintes de l'Article T.8.

4.4.4.8 Protection contenant de l'air

Lorsqu'une **protection** est composée d'air (par exemple, une **distance 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.

4.4.4.9 Critères de conformité

Pendant et après les essais:

– *A l'exception de PS3, les sources d'énergie de classe 3 ne doivent pas devenir* ***accessibles*** *à une* ***personne ordinaire*** *ou à une* ***personne avertie****; et*

– *le verre:*

  • *ne doit pas se casser ou se fissurer; ou*

  • *ne doit pas expulser des morceaux de verre d'une masse supérieure à 30 g ou de dimension supérieure à 50 mm; ou*

  • *doit être soumis à l'essai de fragmentation de l'Article T.10 sur une éprouvette séparée; et*

– *toutes les autres* ***protections*** *doivent rester opérationnelles*.

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, ou

– 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**.

Si une **explosion** se produit dans les **conditions de premier défaut**, elle ne doit pas être préjudiciable et l'équipement doit être conforme aux parties appropriées de la présente norme.

La conformité est vérifiée par examen et par les essais spécifiés dans les Articles B.2, B.3 et B.4.

4.6 Fixation des conducteurs

4.6.1 Exigences

Les conducteurs doivent être tels que le déplacement ne puisse supprimer une **protection**, tel que de réduire les **distances dans l'air** ou les **lignes de fuite** en dessous des valeurs spécifiées en 5.4.2 et 5.4.3.

La fixation des conducteurs doit être telle que si un conducteur se desserre ou se détache, il ne peut supprimer une **protection**, au risque de réduire les **distances dans l'air** ou les **lignes de fuite** au-dessous des valeurs spécifiées en 5.4.2 et 5.4.3.

Pour les besoins de ces exigences, il est supposé que:

– deux fixations indépendantes ne se desserreront pas ni ne se détacheront en même temps; et

– les parties fixées par des vis ou des écrous avec des rondelles autobloquantes ou autre moyen de blocage ne risquent pas de se desserrer ou de se détacher.

NOTE Les rondelles élastiques et dispositif analogue peuvent assurer un verrouillage satisfaisant.

4.6.2 Critères de conformité

La conformité est vérifiée par examen, par mesure ou en cas de doute en appliquant une force de 10 N dans la direction la plus défavorable.

EXEMPLE Les constructions considérées comme satisfaisant aux exigences comprennent:

– les tubes ajustés (par exemple, une gaine thermorétractable ou en caoutchouc), appliqués sur le fil et ses extrémités;

– les conducteurs raccordés par soudage et maintenus en place à proximité de l'extrémité, indépendamment de la connexion soudée;

– les conducteurs raccordés par soudage et fermement accrochés avant soudage, à condition que l'orifice par lequel passe le conducteur ne soit pas indûment grand;

– les conducteurs raccordés aux bornes à vis, avec une fixation supplémentaire à proximité de la borne qui permet d'accrocher, pour des conducteurs toronnés, l'isolation et pas seulement les conducteurs;

– les conducteurs raccordés aux bornes à vis et munis d'extrémités peu susceptibles de se libérer (par exemple, des attaches annulaires serties sur les conducteurs). Le pivotement de ce type d'extrémité est pris en compte;

– les conducteurs rigides courts qui restent en place lorsque la vis de la borne est desserrée.

4.7 Equipement pour insertion directe dans des socles d'alimentation

4.7.1 Généralités

Les équipements qui possèdent des broches intégrées destinées à être insérées dans les socles d'**alimentation** ne doivent pas imposer de couple excessif aux socles. Les moyens utilisés pour retenir les broches doivent résister aux forces auxquelles celles-ci sont susceptibles d'être soumises en utilisation normale.

4.7.2 Exigences

La partie fiche d'**alimentation** doit être conforme à la norme applicable à la fiche d'**alimentation** correspondante.

L'équipement est inséré, comme en utilisation normale, dans un socle fixe ayant une configuration telle que prévue par le fabricant, qui peut pivoter autour d'un axe horizontal coupant les axes des alvéoles à une distance de 8 mm en arrière de la surface d'engagement du socle.

4.7.3 Critères de conformité

La conformité est vérifiée par examen et, le couple supplémentaire qui est à appliquer au socle pour maintenir la face d'insertion dans le plan vertical ne doit pas dépasser 0,25 Nm. Le couple nécessaire pour maintenir le socle lui-même dans le plan vertical n'est pas inclus dans cette valeur.

NOTE 1 En Australie et en Nouvelle-Zélande, la conformité est vérifiée conformément à la norme AS/NZS 3112.

NOTE 2 Au Royaume-Uni, l'essai de couple est réalisé en utilisant un socle conforme à la norme BS 1363, et la partie fiche doit être évaluée selon les articles applicables de la norme BS 1363.

4.8 Produits contenant un accumulateur bouton au lithium

4.8.1 Généralités

Ces exigences s'appliquent aux équipements, incorporant des télécommandes, qui:

– ne sont pas susceptibles d'être **accessibles** aux enfants, en tenant compte des informations données par le fabricant; et
– contiennent des **accumulateurs boutons** au lithium dont le diamètre est inférieur ou égal à 32 mm.

Ces exigences ne s'appliquent pas aux:

– équipements professionnels;

  NOTE Les équipements professionnels sont des équipements vendus par des circuits de vente particuliers. Tous les équipements vendus par des magasins d'électronique normaux sont considérés comme n'étant pas des équipements professionnels.

– équipements destinés à des emplacements où la présence d'enfants est peu probable;ou
– équipements contenant des **accumulateurs boutons** au lithium qui sont soudés en place.

4.8.2 Protection par instructions

Les équipements qui contiennent un ou plusieurs **accumulateurs boutons** au lithium doivent posséder une **protection par instructions** conforme à l'Article F.5.

La **protection par instructions** n'est pas exigée lorsque ces **accumulateurs** ne sont pas destinés à être remplacés ou lorsqu'ils sont **accessibles** uniquement après un endommagement de l'équipement.

La **protection par instruction**s doit comporter les éléments suivants:

– élément 1a: non disponible.

– élément 2: “Ne pas ingérer l’accumulateur, Risque de brûlure chimique” ou un libellé équivalent.

– élément 3: le texte suivant ou équivalent

[La télécommande fournie avec] Ce produit contient un accumulateur bouton. En cas d’ingestion, l’accumulateur bouton, peut causer des brûlures internes sévères en à peine 2 heures qui peuvent être mortelles.

– élément 4: le texte suivant ou équivalent

Conserver les accumulateurs neufs et usagés hors de portée des enfants.

Si le compartiment de l’accumulateur ne se ferme pas de manière sûre, ne plus utiliser le produit et le tenir hors de portée des enfants.

En cas de soupçon d’ingestion d’un accumulateur ou d’introduction dans une partie quelconque du corps, demander immédiatement un avis médical.

4.8.3 Construction

Les équipements dont l’accès au compartiment d’**accumulateurs** est protégé par une porte / un couvercle doivent être conçus de manière à réduire la probabilité que des enfants retirent l’**accumulateur** par l’une des méthodes suivantes:

– un **outil**, de type tourne-vis ou pièce, est nécessaire pour ouvrir le compartiment des **accumulateurs**; ou

– la réalisation d’au moins deux mouvements indépendants et simultanés sur le mécanisme de sécurité est nécessaire pour ouvrir manuellement la porte ou le couvercle du compartiment d’**accumulateurs**.

4.8.4 Essais

4.8.4.1 Ordre des essais

Un échantillon doit être soumis aux essais applicables de 4.8.4.2 à 4.8.4.6. S’il est applicable, l’essai de 4.8.4.2 doit être réalisé le premier.

4.8.4.2 Essai de résistance aux contraintes

*Si le compartiment des **accumulateurs** utilise des matériaux thermoplastiques moulés ou formés, l’échantillon comprenant l’équipement complet, ou l’**enveloppe** complète avec tout cadre de support, est soumis à l’essai de résistance aux contraintes de l’Article T.8.*

*Pendant l’essai, l’**accumulateur** peut être retiré.*

4.8.4.3 Essai de remplacement de l’accumulateur

*Pour les équipements dont le compartiment des **accumulateurs** est protégé par une porte / un couvercle, ce compartiment d'**accumulateurs** doit être ouvert et fermé et les **accumulateurs** doivent être retirés et remplacés dix fois pour simuler un remplacement normal conformément aux instructions du fabricant.*

*Si la porte / le couvercle du compartiment des **accumulateurs** est sécurisé par une ou plusieurs vis, celles-ci sont desserrées puis resserrées en appliquant un couple linéaire continu conformément au Tableau 37, en utilisant un tourne-vis adapté ou une clé. Les vis sont à retirer et réinsérer complètement à chaque fois.*

4.8.4.4 Essai de chute

Les équipements portables dont la masse est inférieure ou égale à 7 kg sont soumis à trois chutes sur une surface horizontale en les lâchant d'une hauteur de 1 m dans des positions susceptibles de produire la force maximale sur le compartiment des ***accumulateurs*** *conformément à l'Article T.7.*

Si l'équipement est une télécommande, il doit subir dix chutes.

4.8.4.5 Essai de choc

La porte / le couvercle du compartiment des ***accumulateurs*** *doit être soumis à trois chocs qui lui sont appliqués perpendiculairement à la porte / le couvercle du compartiment des* ***accumulateurs*** *conformément à la méthode d'essai de l'Article T.6 avec une force de:*

- *0,5 J (102 mm ± 10 mm de haut) pour les verres utilisés pour regarder, par exemple, une télévision 3D; ou*
- *2 J (408 mm ± 10 mm de haut) pour tous autres portes / couvercles.*

4.8.4.6 Essai d'écrasement

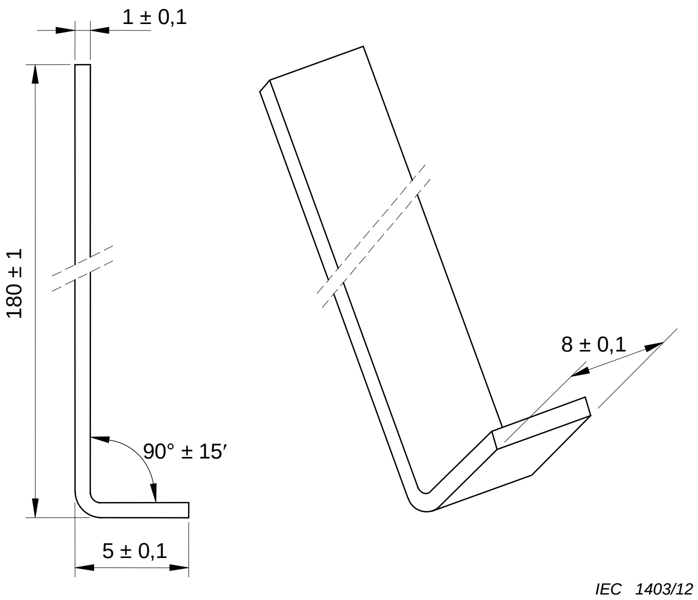
Les dispositifs de télécommande tenus à la main sont à placer sur une surface support rigide fixe dans une position susceptible de produire les résultats les plus défavorables tant que la position peut être maintenue. Une force d'écrasement de 330 N ± 5 N est appliquée aux surfaces exposées supérieure et arrière des dispositifs de télécommande placés de façon stable au moyen d'une surface plane mesurant approximativement 100 mm sur 250 mm pendant une durée de 10 s.

4.8.5 Critères de conformité

La conformité est vérifiée en appliquant une force de 30 N ± 1 N pendant 10 s sur la porte / le couvercle du compartiment des ***accumulateurs*** *au moyen d'un doigt d'essai rigide conforme à la sonde d'essai de la Figure V.2 à l'endroit le plus défavorable et dans la direction la plus défavorable. La force doit être appliquée dans une seule direction à la fois.*

La porte / le couvercle du compartiment des ***accumulateurs*** *doit rester fonctionnel, et:*

- *l'****accumulateur*** *ne doit pas devenir* ***accessible****; ou*
- *il ne doit pas être possible de retirer l'****accumulateur*** *du produit avec le crochet d'essai de la Figure 20 en utilisant une force d'environ 20 N.*



Matériau: acier *Dimensions en millimètres*

Figure 20 – Crochet d'essai

4.9 Probabilité d'incendie ou de choc dû à l'entrée d'objets conducteurs

Lorsque l'entrée d'un objet conducteur depuis l'extérieur de l'équipement ou depuis une autre partie de l'équipement peut provoquer:

– sa mise en parallèle au sein des circuits PS2, PS3 et ES3; ou
– la mise en parallèle d'un circuit ES3 aux parties conductrices **accessibles** non mises à la terre;

les ouvertures supérieures et latérales au-dessus des circuits PS2, PS3 et ES3 doivent:

– être situées à plus de 1,8 m au-dessus du sol; ou
– être conformes à l'Annexe P.

La conformité est vérifiée par examen ou conformément à l'Annexe P.

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 l'Article 5.

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 de courant ou de tension

– ne dépassent pas les limites de ES1 dans

  - les **conditions normales de fonctionnement**, et
  - les **conditions anormales de fonctionnement**, et
  - les **conditions de premier défaut** d'un composant, dispositif ou isolation n'assurant pas une fonction de **protection**; et
- ne dépassent pas les limites de ES2 dans les **conditions de premier défaut** d'une **protection principale**.

5.2.1.2 ES2

ES2 est une source d'énergie électrique de classe 2 dont

- la **tension de contact présumée** et le **courant de contact** ne dépassent pas les limites de ES1; et
- dans
  - les **conditions normales de fonctionnement**, et
  - les **conditions anormales de fonctionnement**, et
  - les **conditions de premier défaut**,

ou la **tension de contact présumée** et le **courant de contact** ne dépassent pas les limites de ES2.

5.2.1.3 ES3

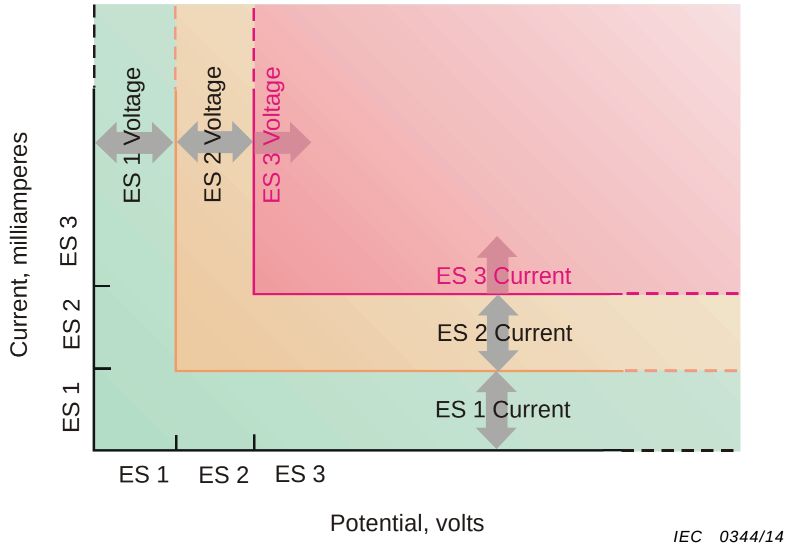
ES3 est une source d'énergie électrique de classe 3 dont la **tension de contact présumée** et le **courant de contact** dépassent les limites de ES2.

5.2.2 Limites des sources d'énergie électrique ES1 et ES2

5.2.2.1 Généralités

Les limites spécifiées en 5.2.2 sont relatives à la terre ou bien à une partie **accessible**.

NOTE Dans 5.2.2, le terme "tension" signifie "**tension de contact présumée**" De même, le terme "courant" signifie "**courant de contact**."



Légende

Anglais	Français
Current, milliamperes	Courant, milliampères
ES 1/2/3 Voltage	Tension ES 1/2/3
ES 1/2/3 Current	Courant ES 1/2/3
Potential	Potentiel

Figure 21 – Illustration montrant les limites ES pour la tension et le courant

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. Voir la Figure 21.

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 dans les **conditions normales de fonctionnement,** dans les **conditions anormales de fonctionnement** et dans les **conditions de premier défaut** (voir le Tableau 4).

Il s'agit des valeurs maximales pouvant être fournies par la source. Le régime stable est considéré établi lorsque les valeurs de tension ou de courant sont stables pendant 2 s ou plus; sinon les limites de 5.2.2.3, 5.2.2.4 ou 5.2.2.5 s'appliquent, selon le cas.

NOTE Au Danemark, un avertissement (**protection** de marquage) pour le **courant de contact** élevé est exigé si le **courant de contact** dépasse les limites de 3,5 mA c.a. ou 10 mA c.c.

Tableau 4 – Limites de sources d'énergie électrique pour les sources d'énergie ES1 et ES2 stables

<table>
<tr><th rowspan="2">Source d'énergie</th><th colspan="2">Limites ES1</th><th colspan="2">Limites ES2</th><th rowspan="2">ES3</th></tr>
<tr><th>Tension</th><th>Courant [a, c]</th><th>Tension</th><th>Courant [b, c]</th></tr>
<tr><td>c.c.</td><td>60 V</td><td>2 mA</td><td>120 V</td><td>25 mA</td><td rowspan="5">> ES2</td></tr>
<tr><td>c.a. jusqu'à 1 kHz</td><td>30 V efficace
42,4 V de crête</td><td rowspan="3">0,5 mA efficace
0,707 mA de crête</td><td>50 V efficace
70,7 V de crête</td><td rowspan="3">5 mA efficace
7,07 mA de crête</td></tr>
<tr><td>c.a. > 1 kHz jusqu'à 100 kHz</td><td>30 V efficace + 0,4 f</td><td>50 V efficace + 0,9 f</td></tr>
<tr><td>c.a. supérieur à 100 kHz</td><td>70 V efficace</td><td>140 V efficace</td></tr>
<tr><td>c.a. et c.c. combinés</td><td>$\frac{U_{dc}\ \text{V}}{60} + \frac{U_{ac}\ \text{V efficace}}{30} \le 1$
$\frac{U_{dc}\ \text{V}}{60} + \frac{U_{ac}\ \text{V crête}}{42,4} \le 1$</td><td>$\frac{I_{dc}\ \text{mA}}{2} + \frac{I_{ac}\ \text{mA efficace}}{0,5} \le 1$
$\frac{I_{dc}\ \text{mA}}{2} + \frac{I_{ac}\ \text{mA crête}}{0,707} \le 1$</td><td>Voir la Figure 23</td><td>Voir la Figure 22</td></tr>
<tr><td colspan="6">La formulation ci-après en fonction de la fréquence peut être utile pour les concepteurs de formes d'onde sinusoïdales</td></tr>
<tr><th rowspan="2">Source d'énergie</th><th colspan="2">Limites ES1</th><th colspan="2">Limites ES2</th><th rowspan="2">ES3</th></tr>
<tr><th colspan="2">Courant [c]
efficace</th><th colspan="2">Courant [c]
Efficace</th></tr>
<tr><td>c.a. jusqu'à 1 kHz</td><td colspan="2">0,5 mA</td><td colspan="2">5 mA</td><td rowspan="3">> ES2</td></tr>
<tr><td>c.a. > 1 kHz jusqu'à 100 kHz</td><td colspan="2">0,5 mA + f [d]</td><td colspan="2">5 mA + 0,95 f [e]</td></tr>
<tr><td>c.a. supérieur à 100 kHz</td><td colspan="2">50 mA [d]</td><td colspan="2">100 mA [e]</td></tr>
<tr><td colspan="6">f est en kHz.
Les valeurs crête doivent être utilisées pour la tension et le courant non sinusoïdal. Les valeurs efficaces ne peuvent être utilisées que pour la tension et le courant sinusoïdal.
Voir 5.7 pour la mesure de la tension de contact présumée et du courant de contact.</td></tr>
<tr><td colspan="6">[a] Le courant est mesuré en utilisant le réseau de mesure spécifié à la Figure 4, CEI 60990:1999.
Le courant est mesuré en utilisant le réseau de mesure spécifié à la Figure 5, CEI 60990:1999.
[c] Pour des formes d'onde sinusoïdales et le courant continu, le courant peut être mesuré en utilisant une résistance de 2 000 Ω.
[d] Au-delà de 22 kHz, la zone accessible est limitée à 1 cm^2.
[e] Au-delà de 36 kHz la zone accessible est limitée à 1 cm^2.</td></tr>
</table>

Dans les **conditions normales de fonctionnement, les conditions anormales de fonctionnement** et les **conditions de premier défaut** (sauf pour un défaut de **protection**), la tension de contact ou le **courant de contact** doit être mesuré à partir de toutes les parties conductrices **accessibles** non mises à la terre. Le **courant de contact** (courants [a] et [b] du Tableau 4) doit être mesuré selon 5.1.1 et 6.2.1 de la CEI 60990:1999.

Dans les **conditions de premier défaut** d'une **protection principale** ou d'une **protection supplémentaire** appropriée, y compris 6.2.2.1 de la CEI 60990:1999, la tension de contact ou le **courant de contact** doit être mesuré à partir de toutes les parties conductrices **accessibles** non mises à la terre. Le **courant de contact** (courant [b] du Tableau 4) doit être mesuré avec le réseau spécifié à la Figure 5 de la CEI 60990:1999.

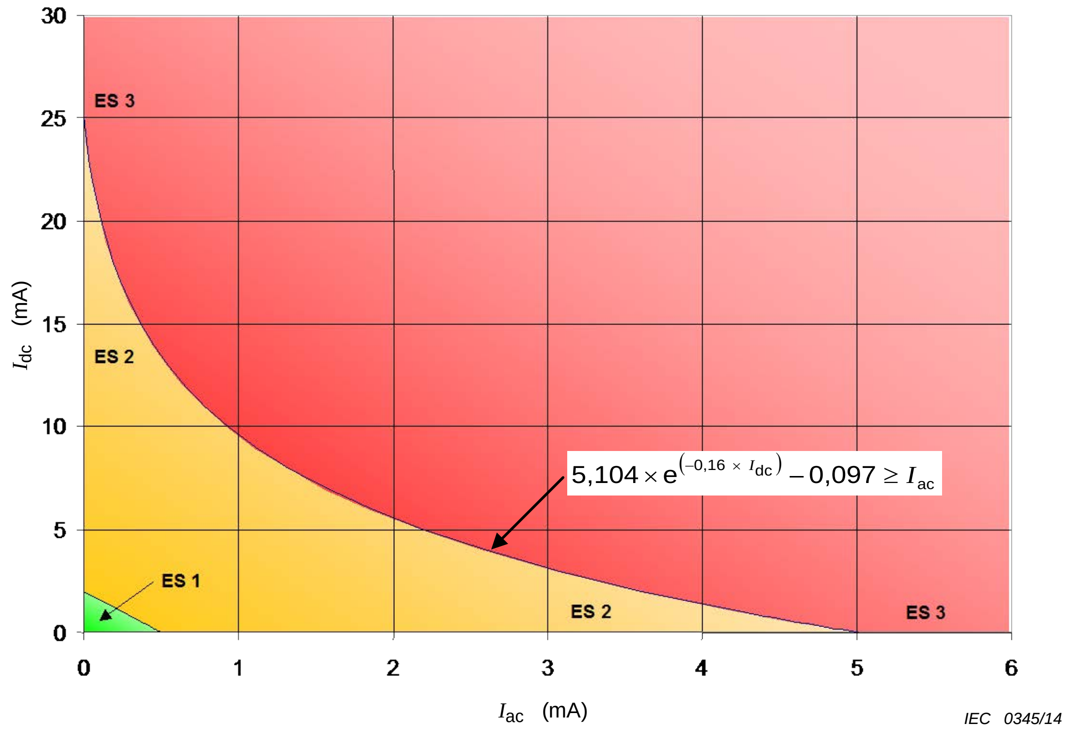


Figure 22 – Valeurs maximales pour les courants alternatif et continu combinés

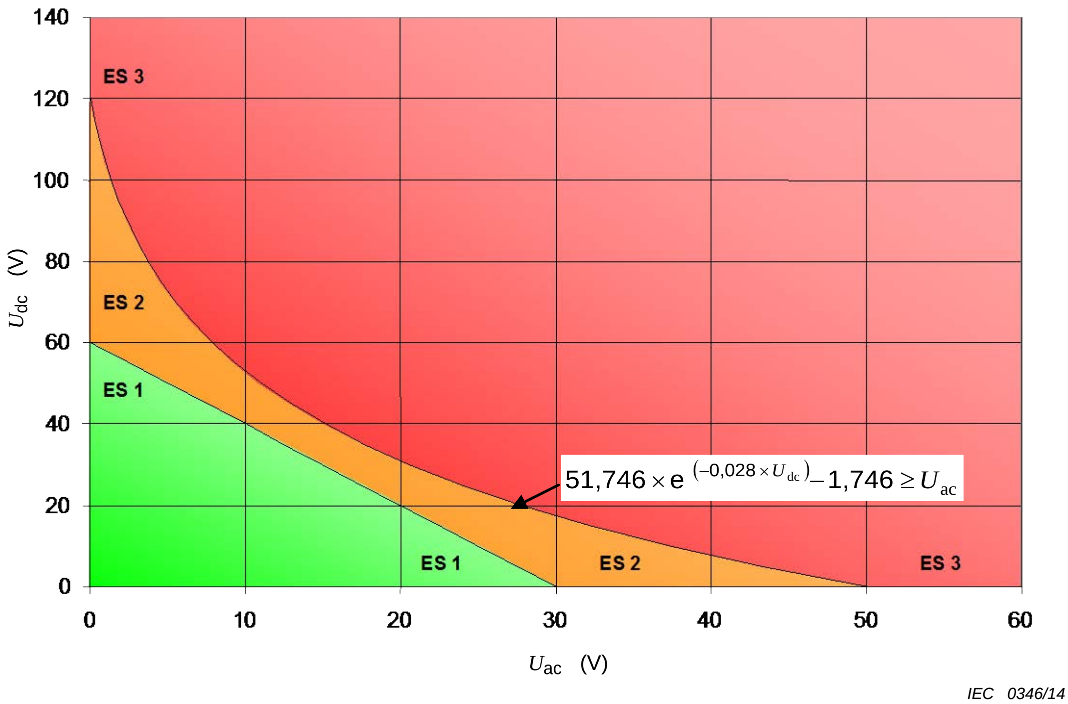


Figure 23 – Valeurs maximales pour les tensions alternative et continue combinées

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 5.

NOTE 1 Les valeurs de capacité pour ES2 proviennent du Tableau A.2 de la CEI/TS 61201:2007.

NOTE 2 Les valeurs pour ES1 sont calculées en divisant les valeurs du Tableau A.2 de la CEI/TS 61201:2007 par deux (2).

Tableau 5 – Limites de sources d’énergie électrique pour un condensateur chargé

<table>
<tr><th>C
nF</th><th>ES1
$U_{\text{crête}}$
V</th><th>ES2
$U_{\text{crête}}$
V</th><th>ES3
$U_{\text{crête}}$
V</th></tr>
<tr><td>300 ou supérieur</td><td>60</td><td>120</td><td rowspan="15">> ES2</td></tr>
<tr><td>170</td><td>75</td><td>150</td></tr>
<tr><td>91</td><td>100</td><td>200</td></tr>
<tr><td>61</td><td>125</td><td>250</td></tr>
<tr><td>41</td><td>150</td><td>300</td></tr>
<tr><td>28</td><td>200</td><td>400</td></tr>
<tr><td>18</td><td>250</td><td>500</td></tr>
<tr><td>12</td><td>350</td><td>700</td></tr>
<tr><td>8,0</td><td>500</td><td>1 000</td></tr>
<tr><td>4,0</td><td>1 000</td><td>2 000</td></tr>
<tr><td>1,6</td><td>2 500</td><td>5 000</td></tr>
<tr><td>0,8</td><td>5 000</td><td>10 000</td></tr>
<tr><td>0,4</td><td>10 000</td><td>20 000</td></tr>
<tr><td>0,2</td><td>20 000</td><td>40 000</td></tr>
<tr><td>0,133 ou inférieur</td><td>30 000</td><td>60 000</td></tr>
<tr><td colspan="4">Une interpolation linéaire peut être utilisée entre les deux points les plus proches.</td></tr>
</table>

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 le Tableau 6 et le Tableau 7. 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.

Si plusieurs impulsions sont détectées en l’espace de 3 s, la source d’énergie électrique est considérée comme une impulsion répétitive et les limites de 5.2.2.5 s’appliquent.

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 6 – Limites de tension pour les impulsions uniques

<table>
<tr><th rowspan="2">Durée d'impulsion jusqu'à et y compris
ms</th><th colspan="3">Niveau de la source d'énergie électrique</th></tr>
<tr><th>ES1
$U_{crête}$
V</th><th>ES2
$U_{crête}$
V</th><th>ES3
$U_{crête}$
V</th></tr>
<tr><td>10</td><td rowspan="6">60</td><td>196</td><td rowspan="6">> ES2</td></tr>
<tr><td>20</td><td>178</td></tr>
<tr><td>50</td><td>150</td></tr>
<tr><td>80</td><td>135</td></tr>
<tr><td>100</td><td>129</td></tr>
<tr><td>200 et plus longue</td><td>120</td></tr>
<tr><td colspan="4">Si la durée se situe entre les valeurs de deux des lignes, la valeur ES2 de $U_{crête}$ de la ligne en dessous doit être utilisée ou bien une interpolation linéaire entre deux lignes adjacentes peut être utilisée, en arrondissant la valeur de tension crête calculée au volt le plus proche.

Si la tension de crête pour ES2 se situe entre les valeurs de deux des lignes, la valeur de la durée dans la ligne supérieure peut être utilisée ou une interpolation linéaire peut être utilisée entre deux lignes adjacentes avec la durée calculée, arrondie à la milliseconde la plus proche.</td></tr>
</table>

Tableau 7 – Limites de courant pour les impulsions uniques

<table>
<tr><th rowspan="2">Durée d'impulsion jusqu'à et y compris
ms</th><th colspan="3">Niveau de la source d'énergie électrique</th></tr>
<tr><th>ES1
$I_{crête}$
mA</th><th>ES2
$I_{crête}$
mA</th><th>ES3
$I_{crête}$
mA</th></tr>
<tr><td>10</td><td rowspan="8">2</td><td>200</td><td rowspan="8">> ES2</td></tr>
<tr><td>20</td><td>153</td></tr>
<tr><td>50</td><td>107</td></tr>
<tr><td>100</td><td>81</td></tr>
<tr><td>200</td><td>62</td></tr>
<tr><td>500</td><td>43</td></tr>
<tr><td>1 000</td><td>33</td></tr>
<tr><td>2 000 et plus longue</td><td>25</td></tr>
<tr><td colspan="4">Si la durée se situe entre les valeurs de deux des lignes, la valeur ES2 de $I_{crête}$ de la ligne en dessous doit être utilisée ou bien une interpolation linéaire entre deux lignes adjacentes peut être utilisée, en arrondissant la valeur calculée au milliampère le plus proche.

Si la tension de crête pour ES2 se situe entre les valeurs de deux des lignes, la valeur de la durée dans la ligne supérieure peut être utilisée ou une interpolation linéaire peut être utilisée entre deux lignes adjacentes avec la durée calculée, arrondie à la milliseconde la plus proche.</td></tr>
</table>

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 8). 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.

Tableau 8 – 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	> ES2
	Tension	42,4 V en valeur crête	70,7 V en valeur crête	
3 s ou plus	Courant	Voir 5.2.2.4	Voir 5.2.2.4	
	Tension			

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.

5.3 Protection contre les sources d’énergie électrique

5.3.1 Généralités

A l’exception de ce qui est indiqué ci-dessous, des exigences de protection pour les parties **accessibles** aux **personnes ordinaires**, aux **personnes averties** et aux **personnes qualifiées** sont données en 4.3.

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 par une **personne qualifiée** soit improbable (voir la Figure 19).

5.3.2 Accessibilité des sources d’énergie électrique et des protections

5.3.2.1 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** au calibre d’essai 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.

5.3.2.2 Exigences en matière de contact

Pour les tensions ES3 jusqu’à 420 V valeur de 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 24).

Cet entrefer doit:

a) satisfaire à un essai de rigidité diélectrique conformément à 5.4.9.1 à une tension d’essai (continue ou alternative de crête) égale à la tension d'essai pour l'**isolation principale** du Tableau 27 correspondant à la **valeur de crête de la tension de service**; ou

b) présenter une distance minimale conformément au Tableau 9.

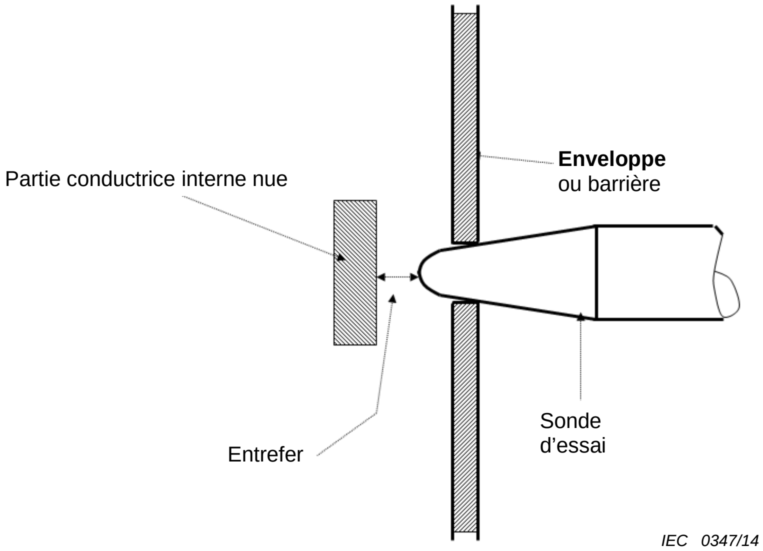


Figure 24 – Exigences en matière de contact avec des parties conductrices internes nues

Tableau 9 – Distance d’entrefer minimale

Valeur de crête de la tension de service	**Distance d’entrefer** mm	
V de crête ou c.c.	**Degré de pollution**	
Jusqu’à et y compris	**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	

Valeur de crête de la tension de service	**Distance d'entrefer** mm	
V de crête ou c.c.	**Degré de pollution**	
Jusqu'à et y compris	**2**	**3**
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.		

5.3.2.3 Critères de conformité

La conformité est vérifiée en réalisant l'essai de l'Article T.3.

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 à soumettre à essai lorsqu'ils sont utilisés dans le produit fini.

5.3.2.4 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** 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). Les parties des bornes de signaux audio munies des **protections** du Tableau E.1 ne sont pas soumises aux essais.

La conformité est vérifiée par l'essai de V.1.6 pour chaque ouverture de borne de contact ainsi que toute ouverture à 25 mm de la borne. Pendant l'essai, aucune partie de la sonde insérée dans la borne ou l'ouverture ne doit toucher ES2 ou ES3.

5.4 Matériaux d'isolation et exigences

5.4.1 Généralités

5.4.1.1 Isolation

Les matériaux isolants, les **distances dans l'air**, les **lignes de fuite** et l'**isolation réalisée avec un isolant solide** qui assurent une fonction de **protection** sont désignés 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.

5.4.1.3 Critères de 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 5.4.8. L'isolation est ensuite soumise à l'essai de rigidité diélectrique approprié décrit en 5.4.9.1 alors qu'elle se trouve toujours dans l'enceinte humide ou dans le local dans lequel les échantillons ont été amenés à la température spécifiée.

5.4.1.4 Températures de fonctionnement maximales pour les matériaux, composants et systèmes

5.4.1.4.1 Exigences

Dans les **conditions normales de fonctionnement**, les températures du matériau isolant ne doivent pas dépasser la limite de température de l'EIS, y compris les matériaux isolants des composants, ni la limite de température maximale du système d'isolation telle que donnée dans le Tableau 10.

Pour les températures maximales inférieures ou égales à 100 ºC, aucun système d'isolation classifié n'est nécessaire. Un EIS non classifié est considéré comme étant de la classe 105.

5.4.1.4.2 Méthode d'essai

Les températures du matériau isolant sont mesurées conformément à B.1.6.

L'équipement ou des parties de l'équipement fonctionnent dans les ***conditions normales de fonctionnement*** *(voir l'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 l'essai dans les conditions réelles ou simulées les plus défavorables spécifiées dans les instructions d'installation.

5.4.1.4.3 Critères de conformité

La température du matériau d'isolation électrique ou du système d'isolation électrique (EIS) ne doit pas dépasser les limites du Tableau 10.

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.

Pour un EIS, les données de classe thermique disponibles de l'EIS indiquées par le fabricant peuvent être utilisées si cela convient à la classe d'isolation applicable.

Pour les classifications thermiques au-dessus de la classe 105, l'EIS doit satisfaire à la CEI 60085.

Tableau 10 – 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 – avec marquage de la température	70 Température marquée sur le câble ou la bobine, ou valeur assignée fixée par le fabricant
Autre isolation thermoplastique	Voir 5.4.1.10
Composants	Voir également l'Annexe G et 4.1.2

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.

[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.

5.4.1.5 Degrés de pollution

5.4.1.5.1 Généralités

Les différents degrés de pollution de l'environnement de fonctionnement ou du microenvironnement pour les produits traités par la présente norme sont donnés ci-dessous.

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.

5.4.1.5.2 Essai pour l'environnement de degré de pollution 1 et pour un composé isolant

Un échantillon est soumis à la séquence de cycles thermiques de 5.4.1.5.3.

Après refroidissement jusqu'à la température ambiante, l'échantillon est soumis à l'épreuve hygroscopique de 5.4.8.

*Si l'essai est réalisé pour la vérification de **l'isolation solide** faite dans un composé isolant, comme exigé en 5.4.4.3, le conditionnement est suivi immédiatement par l'essai de rigidité diélectrique de 5.4.9.1.*

*Pour les cartes imprimées, la conformité est vérifiée par examen visuel. Il ne doit pas y avoir de délaminage affectant les **lignes de fuite** nécessaires à la satisfaction des exigences du **degré de pollution** 1.*

Pour des éléments autres que les cartes imprimées, la conformité est vérifiée par examen de la section et il ne doit pas y avoir de vides apparents ou fissures dans le matériau isolant.

5.4.1.5.3 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*	*($T_1 \pm 2$) °C;*
1 h	*à*	*(25 ± 2) °C;*
2 h	*à*	*(0 ± 2) °C;*
$\geq$ 1 h	*à*	*(25 ± 2) °C.*

$T_1 = T_2 + T_{ma} - T_{amb} + 10$ K, mesuré conformément à B.1.6 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 5.4.1.4.

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.

5.4.1.6 Isolation dans les transformateurs à dimensions variables

Si l'isolation d'un transformateur présente différentes **tensions de service** sur la longueur de l'enroulement, les **distances 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.

5.4.1.7 Isolation dans les circuits générant des impulsions de démarrage

Pour les circuits générant des impulsions de démarrage supérieures à ES1 (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.

NOTE 1 Pour les **tensions de service** dans les cas ci-dessus, voir 5.4.1.8.1 i).

NOTE 2 Si l'impulsion de démarrage est une forme d'onde c.a., la largeur de l'impulsion est déterminée en prenant en compte les valeurs de crête de la forme d'onde c.a.

Les **distances dans l'air** sont déterminées à l'aide de l'une des méthodes suivantes:

– déterminer la **distance dans l'air** minimale selon 5.4.2; ou
– effectuer l'un des essais de rigidité diélectrique suivants, les bornes de connexion du circuit des impulsions de démarrage (par exemple une lampe) étant court-circuitées ensemble:
  - l'essai donné en 5.4.9.1, ou
  - effectuer 30 impulsions dont l'amplitude est égale à la plus élevée des tensions d'essai requises indiquées en 5.4.9.1 à l'aide d'un générateur d'impulsions externe. La largeur de l'impulsion doit être supérieure ou égale à l'impulsion de démarrage générée en interne.

La conformité est vérifiée par examen ou essai. Pendant l'essai, l'isolation ne doit présenter aucun signe de rupture ou de contournement.

5.4.1.8 Détermination de la tension de service

5.4.1.8.1 Généralités

Pour la détermination des **tensions de service**, toutes les exigences suivantes s'appliquent:

a) les parties conductrices **accessibles** non mises à la terre sont supposées mises à la terre;
b) 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;
c) à l'exception des spécifications de 5.4.1.6, 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;
d) à l'exception des spécifications de 5.4.1.6, 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**;
e) 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 à travers 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 d'alimentation**

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 5.4.1.7), 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 fréquence de la **tension de service** permettant de déterminer la **distance dans l'air** minimale peut être supposée inférieure à 30 kHz. 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 sont à prendre en considération.

5.4.1.8.2 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**.

5.4.1.8.3 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 requise** pour des **distances 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 0;

– 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.

5.4.1.9 Surfaces isolantes

Une surface isolante **accessible** est considérée couverte d'une feuille métallique fine pour la détermination des **distances dans l'air**, des **lignes de fuite** et des distances dans l'isolation (voir la Figure O.13).

5.4.1.10 Parties thermoplastiques sur lesquelles les parties métalliques conductrices sont montées directement

5.4.1.10.1 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**.

5.4.1.10.2 Critère de 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 ci-dessous, soit par l'essai à la bille décrit en 5.4.1.10.3.

La température mesurée dans les ***conditions normales de fonctionnement****, telles que spécifiées dans 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.*

5.4.1.10.3 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 $(T - T_{amb} + T_{ma} + 15\ °C) \pm 2\ °C$ *(voir B.2.6.1 pour l'explication de* T, T_{ma} *et* T_{amb}*). 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.*

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 dans l'air

5.4.2.1 Exigences générales

Les **distances dans l'air** doivent être dimensionnées de manière à ce que la probabilité de rupture due aux

– **surtensions temporaires**, et
– tensions transitoires qui peuvent entrer dans l'équipement, et
– **valeurs de crête de la tension de service** qui peuvent être générées à l'intérieur de l'équipement, et
– fréquences générées à l'intérieur de l'équipement

soit réduite.

Toutes les **distances dans l'air** et les tensions d'essai exigées s'appliquent à une altitude jusqu'à 2 000 m. Pour des altitudes plus élevées, les facteurs de multiplication de 5.4.2.5 s'appliquent.

NOTE 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. Pour les distances entre les contacts des composants, voir l'Annexe G. Pour les connecteurs, voir G.4.1.

Sauf spécification contraire du fabricant et prévision de moyens permettant de garantir des **distances dans l'air** minimales pendant tous les modes de fonctionnement normal, la bobine mobile et les parties conductrices adjacentes d'un haut-parleur sont considérées comme étant en connexion conductrice.

Pour déterminer la **distance dans l'air**, la valeur la plus élevée des deux procédures suivantes doit être utilisée:

Méthode 1: Déterminer les **distances dans l'air** conformément à 5.4.2.2 à l'aide de la **valeur de crête de la tension de service**.

Méthode 2: Déterminer les **distances dans l'air** conformément à 5.4.2.3 à l'aide des **tensions de tenue requises**. En variante, le caractère approprié des **distances dans l'air** peut être déterminé en réalisant un essai de rigidité électrique conformément à 5.4.2.4, auquel cas, les valeurs selon la méthode 1 doivent être maintenues.

5.4.2.2 Procédure pour déterminer la distance dans l'air avec la valeur de crête de la tension de service

Pour déterminer la **valeur de crête de la tension de service**, la valeur la plus élevée des tensions suivantes est prise en compte selon le cas:

– les tensions stables; et

– les tensions de crête récurrentes à prendre égales à 1,1 fois la tension du **réseau d'alimentation** (voir 5.3.3.2.4 de la CEI 60664-1:2007); et

– les **surtensions temporaires** telles que données ci-dessous (voir également 5.3.3.2.3 de la CEI 60664-1:2007).

La valeur de la **surtension temporaire** est prise égale à 2 000 V crête si la tension nominale du système du **réseau d'alimentation** ne dépasse pas 250 V et est prise égale à 2 500 V crête si la tension nominale du système du **réseau d'alimentation** dépasse 250 V sans toutefois dépasser 600 V.

En variante, la **surtension temporaire** peut être déterminée conformément à 5.3.3.2.3 de la CEI 60664-1:2007 à la discrétion du fabricant.

La valeur la plus élevée de la **distance dans l'air** telle que déterminée ci-dessous doit être utilisée:

– les valeurs de **distance dans l'air** du Tableau 11 pour les circuits avec des fréquences fondamentales jusqu'à 30 kHz;

– les valeurs de **distance dans l'air** du Tableau 12 pour les circuits avec des fréquences fondamentales supérieures à 30 kHz;

– les valeurs les plus élevées de la **distance dans l'air** du Tableau 11 et du Tableau 12 pour les circuits présentant des fréquences inférieures à 30 kHz et supérieures à 30 kHz.

Tableau 11 – Distances dans l'air minimales pour des tensions avec des fréquences jusqu'à 30 kHz

<table>
<tr><th rowspan="3">Valeur de crête de la tension de service ou c.c.

jusqu'à et y compris</th><th colspan="3">Isolation principale ou isolation supplémentaire
mm</th><th colspan="3">Isolation renforcée
Mm</th></tr>
<tr><th colspan="3">Degré de pollution</th><th colspan="3">Degré de pollution</th></tr>
<tr><th>1 [a]</th><th>2</th><th>3</th><th>1 [a]</th><th>2</th><th>3</th></tr>
<tr><td>330</td><td>0,01</td><td rowspan="5">0,2</td><td rowspan="8">0,8</td><td>0,02</td><td rowspan="5">0,4</td><td rowspan="7">1,5</td></tr>
<tr><td>400</td><td>0,02</td><td>0,04</td></tr>
<tr><td>500</td><td>0,04</td><td>0,08</td></tr>
<tr><td>600</td><td>0,06</td><td>0,12</td></tr>
<tr><td>800</td><td>0,13</td><td>0,26</td></tr>
<tr><td>1 000</td><td>0,26</td><td>0,26</td><td>0,52</td><td>0,52</td></tr>
<tr><td>1 200</td><td colspan="2">0,42</td><td colspan="2">0,84</td></tr>
<tr><td>1 500</td><td colspan="2">0,76</td><td colspan="2">1,52</td><td>1,6</td></tr>
<tr><td>2 000</td><td colspan="3">1,27</td><td colspan="3">2,54</td></tr>
<tr><td>2 500</td><td colspan="3">1,8</td><td colspan="3">3,6</td></tr>
<tr><td>3 000</td><td colspan="3">2,4</td><td colspan="3">4,8</td></tr>
<tr><td>4 000</td><td colspan="3">3,8</td><td colspan="3">7,6</td></tr>
<tr><td>5 000</td><td colspan="3">5,7</td><td colspan="3">11,0</td></tr>
<tr><td>6 000</td><td colspan="3">7,9</td><td colspan="3">15,8</td></tr>
<tr><td>8 000</td><td colspan="3">11,0</td><td colspan="3">20</td></tr>
<tr><td>10 000</td><td colspan="3">15,2</td><td colspan="3">27</td></tr>
<tr><td>12 000</td><td colspan="3">19</td><td colspan="3">33</td></tr>
<tr><td>15 000</td><td colspan="3">25</td><td colspan="3">42</td></tr>
<tr><td>20 000</td><td colspan="3">34</td><td colspan="3">59</td></tr>
<tr><td>25 000</td><td colspan="3">44</td><td colspan="3">77</td></tr>
<tr><td>30 000</td><td colspan="3">55</td><td colspan="3">95</td></tr>
<tr><td>40 000</td><td colspan="3">77</td><td colspan="3">131</td></tr>
<tr><td>50 000</td><td colspan="3">100</td><td colspan="3">175</td></tr>
<tr><td>60 000</td><td colspan="3">120</td><td colspan="3">219</td></tr>
<tr><td>80 000</td><td colspan="3">175</td><td colspan="3">307</td></tr>
<tr><td>100 000</td><td colspan="3">230</td><td colspan="3">395</td></tr>
<tr><td colspan="7">Une interpolation linéaire peut être utilisée entre les deux points les plus proches, les distances dans l'air minimales calculées arrondies à l'incrément spécifié supérieur ou la valeur de la ligne suivante, la valeur la plus faible étant retenue. Pour les valeurs
- ne dépassant pas 0,5 mm, l'incrément spécifié est de 0,01 mm; et
- dépassant 0,5 mm, l'incrément spécifié est de 0,1 mm.</td></tr>
<tr><td colspan="7">[a] Les valeurs pour le degré de pollution 1 peuvent être utilisées si un échantillon est conforme aux essais de 5.4.1.5.2.</td></tr>
</table>

Tableau 12 – Distances dans l'air minimales pour des tensions avec des fréquences supérieures à 30 kHz

Valeur de crête de la tension de service **jusqu'à et y compris**	**Isolation principale ou isolation supplémentaire** mm	**Isolation renforcée** mm
600	0,07	0,14
800	0,22	0,44
1 000	0,6	1,2
1 200	1,68	3,36
1 400	2,82	5,64
1 600	4,8	9,6
1 800	8,04	16,08
2 000	13,2	26,4

Une interpolation linéaire peut être utilisée entre les deux points les plus proches, les **distances dans l'air** minimales calculées arrondies à l'incrément spécifié supérieur ou la valeur de la ligne suivante, la valeur la plus faible étant retenue. Pour les valeurs:

- ne dépassant pas 0,5 mm, l'incrément spécifié est de 0,01 mm; et
- dépassant 0,5 mm, l'incrément spécifié est de 0,1 mm.

Pour le **degré de pollution** 1, utiliser un facteur de multiplication de 0,8.

Pour le **degré de pollution** 3, utiliser un facteur de multiplication de 1,4.

5.4.2.3 Détermination de la distance dans l'air à l'aide de la tension de tenue requise

5.4.2.3.1 Généralités

La dimension pour une **distance dans l'air** soumise à des tensions transitoires du **réseau d'alimentation** ou d'un **circuit externe** est déterminée à partir de la **tension de tenue requise** pour la **distance dans l'air** considérée.

Chaque **distance dans l'air** doit être déterminée selon les étapes suivantes:

– déterminer la tension transitoire selon 5.4.2.3.2; et
– déterminer la **tension de tenue requise** selon 5.4.2.3.3; et
– déterminer la **distance dans l'air** minimale selon 5.4.2.3.4.

5.4.2.3.2 Détermination des tensions transitoires

5.4.2.3.2.1 Généralités

Les tensions transitoires peuvent être déterminées en fonction de leur origine ou peuvent être mesurées selon 5.4.2.3.2.5.

Si différentes tensions transitoires affectent la même **distance dans l'air**, la valeur la plus élevée de ces tensions est utilisée. Les valeurs ne sont pas ajoutées les unes aux autres.

5.4.2.3.2.2 Détermination des tensions transitoires du réseau d'alimentation en courant alternatif

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 et est donnée dans le Tableau 13. En général, les **distances 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.

Tableau 13 – 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	**Catégorie de surtension**			
	I	**II**	**III**	**IV**
50	330	500	800	1 500
100 [c]	500	800	1 500	2 500
150 [d]	800	1 500	2 500	4 000
300 [e]	1 500	2 500	4 000	6 000
600 [f]	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] 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.

[d] Y compris 120/208 V et 120/240 V.

[e] Y compris 230/400 V et 277/480 V.

[f] Y compris 400/690 V.

5.4.2.3.2.3 Détermination des tensions transitoires du réseau d'alimentation en courant continu

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 par rapport à la terre 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 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 5.4.2.3.2.4.

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.

5.4.2.3.2.4 Détermination des tensions transitoires du circuit externe

La valeur applicable de la tension transitoire qui peut apparaître sur un **circuit externe** doit être déterminée à l'aide du Tableau 14. Lorsque plus d'un emplacement ou d'une condition est applicable, la tension transitoire la plus élevée 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 de la tension transitoire.

Si la tension transitoire est inférieure à la tension crête du signal de courte durée (comme une sonnerie de téléphone), la tension crête du signal de courte durée doit être utilisée comme tension transitoire.

Si les tensions transitoires du **circuit externe** sont réputées supérieures aux valeurs indiquées dans le Tableau 14, la valeur connue doit être utilisée.

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 tensions transitoires présentées à l'équipement dépassent les valeurs spécifiées dans le Tableau 14. Dans les installations où des tensions transitoires présentées à l'équipement sont supposées dépasser les valeurs spécifiées dans le Tableau 14, des mesures supplémentaires telles qu'une limitation des surtensions peuvent se révéler nécessaires.

NOTE 3 En Europe, l'exigence relative à l'interconnexion avec le **circuit externe** est également donnée dans l'EN 50491-3:2009, *Exigences générales relatives aux systèmes électroniques pour les foyers domestiques et les bâtiments (HBES) et aux Systèmes de Gestion Technique du Bâtiment (SGTB) – Partie 3: exigences de sécurité électrique*.

Tableau 14 – Tensions transitoires du circuit externe

ID	Type de câble	Conditions supplémentaires	Tensions transitoires
1	Conducteur à paires [a] – blindé ou non blindé	Le bâtiment ou la structure peut disposer ou non d'une liaison équipotentielle	1 500 V 10/700 µs Différentiel uniquement si un conducteur est mis à la terre dans l'équipement
2	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
3	Câble coaxial dans le système de distribution du câble	Equipement 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 µs Conducteur central au blindage
4	Câble coaxial dans le système de distribution du câble	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 µs Conducteur central au blindage
5	Câble coaxial dans le système de distribution du câble	Equipement 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 µs Conducteur central au blindage 1 500 V 1,2/50 µs blindage à la terre
6	Câble coaxial	Le câble se connecte à une antenne extérieure	pas de transitoire, voir [c]
7	Conducteur à paires [a]	Le câble se connecte à une antenne extérieure	pas de transitoire, voir [c]
8	Câble coaxial dans le bâtiment [b]	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

En général, pour les **circuits externes** installés complètement dans la même structure du bâtiment, les transitoires ne sont pas pris en compte. Cependant, 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.

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.

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 Ω/km (pour f inférieur à 1 MHz).

NOTE 1 Les appareils domestiques tels que les produits audio, vidéo et multimédia sont désignés par ID 6, 7 et 8.

NOTE 2 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 (voir la note en 5.7.6). Pour les conditions d'installation, voir l'EN 60728-11.

[a] Un conducteur à paires comprend une paire torsadée.

[b] Lors de la détermination des exigences de séparation en 5.4.10, les transitoires sur les **circuits externes** sont pris en compte.

[c] Ces câbles ne sont pas soumis à des transitoires mais ils peuvent être affectés par une tension de décharge électrostatique de 10 kV (d'une capacité de 1 nF). L'effet de ces tensions de décharge électrostatique n'est pas pris en compte lors de la détermination des **distances dans l'air**. La conformité est vérifiée par l'essai de G.10.3.2.

5.4.2.3.2.5 Détermination des niveaux de tension transitoire par mesure

La tension transitoire à travers la **distance dans l'air** est mesurée à l'aide de la procédure d'essai suivante.

Au cours des mesures, 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 la mesure.

Pour mesurer la tension transitoire à travers une **distance dans l'air**, le générateur d'impulsions d'essai approprié de l'Annexe D est utilisé pour générer les impulsions. Au moins trois impulsions de polarités alternées, avec des intervalles d'au moins 1 s entre les impulsions, sont appliquées entre tous les points applicables.

a) Tensions transitoires venant d'un **réseau d'alimentation** en courant alternatif

   Le générateur d'impulsions d'essai du circuit 2 du Tableau D.1 est utilisé pour générer des impulsions 1,2/50 µs égales aux **tensions transitoires du réseau d'alimentation** en courant alternatif, aux points suivants:

   – 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; et
   – le neutre et la terre de protection.

b) Tensions transitoires venant d'un **réseau d'alimentation** en courant continu

   Le générateur d'impulsions d'essai du circuit 2 du Tableau D.1 est utilisé pour générer des impulsions 1,2/50 µs égales aux **tensions transitoires du réseau d'alimentation** en courant continu, aux points suivants:

   – les points de connexion d'alimentation positif et négatif; et
   – tous les points de connexion d'alimentation reliés ensemble et la terre de protection.

c) Tensions transitoires d'un **circuit externe**

   Le générateur d'essai adapté de l'Annexe D est utilisé pour générer des impulsions applicables et décrites dans le Tableau 14 qui 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); et
   – toutes les bornes d'un type d'interface unique reliées ensemble et la terre.

Un dispositif de mesure de tension est connecté à travers la **distance dans l'air** concernée.

S'il existe plusieurs circuits identiques, un seul est soumis à essai.

5.4.2.3.3 Détermination de la tension de tenue requise

La **tension de tenue requise** est égale à la tension transitoire déterminée en 5.4.2.3.2, à l'exception des cas suivants:

– Si un circuit isolé du **réseau d'alimentation** est connecté à une borne principale de mise à la terre de protection conforme à 5.6.7, la **tension de tenue requise** peut être d'une catégorie de surtension inférieure du Tableau 13.
– 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 requise** 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** sans retrait de l'équipement, la tension transitoire est nulle et la **tension de tenue requise** est égale à la **valeur de crête de la tension de service**.

5.4.2.3.4 Détermination des distances dans l'air avec la tension de tenue requise

Chaque **distance dans l'air** doit être conforme à la valeur applicable du Tableau 15.

Tableau 15 – Distances dans l'air minimales avec la tension de tenue requise

<table>
<tr><th>Tension de tenue requise</th><th colspan="3">Isolation principale ou isolation supplémentaire
mm</th><th colspan="3">Isolation renforcée
mm</th></tr>
<tr><th rowspan="2">V de crête ou c.c.
jusqu'à et y compris</th><th colspan="3">Degré de pollution</th><th colspan="3">Degré de pollution</th></tr>
<tr><th>1 [a]</th><th>2</th><th>3</th><th>1 [a]</th><th>2</th><th>3</th></tr>
<tr><td>330</td><td>0,01</td><td rowspan="6">0,2</td><td rowspan="8">0,8</td><td>0,02</td><td rowspan="6">0,4</td><td rowspan="8">1,5</td></tr>
<tr><td>400</td><td>0,02</td><td>0,04</td></tr>
<tr><td>500</td><td>0,04</td><td>0,08</td></tr>
<tr><td>600</td><td>0,06</td><td>0,12</td></tr>
<tr><td>800</td><td>0,10</td><td>0,2</td></tr>
<tr><td>1 000</td><td>0,15</td><td>0,3</td></tr>
<tr><td>1 200</td><td colspan="2">0,25</td><td colspan="2">0,5</td></tr>
<tr><td>1 500</td><td colspan="2">0,5</td><td colspan="2">1,0</td></tr>
<tr><td>2 000</td><td colspan="3">1,0</td><td colspan="3">2,0</td></tr>
<tr><td>2 500</td><td colspan="3">1,5</td><td colspan="3">3,0</td></tr>
<tr><td>3 000</td><td colspan="3">2,0</td><td colspan="3">3,8</td></tr>
<tr><td>4 000</td><td colspan="3">3,0</td><td colspan="3">5,5</td></tr>
<tr><td>5 000</td><td colspan="3">4,0</td><td colspan="3">8,0</td></tr>
<tr><td>6 000</td><td colspan="3">5,5</td><td colspan="3">8,0</td></tr>
<tr><td>8 000</td><td colspan="3">8,0</td><td colspan="3">14</td></tr>
<tr><td>10 000</td><td colspan="3">11</td><td colspan="3">19</td></tr>
<tr><td>12 000</td><td colspan="3">14</td><td colspan="3">24</td></tr>
<tr><td>15 000</td><td colspan="3">18</td><td colspan="3">31</td></tr>
<tr><td>20 000</td><td colspan="3">25</td><td colspan="3">44</td></tr>
<tr><td>25 000</td><td colspan="3">33</td><td colspan="3">60</td></tr>
<tr><td>30 000</td><td colspan="3">40</td><td colspan="3">72</td></tr>
<tr><td>40 000</td><td colspan="3">60</td><td colspan="3">98</td></tr>
<tr><td>50 000</td><td colspan="3">75</td><td colspan="3">130</td></tr>
<tr><td>60 000</td><td colspan="3">90</td><td colspan="3">162</td></tr>
<tr><td>80 000</td><td colspan="3">130</td><td colspan="3">226</td></tr>
<tr><td>100 000</td><td colspan="3">170</td><td colspan="3">290</td></tr>
<tr><td colspan="7">Une interpolation linéaire peut être utilisée entre les deux points les plus proches, les distances dans l'air minimales calculées arrondies à l'incrément spécifié supérieur ou la valeur de la ligne suivante, la valeur la plus faible étant retenue. Pour les valeurs:
– ne dépassant pas 0,5 mm, l'incrément spécifié est de 0,01 mm; et
– dépassant 0,5 mm, l'incrément spécifié est de 0,1 mm.</td></tr>
<tr><td colspan="7">[a] Les valeurs pour le degré de pollution 1 peuvent être utilisées si un échantillon est conforme aux essais de 5.4.1.5.2.</td></tr>
</table>

5.4.2.4 Détermination du caractère approprié d'une distance dans l'air établi d'après l'essai de rigidité diélectrique

*Les **distances dans l'air** doivent supporter un essai de rigidité diélectrique. 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**. La **tension de tenue requise** est déterminée selon 5.4.2.3.*

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 16. Cinq *impulsions de chaque polarité sont appliquées avec un intervalle d'au moins 1 s entre les impulsions.*

L'essai de tension en courant alternatif est réalisé à l'aide d'une tension sinusoïdale avec les valeurs crête spécifiées dans le Tableau 16, appliquée pendant 5 s.

L'essai de ***tension en courant continu*** *est réalisé à l'aide d'une* ***tension en courant continu*** *spécifiée dans le Tableau 16 appliquée pendant 5 s dans une polarité et ensuite pendant 5 s dans la polarité inverse.*

Tableau 16 – Tensions d'essai de rigidité diélectrique

Tension de tenue requise **jusqu'à et y compris** kV de crête	**Tension d'essai de rigidité diélectrique pour les distances dans l'air pour isolation principale ou isolation supplémentaire** kV de crête (impulsion ou c.a. ou c.c.)
0,33	0,36
0,5	0,54
0,8	0,93
1,5	1,75
2,5	2,92
4,0	4,92
6,0	7,39
8,0	9,85
12,0	14,77
U [a]	1,23 × U [a]
Une interpolation linéaire peut être utilisée entre les deux points les plus proches, la tension d'essai minimale calculée arrondie au 0,1 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**. Si l'EUT ne satisfait pas à l'essai en courant alternatif ou en courant continu, l'essai de choc doit être utilisé Si l'essai est réalisé à une altitude de 200 m ou plus au-dessus du niveau de la mer, le Tableau F.5 de la CEI 60664-1:2007 peut être utilisé.	
[a] U est une **tension de tenue requise** supérieure à 12,0 kV.	

5.4.2.5 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 plus de 2 000 m au-dessus du niveau de la mer, les **distances dans l'air** minimales spécifiées dans le Tableau 11, le Tableau 12 et le Tableau 15, et les tensions d'essai de rigidité diélectrique indiquées dans le Tableau 16 sont multipliées par le facteur de multiplication applicable pour l'altitude souhaitée selon le Tableau 17.

NOTE 1 Des altitudes plus élevées peuvent être simulées dans une chambre à vide.

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 17 – 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 dans l'air**	**Facteur de multiplication pour les tensions d'essai de rigidité diélectrique**		
			< 1 mm	**≥ 1 mm à < 10 mm**	**≥ 10 mm à < 100 mm**
2 000	80,0	1,00	1,00	1,00	1,00
3 000	70,0	1,14	1,05	1,07	1,10
4 000	62,0	1,29	1,10	1,15	1,20
5 000	54,0	1,48	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.					

5.4.2.6 Critères de conformité

La conformité est vérifiée par mesure et essai en prenant en compte les articles appropriés de l'Annexe O et de l'Annexe T.

Les conditions suivantes s'appliquent:

– *les parties mobiles sont placées dans leur position la plus défavorable;*

– *les* ***distances 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;*

– *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;*

– *les dimensions des* ***distances dans l'air*** *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;*

– *pour l'essai de choc de l'Article T.9, les endommagements de la finition, les petits éclats ne réduisant pas les* ***distances dans l'air*** *en dessous des valeurs spécifiées, les fissures superficielles et les éléments similaires sont ignorés. Si une fissure apparaît, les* ***distances 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; et*

– *les composants et parties, autres que ceux servant d'****enveloppe****, sont soumis à l'essai de l'Article T.2. Après l'application de la force, les* ***distances dans l'air*** *ne doivent pas être réduites à des valeurs inférieures à celles exigées.*

Pour les circuits connectés à la distribution du câble coaxial et aux antennes extérieures, la conformité est vérifiée par les essais de 5.5.8.

5.4.3 Lignes de fuite

5.4.3.1 Généralités

Les **lignes de fuite** 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).

Les **lignes de fuite** pour **l'isolation principale** et **l'isolation supplémentaire** pour des fréquences jusqu'à 30 kHz doivent être conformes au Tableau 18. Les **lignes de fuite** pour **l'isolation principale** et **l'isolation supplémentaire** pour des fréquences supérieures à 30 kHz et jusqu'à 400 kHz doivent être conformes au Tableau 19.

Les exigences relatives aux **lignes de fuite** pour des fréquences pouvant atteindre 400 kHz peuvent s'appliquer pour des fréquences de plus de 400 kHz, jusqu'à ce que des données supplémentaires soient disponibles.

NOTE 1 Les **lignes de fuite** pour des fréquences supérieures à 400 kHz sont à l'étude.

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
  - nécessite d'être à sa place dans les **conditions normales de fonctionnement**, et
  - est fourni avec une **protection par 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 **lignes de fuite** dans les connecteurs, y compris les connecteurs qui ne sont pas fixés à l'équipement, les valeurs minimales déterminées conformément au 5.4.3 s'appliquent.

Les **lignes de fuite** minimales ci-dessus pour les connecteurs ne s'appliquent pas aux connecteurs énumérés en l'Article G.4.

NOTE 3 Pour les **lignes de fuite** inférieures à 2 mm, des informations supplémentaires sont disponibles dans la CEI 60664-5.

*Si la **ligne de fuite** minimale dérivée du Tableau 18 ou du Tableau 19 est inférieure à la **distance 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 dans l'air** minimale applicable, la valeur de la **distance dans l'air** minimale peut être appliquée comme **ligne de fuite** minimale.*

*Pour une **isolation renforcée**, les valeurs pour les **lignes de fuite** représentent le double des valeurs pour une **isolation principale** dans le Tableau 18 ou le Tableau 19.*

5.4.3.2 Méthode d'essai

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 en G.7 et aussi sans conducteurs;*

- *lors de la mesure des **lignes de fuite** depuis la surface extérieure **accessible** 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 extérieure **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 selon 4.4.4;*
- *pour l'essai de bris de glace de 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;*
- *les composants et parties, autres que ceux servant d'**enveloppe**, sont soumis à l'essai de l'Article T.2. Après l'application de la force, les **lignes de fuite** ne doivent pas être réduites à des valeurs inférieures à celles exigées.*

5.4.3.3 Groupe de matériaux et IRC

Les groupes de matériaux sont fondés sur l'IRC et sont classifiés comme suit:

Groupe de matériaux I	600 ≤ IRC
Groupe de matériaux II	400 ≤ IRC < 600
Groupe de matériaux IIIa	175 ≤ IRC < 400
Groupe de matériaux IIIb	100 ≤ 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.

5.4.3.4 Critères de conformité

La conformité est vérifiée par mesure, en prenant en compte l'Annexe O, l'Annexe T et l'Annexe V.

Tableau 18 – 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 [b]
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			
32 000	125	160	220	320			
40 000	160	200	280	400			
50 000	200	250	360	500			
63 000	250	320	450	600			

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 5.4.1.5.2.

[b] 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.

Tableau 19 – Lignes de fuite minimales pour des fréquences supérieures à 30 kHz et jusqu'à 400 kHz en mm

Valeur de crête de la tension de service kV	30 kHz < f ≤ 100 kHz	100 kHz < f ≤ 200 kHz	200 kHz < f ≤ 400 kHz
0,1	0,0167	0,02	0,025
0,2	0,042	0,043	0,05
0,3	0,083	0,09	0,1
0,4	0,125	0,13	0,15
0,5	0,183	0,23	0,25
0,6	0,267	0,38	0,4
0,7	0,358	0,55	0,68
0,8	0,45	0,8	1,1
0,9	0,525	1,0	1,9
1	0,6	1,15	3

Les valeurs pour les **lignes de fuite** du tableau s'appliquent pour le **degré de pollution** 1. Pour le **degré de pollution** 2, un facteur de multiplication de 1,2 et pour le **degré de pollution** 3, un facteur de multiplication de 1,4 doivent être utilisés.

Une interpolation linéaire peut être appliquée.

Les données mentionnées dans ce Tableau 19 (tiré du Tableau 2 de la CEI 60664-4:2005) ne prennent pas en compte l'influence des phénomènes de cheminement. Pour cette raison, le Tableau 18 est à prendre en compte. Cependant, si les valeurs du Tableau 19 sont inférieures à celles du Tableau 18, les valeurs du Tableau 18 s'appliquent.

5.4.4 Isolation réalisée avec un isolant solide

5.4.4.1 Exigences générales

Les exigences ci-dessous s'appliquent à une **isolation réalisée avec un isolant solide** y compris aux composés et aux matériaux gel utilisés comme isolation

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'émail 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.6.2.

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 dans l'Article T.9. Les endommagements de la finition, les petits éclats ne réduisant pas les **distances dans l'air** en dessous des valeurs spécifiées, les fissures superficielles et les éléments similaires sont ignorés. Si une fissure apparaît, les **distances dans l'air** et les **lignes de fuite** ne doivent pas être réduites en dessous des valeurs spécifiées.

Pour les cartes imprimées, voir l'Article G.13. Pour les dispositifs de connexion extérieure d'antenne, voir 5.4.4.5. 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 dans l'air** ni de **ligne de fuite** interne 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); et
– le composant ou sous-ensemble répond aux distances minimales à travers l'isolation de 5.4.4.2; et
– un seul échantillon réussit les essais de 5.4.1.5.2.

NOTE Des exemples de traitements de ce type diversement connus comprennent l'enrobage, la mise sous boîtier rempli et l'imprégnation sous vide.

De telles constructions contenant des joints scellés doivent aussi satisfaire au 5.4.4.5.

Les autres exigences relatives aux dispositifs à semi-conducteurs sont indiquées en 5.4.4.4.

Pour les cartes imprimées, voir l'Article G.13 et pour les composants bobinés, voir 5.4.4.7.

La conformité est vérifiée en découpant en sections l'échantillon. Il ne doit pas y avoir de vides apparents dans le matériau isolant.

5.4.4.4 Isolation réalisée avec un isolant solide dans des dispositifs à semi-conducteurs

Il n'existe pas de **distance 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 aux **essais de type** et aux critères d'examen décrits en 5.4.7, ainsi que les **essais individuels de série** de rigidité diélectrique au cours de la fabrication, selon l'essai approprié décrit en 5.4.9.1; ou
– satisfasse à l'Article G.12.

De telles constructions contenant des joints scellés doivent aussi satisfaire au 5.4.4.5.

En variante, un semi-conducteur peut être évalué conformément à 5.4.4.3.

5.4.4.5 Composé isolant constituant des joints scellés

Les exigences spécifiées ci-dessous s'appliquent 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. Ces exigences ne s'appliquent pas aux optocoupleurs conformes à la CEI 60747-5-5.

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 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 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 5.4.1.5.2. Les exigences relatives à la distance à travers l'isolation décrites en 5.4.4.2 ne s'appliquent pas le long du joint.

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 5.4.7.

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, le groupe de matériaux IIIb doit être utilisé.

Pour b) et c) ci-dessus, les essais de 5.4.1.5.2 et de 5.4.7 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 5.4.1.4 ne dépasse pas 90 °C.

NOTE Les exemples de joints scellés comprennent les suivants:

– deux parties non conductrices scellées ensemble (par exemple, deux couches d'une carte multicouches, 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 29.

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; et
– l'isolation se situe à l'intérieur de l'**enveloppe** de l'équipement; et

– 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 ont à présenter les mêmes matériaux et épaisseurs.

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 20 s'appliquent. Il n'existe aucune exigence stipulant que toutes les couches de l'isolation ont à présenter les mêmes matériaux et épaisseur.

La conformité est vérifiée par examen et par les essais spécifiés dans le Tableau 20.

Tableau 20 – 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 5.4.9.1 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 tension d'essai spécifiée en 5.4.9.1 pour une **isolation supplémentaire** ou une **isolation renforcée** selon le cas.*

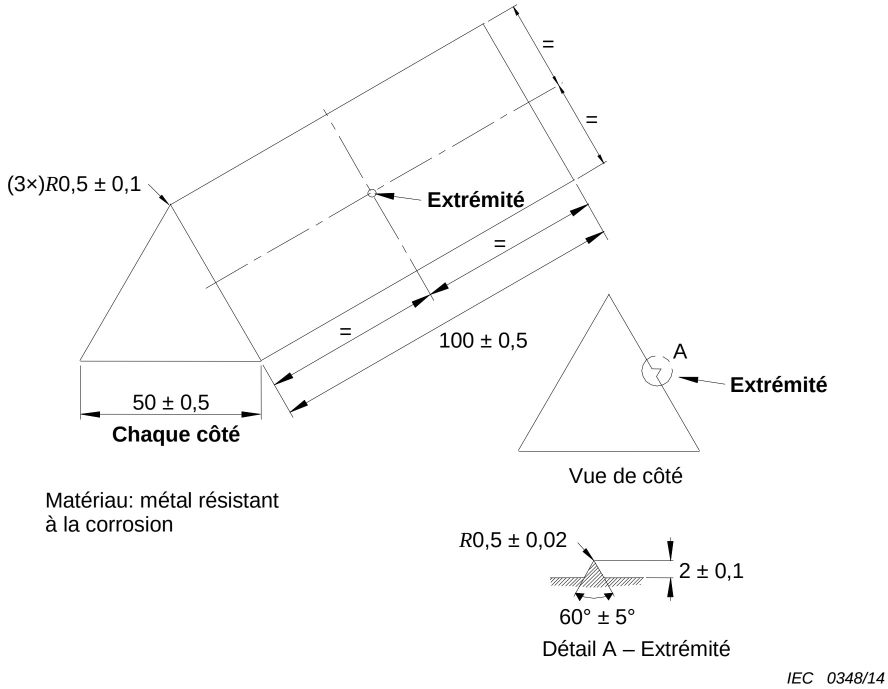
NOTE À moins que toutes les couches ne soient composées du même matériau et présentent la même épaisseur, il existe une possibilité que la tension d'essai soit inégalement répartie entre les couches, provoquant la rupture d'une couche qui aurait satisfait à l'essai séparément.

5.4.4.6.5 Essai du mandrin

*Les exigences d'essai pour une **isolation renforcée** composée de trois fines couches isolantes ou plus de matériau qui ne sont pas séparables sont spécifiées ci-dessous.*

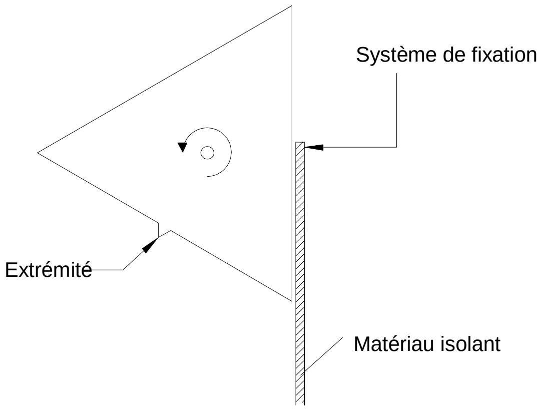
NOTE L'essai est fondé sur la CEI 61558-1 et donne les mêmes résultats.

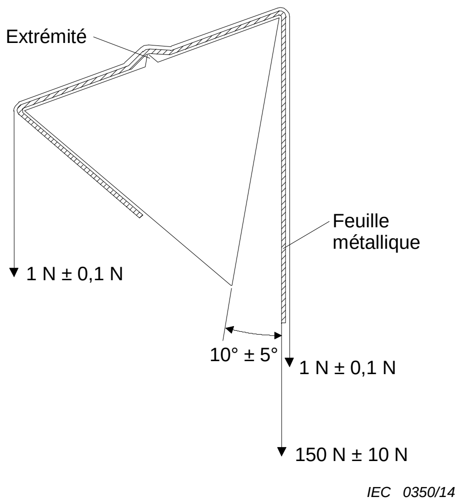
*Trois échantillons d'essai, chaque échantillon individuel étant composé de trois couches ou plus de matériau en fines feuilles non séparables formant l'**isolation renforcée**, sont utilisés. Un échantillon est fixé au mandrin du dispositif d'essai (Figure 25). La fixation doit être réalisée comme représentée à la Figure 26.*



Dimensions en millimètres

Figure 25 – Mandrin





La position finale du mandrin subit une rotation de 230 °± 5° par rapport à la position initiale.

Dimensions en millimètres

Figure 26 – Position initiale du mandrin **Figure 27 – Position finale du mandrin**

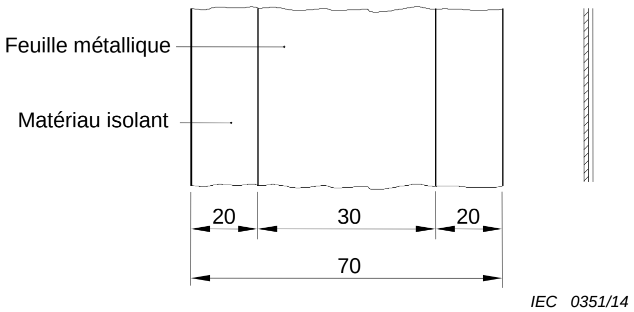
Une traction est appliquée à l'extrémité libre de l'échantillon, à l'aide d'un dispositif de serrage approprié. Le mandrin subit une rotation:

– *de la position initiale (Figure 26) à la position finale (Figure 27) et inversement 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 mm ± 0,005 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 27). 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 28). La feuille est ensuite resserrée par deux poids égaux, un à chaque extrémité, en utilisant des dispositifs de serrage appropriés.



Dimensions en millimètres

Figure 28 – 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 5.4.9.1. La tension d'essai est égale à 150 % de U_{essai}, mais pas inférieure à 5 kV efficace, où U_{essai} est la tension d'essai spécifiée en 5.4.9.1 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

Une **isolation principale,** une **isolation supplémentaire** ou une **isolation renforcée** dans un composant bobiné peut être assurée par

– l'isolation sur les composants bobinés (voir l'Article G.5); ou
– l'isolation sur un autre câble (voir l'Article G.6); ou
– une combinaison des deux.

Les composants bobinés contenant des joints scellés doivent aussi satisfaire au 5.4.4.5.

Les transformateurs planaires doivent satisfaire aux exigences de l'Article G.13.

5.4.4.8 Critères de 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 5.4.9.1 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 à la fréquence du **réseau d'alimentation** E_P en kV/mm pour le matériau isolant. Voir le Tableau 21 pour des exemples de matériaux communément utilisés à la fréquence du **réseau d'alimentation**.

– Déterminer le facteur de réduction K_R pour la résistance du champ électrique de rupture du matériau isolant à la fréquence applicable du Tableau 22 ou du Tableau 23. Si le matériau ne fait pas partie des matériaux énumérés dans le Tableau 22 ou le Tableau 23, utiliser le facteur de réduction moyen indiqué dans la dernière colonne du Tableau 22 ou du Tableau 23, 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 %.

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

En variante,

– l'essai de rigidité diélectrique de 5.4.9.1 peut être réalisé 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**; ou

– l'isolation peut être soumise à l'essai de rupture à haute fréquence conformément au 7.4 de la CEI 60664-4:2005 avec le potentiel d'essai à la fréquence de la **tension de service** réelle mesurée

NOTE Dans ce contexte, le champ électrique est considéré comme à peu près uniforme si les écarts sont inférieurs à 20 % de la valeur moyenne de la résistance du champ.

Tableau 21 – Résistance du champ électrique E_P pour quelques matériaux couramment utilisés

Matériau	Résistance du champ électrique de rupture E_P kV/mm				
	Epaisseur du matériau mm				
	0,75	**0,08**	**0,06**	**0,05**	**0,03**
Porcelaine [a]	9,2	-	-	-	-
Silicium-verre [a]	14	-	-	-	-
Phénolique [a]	17	-	-	-	-
Céramique [a]	19	-	-	-	-
Téflon ® ou équivalent [a] [3]	27	-	-	-	-
Mélamine-verre [a]	27	-	-	-	-
Mica [a]	29	-	-	-	-
Papier phénolique [a]	38	-	-	-	-
Polyéthylène [b]	50	-	-	52	-
Polystyrène [c]	55	65	-	-	-
Verre [c]	60	-	-	-	-
Kapton ® [a] [4]	303	-	-	-	-
FR530L [a]	33	-	-	-	-
Phénolique chargé de mica [a]	28	-	-	-	-
Laminé verre-silicone [a]	18	-	-	-	-
Acétobutyrate de cellulose [d]	-	-	120	-	210
Polycarbonate [d]	-	-	160	-	270
Triacétate de cellulose [d]	-	-	120	-	210

NOTE Les valeurs manquantes et les valeurs pour les autres matériaux ne figurant pas dans la liste font l'objet d'une enquête

[a] Pour la distribution de la résistance de champ électrique des matériaux spécifiés, la valeur E_P de 0,75 mm d'épaisseur peut être utilisée pour toutes les épaisseurs.

[b] La valeur E_P de 0,05 mm d'épaisseur est utilisée pour l'isolation égale ou inférieure à 0,05 mm. Sinon, la valeur E_P de 0,75 mm d'épaisseur est utilisée.

[c] La valeur E_P de 0,08 mm d'épaisseur est utilisée pour l'isolation égale ou inférieure à 0,08 mm. Sinon, la valeur E_P de 0,75 mm d'épaisseur est utilisée.

[d] La valeur E_P de 0,03 mm d'épaisseur est utilisée pour l'isolation égale ou inférieure à 0,03 mm. La valeur E_P de 0,06 mm d'épaisseur est utilisée pour l'isolation égale ou inférieure à 0,06 mm et supérieure à 0,03 mm.

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[3] Teflon® est l'appellation commerciale d'un produit distribué par DuPont. Cette information est donnée à l'intention des utilisateurs du présent document et ne signifie nullement que la CEI approuve ou recommande l'emploi exclusif du produit ainsi désigné. Des produits équivalents peuvent être utilisés s'il est démontré qu'ils conduisent aux mêmes résultats.

[4] Kapton® est l'appellation commerciale d'un produit distribué par DuPont. Cette information est donnée à l'intention des utilisateurs du présent document et ne signifie nullement que la CEI approuve ou recommande l'emploi exclusif du produit ainsi désigné. Des produits équivalents peuvent être utilisés s'il est démontré qu'ils conduisent aux mêmes résultats.

Tableau 22 – 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

Si la fréquence se situe entre les valeurs d'une des deux colonnes, la valeur du facteur de réduction dans la colonne suivante doit être utilisée ou une interpolation logarithmique peut être utilisée entre l'une des deux colonnes adjacentes avec la valeur calculée arrondie au 0,01 le plus proche.

[a] Ces données correspondent aux matériaux qui ont une épaisseur de 0,75 mm.

Tableau 23 – Facteurs de réduction pour la valeur de la résistance du champ électrique de rupture E_P à des fréquences plus élevées pour les matériaux fins

Matériau fin	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 fins	0,68	0,46	0,34	0,29	0,25	0,22	0,16	0,12	0,10	0,08	0,06

Si la fréquence se situe entre les valeurs d'une des deux colonnes, la valeur du facteur de réduction dans la colonne suivante doit être utilisée ou une interpolation logarithmique peut être utilisée entre l'une des deux colonnes adjacentes avec la valeur calculée arrondie au 0,01 le plus proche.

5.4.5 Isolation des bornes d'antenne

5.4.5.1 Généralités

L'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**.

doit être capable de supporter les décharges électrostatiques 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 5.6.7.

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 conditionnée comme décrit en G.10.3.1 et soumise à essai comme décrit en G.10.3.2. 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 Critères de conformité

La conformité est vérifiée en mesurant la résistance d'isolement avec 500 V en courant continu.

L’appareil est considéré comme satisfaisant aux exigences si la résistance d'isolement, mesurée après 1 min, n'est pas inférieure aux valeurs indiquées au Tableau 24.

Tableau 24 – Valeurs pour la résistance d'isolement

Exigences relatives à l’isolation entre les parties	Résistance d'isolement 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

*En variante, la conformité peut être vérifiée par un essai de rigidité diélectrique conformément à 5.4.9.1 pour l’**isolation principale** ou l’**isolation renforcée** selon le cas. La tension d’essai doit correspondre à la plus élevée des tensions d’essai déterminées par les méthodes 1, 2 et 3. Il ne doit pas y avoir de rupture de l’isolation.*

5.4.6 Isolation du câblage interne en tant que partie d'une protection supplémentaire

Les exigences ci-dessous 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**.

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**; et

– 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; et

– le fil est dirigé et fixé de telle sorte qu'il ne touche pas les parties conductrices **accessibles** non mises à la terre; et

– l'isolation du fil satisfait à l'essai de rigidité diélectrique de 5.4.9.1 pour l'**isolation supplémentaire**;

– la distance à travers l'isolation du fil doit être au moins celle indiquée dans le Tableau 25.

Tableau 25 – 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 5.4.9.1.

5.4.7 Essais pour les composants à semi-conducteurs et pour les joints scellés

Trois échantillons sont soumis à la séquence de cycles thermiques décrite en 5.4.1.5.3. 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 5.4.9.1, immédiatement après la dernière période à (T_1 ± 2) °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 5.4.9.1 après l'épreuve hygroscopique de 5.4.8, à cette exception près que la tension d'essai est multipliée par 1,6.*

La conformité est vérifiée par un essai et par les examens suivants:

A l'exception des joints scellés sur la même surface intérieure d'une carte imprimée, la conformité est vérifiée par examen de la section et le matériau isolant ne doit pas présenter de vides apparents, de trous ou de craquelures.

Dans le cas d'une isolation entre conducteurs sur la même surface intérieure des cartes imprimées et d'une isolation entre conducteurs sur des surfaces différentes de cartes imprimées multicouches, la conformité est vérifiée par examen visuel externe. Il ne doit pas y avoir de délaminage.

5.4.8 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 ± 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 ± 2) °C et une humidité relative de (93 ± 3) %.

Avant l'épreuve hygroscopique, l'échantillon est amené à une température comprise entre la température spécifiée t et ($t + 4$) °C.

5.4.9 Essai de rigidité diélectrique

5.4.9.1 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 5.4.1.4, 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 5.4.1.4 (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 26 *à l'aide de la **tension de tenue requise** (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 27 *à l'aide de la **valeur de crête de la tension de service**.*
- *Méthode 3: Déterminer la tension d'essai conformément au* Tableau 28 *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, pendant la durée spécifiée ci-dessous, puis la répéter dans la polarité inverse.*

*La tension appliquée à l'isolation soumise à essai est progressivement élevée de zéro à la tension requise et maintenue à cette valeur pendant 60 s (pour les **essais individuels de série**, voir 5.4.9.2).*

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 conforme à l'Article G.8 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****.*

Lorsque les condensateurs sont mis en parallèle avec l'isolation soumise à essai (par exemple, des condensateurs à filtre radioélectriques), on doit utiliser des tensions d'essai en courant continu.

Il est permis 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 5.4.1.6, une méthode d'essai de rigidité diélectrique est utilisée et appliquée selon le type d'isolation le long de l'enroulement.

EXEMPLE Une telle méthode d'essai peut consister en 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 requise.

Tableau 26 – Tensions d'essai pour les essais de rigidité diélectrique basés sur les tensions transitoires

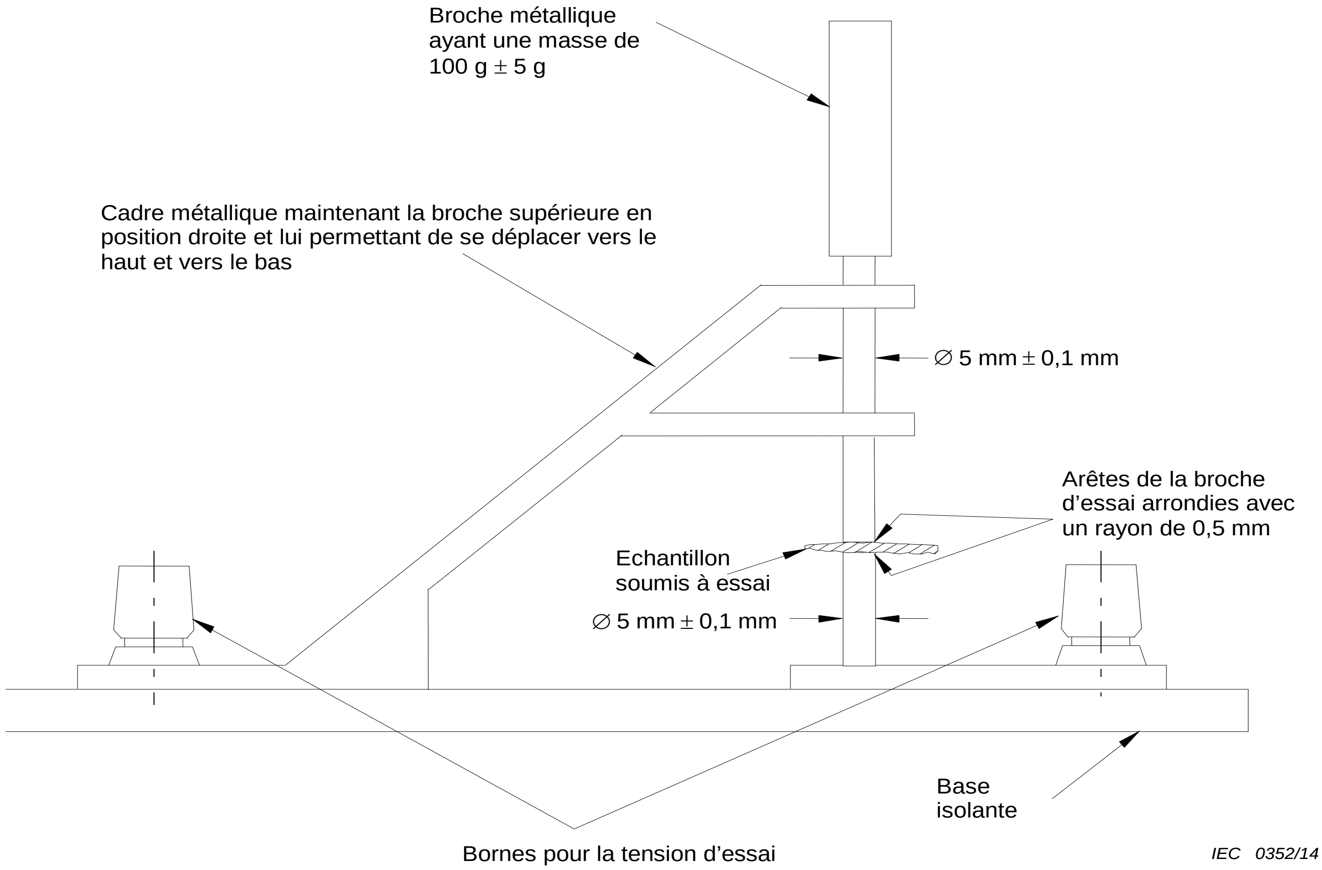
Tension de tenue requise jusqu'à et y compris kV de crête	**Tension d'essai pour l'isolation principale ou l'isolation supplémentaire**	**Tension d'essai pour l'isolation renforcée**
	kV de crête c.a. ou c.c.	
0,33	0,33	0,5
0,5	0,5	0,8
0,8	0,8	1,5
1,5	1,5	2,5
2,5	2,5	4
4,0	4	6
6,0	6	8
8,0	8	12
12	12	18
U_R [a]	U_R [a]	1,5 × 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 requise** supérieure à 12 kV.		

Tableau 27 – 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	Tension d'essai pour l'isolation principale ou l'isolation supplémentaire	Tension d'essai pour l'isolation renforcée
kV de crête	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]
Une interpolation linéaire peut être utilisée entre les deux points les plus proches.		
[a] U_P correspond à toute **valeur de crête de la tension de service** supérieure à 12 kV.		

Tableau 28 – 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 c.c.	
Jusque et y compris 250	2	4
Plus de 250 jusque et y compris 600	2,5	5



Dimensions en millimètres

Figure 29 – Exemple d'instrument d'essai de rigidité diélectrique pour une isolation réalisée avec un isolant solide

NOTE Les isolations à fines couches peuvent être soumises à l'essai en utilisant l'instrument de la Figure 29.

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.

5.4.9.2 Procédure d'essai pour les essais individuels de série

*Les **essais individuels de série** sont effectués conformément à 5.4.9.1, 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 peuvent être réduites de 10 %.*

NOTE Les conditions d'essai ci-dessus s'appliquent 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.

5.4.10 Protections contre les tensions transitoires des circuits externes

5.4.10.1 Exigences

Une séparation électrique appropriée doit être assurée entre les **circuits externes** de l'équipement, comme cela est indiqué dans le Tableau 14, numéro d'identification 1, la Figure 30 et:

a) les parties non conductrices et les parties conductrices non mises à la terre 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);

b) 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** au calibre d'essai de la Figure V.3;

c) une autre partie ES1 ou ES2 séparée du **circuit externe**. L'exigence de séparation s'applique indépendamment de l'accessibilité ou non de la partie ES1 ou ES2.

Ces exigences ne s'appliquent pas lorsque l'analyse du circuit et l'étude de l'équipement indiquent qu'une protection adéquate est assurée par d'autres moyens (par exemple, entre deux circuits dont chacun a une connexion permanente à la terre de protection).

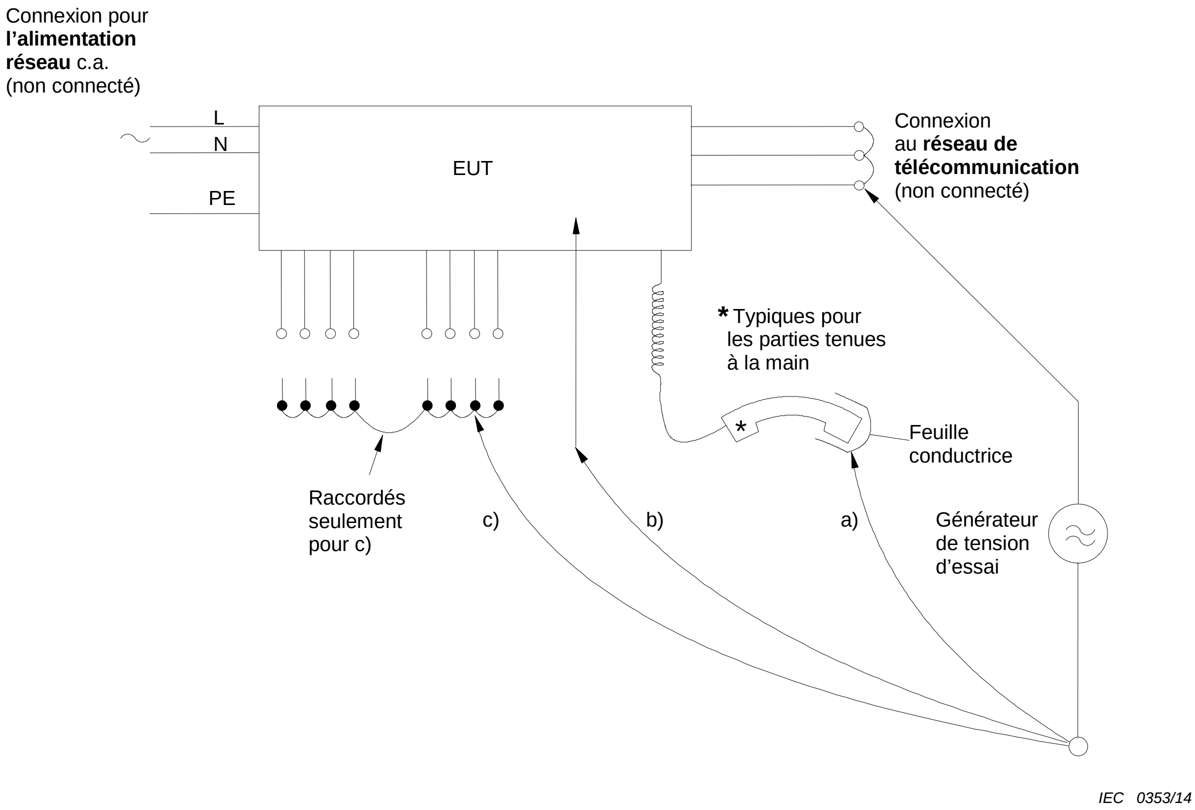


Figure 30 – Points d'application de la tension d'essai

5.4.10.2 Méthodes d'essai

5.4.10.2.1 Généralités

La séparation est vérifiée par l'essai de 5.4.10.2.2 ou de 5.4.10.2.3.

Pendant l'essai:

– *tous les conducteurs 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****; et*

– *tous les conducteurs prévus pour être raccordés à d'autres* ***circuits externes*** *sont raccordés ensemble.*

Tableau 29 – Valeurs pour les essais de rigidité diélectrique

Parties	Essai de choc	Essai en régime constant
Parties indiquées en 5.4.10.1 a) [a]	2,5 kV 10/700 μs	1,5 kV
Parties indiquées en 5.4.10.1 b) et c) [b]	1,5 kV 10/700 μs [c]	1,0 kV

[a] Les parasurtenseurs ne doivent pas être retirés.

[b] Il est admis de retirer les parasurtenseurs, à condition qu'ils satisfassent à l'essai de choc de 5.4.10.2.2 lorsqu'ils sont soumis à essai en tant que composants à l'extérieur de l'équipement

[c] Pendant cet essai, il est admis qu'un parasurtenseur fonctionne et qu'un claquage se produise dans un tube à décharge dans un gaz (GDT).

5.4.10.2.2 Essai de choc

La séparation électrique est soumise à dix impulsions de polarité alternées. L'intervalle entre les impulsions successives est de 60 s avec une valeur de tension conforme au Tableau 29.

5.4.10.2.3 Essai en régime constant

La séparation électrique est soumise à un essai de rigidité diélectrique selon 5.4.9.1, avec une valeur de tension conforme au Tableau 29*.*

5.4.10.3 Critères de conformité

Pendant les essais de 5.4.10.2.2 et 5.4.10.2.3:

– *il ne doit pas se produire de rupture de l'isolation; et*

– *à l'exception des indications du Tableau 29, note [b], le parasurtenseur ne doit pas fonctionner ni un claquage ne doit se produire dans un tube à décharge dans un gaz*.

Pour l'essai de rigidité diélectrique, la rupture de l'isolation est considérée s'être produite lorsque le courant qui circule du fait de l'application de la tension d'essai augmente rapidement de manière incontrôlée.

Pour les essais de choc, la rupture de l'isolation est vérifiée selon l'une des deux méthodes suivantes:

– *pendant l'application des impulsions, par observation des oscillogrammes, le fonctionnement du parasurtenseur ou la rupture dans l'isolation est considéré en fonction de la forme d'un oscillogramme.*

– *après l'application de toutes les impulsions, par un essai de résistance d'isolement. La déconnexion des parasurtenseurs est admise en même temps que la mesure de la résistance d'isolement. La tension d'essai est de 500 V c.c. ou, si les parasurtenseurs sont laissés en place, une tension d'essai c.c. de 10 % inférieure au fonctionnement du parasurtenseur ou à la tension d'amorçage. La résistance d'isolement ne doit pas être inférieure à 2 MΩ.*

5.4.11 Séparation entre des circuits externes et la terre

5.4.11.1 Généralités

Ces exigences s'appliquent uniquement à l'équipement destiné à être raccordé aux **circuits externes** indiqués dans le Tableau 14, numéros d'identification 1 et 2.

Ces exigences ne s'appliquent pas aux:

– **équipements reliés en permanence**, ou
– **équipements enfichables de type B**; ou
– **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
– **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**.

5.4.11.2 Exigences

Une séparation 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 l'essai (EUT), soit par l'intermédiaire d'un autre équipement.

Les dispositifs de protection contre les surtensions (SPD) qui shuntent la séparation 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 dans un gaz) de:

$$U_{\text{op}} = U_{\text{crête}} + \Delta\, U_{\text{sp}} + \Delta\, U_{\text{sa}}$$

où

$U_{\text{crête}}$ 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.

($\Delta U_{\text{sp}} + \Delta U_{\text{sa}}$) peut être une seule valeur fournie par le fabricant du composant.

5.4.11.3 Critères de conformité et méthode d'essai

La conformité est vérifiée par examen et par l'essai de rigidité diélectrique défini en 5.4.9.1.

Les composants qui shuntent 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 31 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 est à utiliser (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 31 ne doit pas dépasser 10 mA.

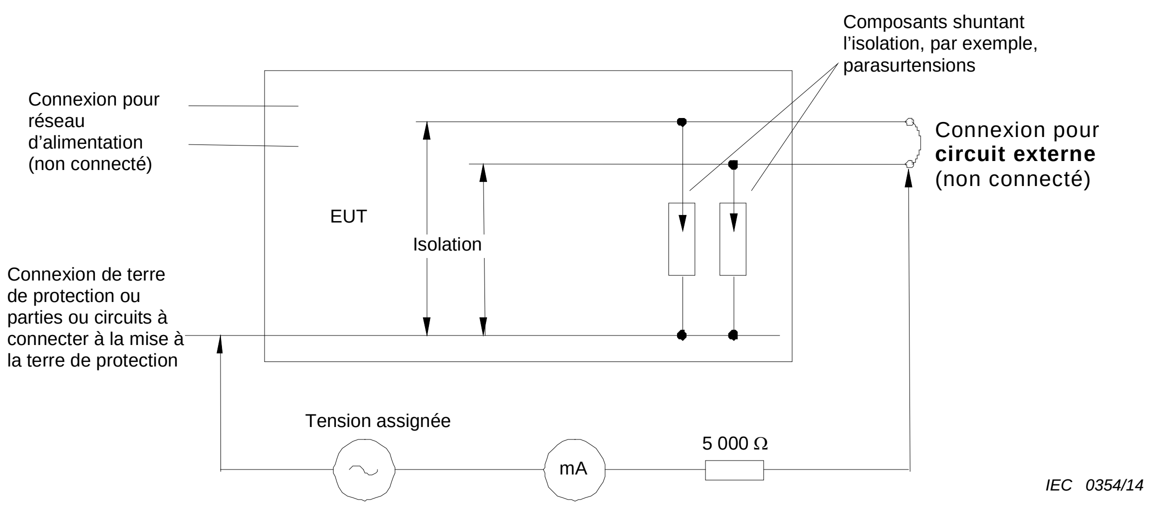


Figure 31 – Essai de séparation entre un circuit externe et la terre

5.5 Composants comme protections

5.5.1 Généralités

Un composant utilisé comme **protection** doit:

– satisfaire à toutes les exigences applicables à la **protection** concernée; et
– être utilisé dans les limites de ses valeurs assignées.

NOTE Voir l'Annexe G pour la qualification des composants utilisés comme **protection**.

5.5.2 Condensateurs et cellules RC

5.5.2.1 Exigences générales

Les condensateurs et cellules RC qui servent de **protections** (électriques) doivent être conformes à la CEI 60384-14. Les cellules RC peuvent être constituées de composants discrets.

Les condensateurs ou cellules RC avec un ou plusieurs condensateurs doivent:

– être conformes à l'Article G.11, cependant, les exigences de l'Article G.11 ne s'appliquent pas au condensateur et cellule RC utilisés comme **protection principale** entre:
  - ES3 isolé du **réseau d'alimentation** et la terre de protection; et
  - ES2 et la terre de protection; et

- ES2 et ES1.

  et

– satisfaire à l'essai de rigidité diélectrique de 5.4.9.1, tenant compte de la **tension de service** totale à travers le ou les condensateurs et cellules RC. Les condensateurs conformes à la CEI 60384-14 n'ont pas besoin d'être soumis à l'essai si:

  - la valeur de crête de la tension d'essai de choc requise du Tableau G.8; et
  - la valeur efficace de la tension d'essai requise du Tableau G.8 multipliée par 1,414,

  sont égales ou supérieures à la tension d'essai requise de 5.4.9.1.

  Lorsque plusieurs condensateurs sont utilisés, les tensions d'essai du Tableau G.8 sont multipliées par le nombre de condensateurs utilisés.

Dans les **conditions de premier défaut**, si un condensateur ou une cellule RC comprend plusieurs condensateurs, la tension aux bornes de chacun des condensateurs individuels restants ne doit pas dépasser la valeur assignée des condensateurs individuels appropriés.

NOTE En Norvège, en raison du système d'alimentation IT utilisé, les condensateurs nécessitent d'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**.

Les condensateurs de classe X ne doivent pas être utilisés comme **protection renforcée**.

5.5.2.2 Protections contre une décharge du condensateur après déconnexion d'un connecteur

Lorsqu'une tension de condensateur devient **accessible** après la déconnexion d'un connecteur (par exemple, le connecteur du **réseau d'alimentation**), la tension **accessible** mesurée dans un délai de 2 s après la déconnexion du connecteur doit être conforme:

– aux limites ES1 du Tableau 5 dans les **conditions normales de fonctionnement** pour une **personne ordinaire**; et

– aux limites ES2 du Tableau 5 dans les **conditions normales de fonctionnement** pour une **personne avertie**; et

– aux limites ES2 du Tableau 5 dans les **conditions de premier défaut** pour une **personne ordinaire** et une **personne avertie**.

Si un IC intégrant une fonction de décharge de condensateur (ICX) est utilisé pour satisfaire aux exigences ci-dessus, alors en **condition de premier défaut** d'un ICX ou de tout composant dans le circuit de décharge de condensateur associé:

– la tension **accessible** (par exemple au niveau du connecteur du **réseau d'alimentation**) ne doit pas dépasser les limites données ci-dessus; ou

– l'ICX avec les circuits associés tels qu'il sont fournis dans l'équipement doit satisfaire aux exigences de l'Article G.16. Tout composant atténuant les impulsions (comme les varistances et les GDT) est déconnecté; ou

– trois échantillons d'ICX soumis séparément à l'essai doivent satisfaire aux exigences de l'Article G.16.

La mesure est réalisée avec un instrument ayant une impédance d'entrée constituée par une résistance de 100 MΩ ± 5 MΩ en parallèle d'une capacité d'entrée de 25 pF ou moins.

Si un interrupeur (par exemple, l'interrupteur d'**alimentation**) a une influence sur le résultat d'essai, il est placé dans la position la plus défavorable. La déconnexion du connecteur (début de la période de décharge) est à réaliser au moment où la capacité d'entrée du dispositif en essai est chargée à sa valeur de crête.

Il est admis d'utiliser d'autres méthodes donnant un résultat similaire à celui de la méthode ci-dessus.

5.5.3 Transformateurs

Les transformateurs utilisés comme **protection** doivent être conformes à G.5.3.

5.5.4 Optocoupleurs

L'isolation des optocoupleurs utilisés comme **protection** doit être conforme aux exigences de 5.4 ou de l'Article G.12.

5.5.5 Relais

L'isolation des relais utilisés comme **protection** doit être conforme aux exigences de 5.4.

5.5.6 Résistances

Les exigences s'appliquent aux résistances:

– utilisées comme **protection**; ou
– qui court-circuitent l'**isolation principale**, l'**isolation supplémentaire** ou l'**isolation renforcée**.

Une résistance unique ou un groupe de résistances doit être conforme aux exigences relatives à la **distance dans l'air** de 5.4.2 et à la **ligne de fuite** de 5.4.3, entre ses extrémités et pour la **tension de service** totale aux bornes de l'isolation (voir Figure O.4).

Une résistance unique utilisée comme **protection renforcée** ou mise en parallèle sur une **isolation renforcée** doit être conforme à G.10.1 et satisfaire à l'essai de G.10.2.

NOTE En Finlande, en Norvège et en Suède, les résistances utilisées comme **protection principale** ou pour court-circuiter l'**isolation principale** dans des **équipements enfichables de type A de classe I** doivent être conformes à G.10.1 et à l'essai de G.10.2.

Pour un groupe de résistances utilisé comme **protection renforcée** ou mis en parallèle sur l'**isolation renforcée,** la **distance 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 G.10.1 et à l'essai de G.10.2.

5.5.7 SPD (Dispositif de protection de l'alimentation)

5.5.7.1 Utilisation d'un SPD connecté à une mise à la terre fiable

Lorsqu'une varistance est utilisée entre le **réseau d'alimentation** et la terre:

– la connexion à la terre doit être conforme à 5.6.7; et
– la varistance doit être conforme à l'Article G.8.

5.5.7.2 Utilisation d'un SPD entre le réseau d'alimentation et la terre de protection

Lorsqu'un SPD est utilisé entre le **réseau d'alimentation** et la terre de protection, il doit comprendre une varistance et un tube à décharge dans un gaz connectés en série, avec application des spécifications suivantes:

– la varistance doit être conforme à l'Article G.8.

– le tube à décharge dans un gaz doit satisfaire:

- à l'essai de rigidité diélectrique de 5.4.9.1 pour l'**isolation principale**; et
- aux exigences relatives à la **distance dans l'air** et **ligne de fuite** externes de 5.4.2 et 5.4.3 respectivement pour l'**isolation principale**.

NOTE 1 Des exemples de SPD sont les MOV, les varistances et les tubes à décharge dans un gaz. Une varistance est parfois désignée VDR ou varistance à oxyde métallique (MOV).

Les exigences ci-dessus ne s'appliquent pas aux SPD:

– destinés à atténuer les tensions transitoires des **circuits externes**; et

– connectés à une terre fiable (voir 5.5.7.1).

NOTE 2 La présente norme ne stipule pas l'exigence selon laquelle les parasurtenseurs nécessitent d'être conformes à la norme particulière sur les composants. Cependant, l'attention est attirée sur la série de normes CEI 61643, notamment:

– CEI 61643-21 (parafoudres dans les applications de télécommunications)

– CEI 61643-311 (tubes à décharge dans un gaz)

– CEI 61643-321 (diodes à avalanche)

– CEI 61643-331 (varistances à oxyde métallique).

5.5.8 Isolation entre le réseau d'alimentation et un circuit externe composé d'un câble coaxial

L'isolation entre le **réseau d'alimentation** et la connexion à un câble coaxial, y compris la résistance en parallèle sur cette isolation, doit pouvoir résister aux surtensions provenant du **circuit externe** et du **réseau d'alimentation**.

Cette exigence ne s'applique à aucun 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 5.6.7.

La combinaison de l'isolation et de la résistance est soumise à l'essai après le conditionnement de G.10.3.1 comme indiqué ci-dessous:

– *pour l'équipement destiné à être connecté à un câble coaxial connecté à une antenne extérieure, l'essai de surtension de G.10.3.2; ou*

– *pour l'équipement destiné à être connecté à un autre câble coaxial, l'essai de choc de G.10.3.3; ou*

– *pour l'équipement destiné à être connecté à une antenne extérieure et à d'autres connexions coaxiales, l'essai de surtension de G.10.3.2 et l'essai de choc de G.10.3.3.*

A l'issue des essais:

– *l'isolation doit être conforme au 5.4.5.3 et la résistance peut être retirée au cours de cet essai;*

– *les résistances doivent être conformes au G.10.3.4 à moins que des données disponibles ne montrent la conformité des résistances.*

5.6 Conducteur de protection

5.6.1 Généralités

Dans les **conditions normales de fonctionnement**, un **conducteur de protection** peut servir:

– de **protection principale** pour éviter que les parties conductrices **accessibles** dépassent les limites de ES1; et

– de moyen de limiter les tensions transitoires dans un circuit mis à la terre.

Dans les **conditions de premier défaut**, un **conducteur de protection** peut servir de **protection supplémentaire** pour éviter que les parties conductrices **accessibles** dépassent les limites de ES2.

5.6.2 Exigences relatives aux conducteurs de protection

5.6.2.1 Exigences générales

Les **conducteurs de protection** ne doivent contenir aucun interrupteur, aucun appareil limiteur de courant et aucun dispositif de protection contre les surintensités.

L'intensité de courant admissible des **conducteurs de protection** doit être appropriée pour la durée du courant de défaut dans les **conditions de premier défaut**.

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**;

NOTE Il appartient aux bonnes pratiques 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.

– une fiche sur un câble d'alimentation;

– un connecteur.

La soudure ne doit pas constituer le seul moyen d'assurer une fixation mécanique du **conducteur de protection**.

L'extrémité du **conducteur de protection** doit être conçue de sorte qu'il soit peu probable qu'elle puisse se desserrer pendant les opérations d'entretien autres que celles du conducteur lui-même. L'extrémité du **conducteur de mise à la terre de protection** ne doit pas servir de moyen pour fixer tout autre composant.

5.6.2.2 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, si fournie, 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.

5.6.3 Exigences relatives aux conducteurs de mise à la terre de protection

Les dimensions des **conducteurs de mise à la terre de protection** doivent être conformes aux valeurs minimales applicables aux conducteurs spécifiées dans le Tableau G.5.

NOTE 1 Pour les **équipements reliés en permanence** équipés d'une ou de plusieurs bornes pour le raccordement au **réseau d'alimentation**, il est fait référence aux exigences nationales applicables aux installations dans les bâtiments pour les dimensions du **conducteur de mise à la terre de protection**.

NOTE 2 La CEI 60364-5-54 peut être aussi utilisée pour déterminer la dimension de conducteur minimale.

Pour les équipements connectés par un câble alimenté par une **alimentation** en courant continu, il est admis que la connexion de mise à la terre de protection soit assurée par une borne séparée.

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 conforme à G.7.1 et pas plus léger que les cordons renforcés; ou

  NOTE 3 On peut consulter la définition du cordon renforcé dans la CEI 60227-1 ou la CEI 60245-1.

– avoir une dimension de conducteur minimale non inférieure à 4 mm^2 s'il n'est pas protégé contre les dommages matériels; ou

– avoir une dimension de conducteur minimale non inférieure à 2,5 mm^2 s'il est protégé contre les dommages matériels; ou

– être protégé par un conduit destiné à être raccordé à l'équipement et avoir une dimension minimale conforme au Tableau 30.

NOTE 4 Pour les câbles d'alimentation du **réseau d'alimentation**, voir aussi l'Article G.7.

NOTE 5 Une enveloppe de cordon renforcé est considérée comme adaptée à la protection contre les dommages matériels.

Tableau 30 – Dimensions 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
Conduit souple métallique	2,5
Conduit métallique non flexible	1,5
Le **conducteur de mise à la terre de protection** est destiné à être installé par une **personne qualifiée**.	

Un **conducteur de mise à la terre de protection** servant de **double protection** peut être utilisé sur un **équipement enfichable de type B** ou sur un **équipement relié en permanence** uniquement et doit être constitué de deux **conducteurs de mise à la terre de protection** indépendants:

La conformité est vérifiée par examen et mesure des dimensions du ***conducteur de mise à la terre de protection*** *selon le Tableau 30 ou le Tableau G.5 selon le cas.*

5.6.4 Exigences relatives aux conducteurs de liaison de protection

5.6.4.1 Exigences

Les **conducteurs de liaison de protection** de parties nécessitant d'être mises à la terre pour des raisons de sécurité doivent être conformes à l'une des exigences suivantes:

– les dimensions minimales des conducteurs indiquées dans le Tableau G.5; ou

– les exigences décrites en 5.6.6 ainsi que, si le **courant assigné** de l'équipement ou la **valeur assignée du courant de protection** du circuit est supérieur à 25 A, les dimensions minimales des conducteurs indiquées dans le Tableau 31; ou

– les exigences décrites en 5.6.6 ainsi que, si le **courant assigné** de l'équipement ou la **valeur assignée du courant de protection** du circuit ne dépasse pas 25 A; soit
  - les dimensions minimales des conducteurs indiquées dans le Tableau 31; soit
  - l'essai de court-circuit limité décrit à l'Annexe R;

– pour les composants uniquement, être supérieur aux conducteurs alimentant le composant.

NOTE La **valeur assignée du courant de protection** est utilisée dans le Tableau 31 et dans l'essai décrit en 5.6.6.2.

Tableau 31 – Dimensions minimales du conducteur de liaison de protection des conducteurs en cuivre

La plus petite des deux valeurs: courant assigné de l'équipement, ou valeur assignée du courant de protection du circuit considéré A **jusqu'à et y compris**	**Dimensions minimales des conducteurs**		
	Section mm^2	**AWG** [section en mm^2]	
3	0,3	22	[0,324]
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 [section en mm^2]	
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 Gage 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.			

5.6.4.2 Détermination de la valeur assignée du courant de protection

5.6.4.2.1 Réseau d'alimentation comme source

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 fourni dans l'installation du bâtiment, ou faisant partie de l'équipement.

Lorsque le dispositif de protection contre les surintensités est fourni dans l'installation du bâtiment, 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 tiroir d'équipement), avec un courant minimal de 16 A;

NOTE 1 Dans la majorité des pays, 16 A est considéré comme une valeur appropriée pour la **valeur assignée du courant de protection** du circuit alimenté par le **réseau**.

NOTE 2 Au Canada et aux États-Unis, la **valeur assignée du courant de protection** du circuit alimenté par le **réseau** est prise égale à 20 A.

NOTE 3 Au Royaume-Uni et en Irlande, la v**aleur 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 devant être fourni comme élément externe à l'équipement.

5.6.4.2.2 Source autre que le réseau d'alimentation

Lorsque la source est une alimentation externe avec un courant maximal limité, par construction, par l'impédance interne de la source (comme un transformateur protégé par impédance), la **valeur assignée du courant de protection** du circuit est le courant le plus élevé que peut fournir cette alimentation sur une charge quelconque.

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 sur une charge résistive quelconque, y compris un court-circuit. Si le courant est limité par une impédance, un fusible, un dispositif à coefficient positif de température ou un disjoncteur, le courant est mesuré 60 s après l'application de la charge. Si le courant est limité par d'autres moyens, le courant est mesuré 5 s après l'application de la charge.

5.6.4.2.3 Circuit interne comme source

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 quelconque, 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.

5.6.4.3 Dispositifs de limitation de courant et de protection contre les surintensités

Le dispositif de limitation du courant (dispositif à coefficient positif de température, PTC) ou le dispositif de protection contre les surintensités (un fusible ou un disjoncteur) ne doit pas être connecté en parallèle avec un autre composant susceptible d'être défaillant en situation de faible résistance.

5.6.4.4 Critères de conformité

La conformité est vérifiée par examen et mesure des dimensions du ***conducteur de liaison de protection*** *conformément au Tableau 31 ou au Tableau G.5 et par l'essai de 5.6.6 ou de l'Annexe R selon le cas.*

5.6.5 Bornes des conducteurs de protection

5.6.5.1 Exigences

Les bornes utilisées pour la connexion de **conducteurs de mise à la terre de protection** doivent être conformes aux dimensions minimales de borne indiquées dans le Tableau 32.

Les bornes utilisées pour la connexion de **conducteurs de liaison de protection** doivent satisfaire à l'une des exigences suivantes:

– les dimensions minimales des bornes données par le Tableau 32; ou

– les exigences de 5.6.6 et, si le **courant assigné** de l'équipement ou les **caractéristiques assignées du courant de protection** du circuit dépassent 25 A, les dimensions de borne de pas plus d'une taille inférieures aux valeurs indiquées dans le Tableau 32; ou

– les exigences de 5.6.6 et, si le **courant assigné** de l'équipement ou les **caractéristiques assignées du courant de protection** du circuit ne dépassent pas 25 A; soit

  - les dimensions de borne de pas plus d'une taille inférieures aux valeurs indiquées dans le Tableau 32; or
  - l'essai de court-circuit limité de l'Annexe R;

– pour les composants uniquement, ne pas être inférieures aux dimensions de borne alimentant le composant.

Tableau 32 – Dimensions des bornes pour les conducteurs de protection

Dimension de conducteur mm² **(du Tableau G.5)**	**Diamètre de filetage nominal minimal** mm		**section** mm²	
	Type pilier ou à tige	**Type à vis** [a]	**Type pilier ou à tige**	**type à vis** [a]
1	3,0	3,5	7	9,6
1,5	3,5	4,0	9,6	12,6
2,5	4,0	5,0	12,6	19,6
4	4,0	5,0	12,6	19,6
6	5,0	5,0	19,6	19,6
10[b]	6,0	6,0	28	28
16[b]	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.

[b] En variante aux exigences du présent tableau, il est admis que le **conducteur de mise à la terre de protection** soit 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 31 ou du Tableau G.5 selon le cas. Les bornes doivent être conformes à la CEI 60998-1 et à la CEI 60999-1 ou à la CEI 60999-2.

La conformité est vérifiée par examen et mesures des dimensions des bornes de protection conformément au Tableau 32, l'essai de 5.6.6 ou l'Annexe R selon le cas.

5.6.5.2 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 des matériaux des conducteurs, des bornes et des parties associées et par détermination de la différence de potentiel.

5.6.6 Résistance du système de liaison de protection

5.6.6.1 Exigences

Les **conducteurs de liaison de protection** et leurs extrémités ne doivent pas avoir de résistance excessive.

NOTE Un système de liaison de protection dans l'équipement comprend un seul conducteur ou une combinaison de parties conductrices, reliant une borne principale de mise à la terre de protection à une partie de l'équipement qui sera mise à la terre pour des raisons de sécurité.

Les **conducteurs de liaison de protection** qui répondent, sur toute leur longueur, aux dimensions minimales de conducteurs du Tableau G.5 dans leur longueur et dont les bornes répondent toutes aux dimensions minimales du Tableau 32 sont considérés comme conformes, sans essai.

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 conducteur dans un câble multiconducteurs qui alimente également ce sous-ensemble ou cet organe, et lorsque le câble est protégé par un dispositif de protection assigné adapté qui prend en compte la dimension du conducteur, la résistance du **conducteur de liaison de protection** dans ce câble n'est pas incluse dans la mesure.

5.6.6.2 Méthode d'essai

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 est à mettre à la terre.

La résistance du ***conducteur de mise à la terre de protection*** *et de tout conducteur mis à la terre dans d'autres câblages externes 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 chute de tension sont réalisées uniquement entre la borne principale de mise à la terre et la partie devant être mise à la terre.*

Il y a lieu de s'assurer que la résistance de contact entre l'extrémité de la sonde d'essai et la partie conductrice en essai n'influence pas les résultats de l'essai. Le courant d'essai et la durée 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 25 A, le courant d'essai correspond à 200 % de la* ***valeur assignée du courant de protection*** *appliquée pendant 2 min.*
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 25 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 33.*

Tableau 33 – 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

c) *Une alternative à b) consiste à baser 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 celui qui équipe l'équipement soumis à l'essai, soit celui qui est spécifié dans les instructions d'installation pour être fourni 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 pour 200 % n'est pas indiquée, on peut utiliser le point le plus près des caractéristiques temps-courant.*

d) *Pour les équipements alimentés par un* ***réseau d'alimentation*** *en courant continu, si la* ***valeur assignée du courant de protection*** *du circuit soumis à l'essai dépasse 25 A, le courant d'essai et la durée sont tels que spécifiés par le fabricant.*

e) *Pour un équipement alimenté par un* ***circuit externe****, le courant d'essai représente 1,5 fois le courant maximal disponible à partir du* ***circuit externe*** *ou 2 A, selon la valeur la plus grande, pendant une durée de 2 min. 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 la méthode d'essai et aux critères de a), b), c) ou d), en fonction de la source d'alimentation.*

5.6.6.3 Critères de conformité

Lorsque les ***caractéristiques assignées du courant de protection*** *sont inférieures à 25 A, la résistance du système de liaison de protection, calculée à partir de la chute de tension, ne doit pas dépasser 0,1 Ω.*

Lorsque les ***caractéristiques assignées du courant de protection*** *sont égales ou supérieures à 25 A, la chute de tension dans le système de protection ne doit pas dépasser 2,5 V.*

5.6.7 Mise à la terre fiable

Pour les **équipements reliés en permanence**, la mise à la terre est considérée comme fiable

Pour les équipements reliés par cordon au **réseau d'alimentation**, la mise à la terre est considérée comme fiable pour:

– 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, accompagnés d'instructions d'installation de ce conducteur pour la mise à la terre par une **personne qualifiée**.

Pour les équipements connectés à un **circuit externe**, tel qu'indiqué dans le Tableau 14, numéros d'identification 1, 2, 3, 4 et 5, la mise à la terre est considérée comme fiable pour 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

Les mesures de la **tension de contact présumée**, du **courant de contact** et du **courant du conducteur de protection** sont effectuées sur l'EUT fonctionnant à la tension d'alimentation la plus défavorable (voir B.2.3).

5.7.2 Dispositifs de mesure et réseaux

5.7.2.1 Mesure du courant de contact

Pour les mesures de **courant de contact**, l'instrument utilisé pour mesurer U_2 et U_3, spécifié respectivement dans les Figures 4 et 5 de la CEI 60990:1999, doit indiquer la tension de crête. Si la forme d'onde du **courant de contact** est sinusoïdale, un instrument indiquant la valeur efficace peut être utilisé.

5.7.2.2 Mesure de la tension de contact présumée

Les équipements ou parties d'équipements qui, dans l'application prévue, sont destinés à être mis à la terre mais qui ne sont pas reliés à la terre tels qu'ils sont fournis, doivent être reliés à la terre pendant la mesure à l'endroit où la **tension de contact présumée** est la plus élevée.

5.7.3 Montage de l'équipement, connexions d'alimentation et connexions de mise à la terre

Le montage de l'équipement, les connexions d'alimentation de l'équipement et la mise à la terre de l'équipement doivent être conformes à l'Article 4, 5.3 et 5.4 de la CEI 60990:1999.

Les équipements pourvus d'une connexion à la terre indépendante du **conducteur de mise à la terre de protection** doivent être soumis à essai avec cette connexion déconnectée.

Dans un système, les équipements interconnectés, raccordés individuellement au **réseau d'alimentation** doivent être soumis à essai 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 accessibles mises à la terre

Au moins une partie conductrice **accessible** mise à la terre doit être soumise à l'essai de **courant de contact** après un défaut 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 Un connecteur est un exemple de **dispositif de déconnexion**.

5.7.5 Courant de conducteur de protection

Le **courant de conducteur de protection** ne doit pas dépasser les limites de ES2 spécifiées en 5.2.2.2 sauf si toutes les conditions ci-dessous sont satisfaites.

– le courant ne doit pas dépasser 5 % du courant absorbé mesuré en **conditions normales de fonctionnement;**
– la construction du circuit de **conducteur de protection** et ses connexions doivent avoir:
  - un **conducteur de mise à la terre de protection** servant de **protection renforcée** ou deux **conducteurs de mise à la terre de protection** indépendants servant de **double protection** comme cela est spécifié en 5.6.3, et
  - une mise à la terre fiable telle que spécifiée en 5.6.7.

Lorsque le **courant de conducteur de protection** dépasse les limites de ES2 de 5.2.2.2, une **protection par instructions** doit être fournie conformément à l'Article F.5, à l'exception du fait que l'élément 3 est facultatif.

Les éléments de la **protection par instructions** doivent être comme suit:

– élément 1a: , CEI 60417-6042 (2010-11) et

, CEI 60417-6173 (2012-10) et

, CEI 60417-5019 (2006-08)

– élément 2: "Attention" ou mot ou texte équivalent, et "Courant de contact élevé" ou texte équivalent;
– élément 3: facultatif;
– élément 4: "Connecter à la terre avant de connecter à l'alimentation" ou texte équivalent.

La **protection par instructions** doit être apposée sur l'équipement adjacent à la connexion d'alimentation de l'équipement.

NOTE Au Danemark, les instructions d'installation doivent être apposées sur l'équipement si le **courant du conducteur de protection** dépasse les limites de 3,5 mA c.a. ou 10 mA c.c.

5.7.6 Tension de contact présumée et courant de contact causés par des circuits externes

5.7.6.1 Courant de contact provenant de câbles coaxiaux

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 1 En Norvège et en Suède, l'écran du réseau de télédistribution est généralement non mis à la terre à l'entrée du bâtiment et il n'existe généralement pas de système de liaison équipotentielle dans le bâtiment. Par conséquent, la mise à la terre de protection de l'installation du bâtiment nécessite d'être isolée de l'écran d'un réseau de distribution par câble.

Il est cependant admis d'assurer l'isolation à l'extérieur de l'équipement par un adaptateur ou un câble d'interconnexion à isolation galvanique qui peut être fourni par exemple par un revendeur.

Le manuel utilisateur doit alors comporter les informations suivantes ou analogues rédigées en norvégien ou en suédois respectivement, en fonction du pays dans lequel l'équipement est destiné à être utilisé:

“L'appareil connecté à la mise à la terre de protection de l'installation du bâtiment par la connexion du réseau d'alimentation ou par d'autres appareils avec une connexion à la mise à la terre de protection – et à un réseau de télédistribution au moyen d'un câble coaxial, peut dans certains cas créer un danger d'incendie. Par conséquent, la connexion à un réseau de télédistribution est à équiper d'un dispositif assurant l'isolation électrique en dessous d'une certaine gamme de fréquences (isolation galvanique, voir l'EN 60728-11).”

NOTE 2 En Norvège, du fait des réglementations applicables aux installations de distribution de télévision par câble, et en Suède, un isolant galvanique doit assurer l'isolation électrique en dessous 5 MHz. L'isolation doit supporter une valeur de rigidité diélectrique de 1,5 kV efficace, 50 Hz ou 60 Hz, pendant 1 minute.

Traduction en norvégien (le texte en suédois est également accepté en Norvège):

“Apparater som er koplet til beskyttelsesjord via nettplugg og/eller via annet jordtilkoplet utstyr – og er tilkoplet et koaksialbasert kabel-TV nett, kan forårsake brannfare. For å unngå dette skal det ved tilkopling av apparater til kabel-TV nett installeres en galvanisk isolator mellom apparatet og kabel-TV nettet.”

Traduction en suédois:

”Apparater som är kopplad till skyddsjord via jordat vägguttag och/eller via annan utrustning och samtidigt är kopplad till kabel-TV nät kan i vissa fall medfőra risk főr brand. Főr att undvika detta skall vid anslutning av apparaten till kabel-TV nät galvanisk isolator finnas mellan apparaten och kabel-TV nätet.”.

5.7.6.2 Tension de contact présumée et courant de contact provenant de circuits externes

Pour les **circuits externes,** numéro d'identification 1 du Tableau 14:

– la **tension de contact présumée** doit être conforme à ES2; or

– le **courant de contact** ne doit pas dépasser 0,25 mA.

Les exigences ci-dessus ne s'appliquent pas aux **circuits externes** reliés à un **conducteur de mise à la terre de protection**.

La conformité est vérifiée par mesure selon 5.7.2 et 5.7.3 en utilisant la configuration de mesure de la Figure 32 pour les équipements monophasés et celle de la Figure 33 pour les équipements triphasés.

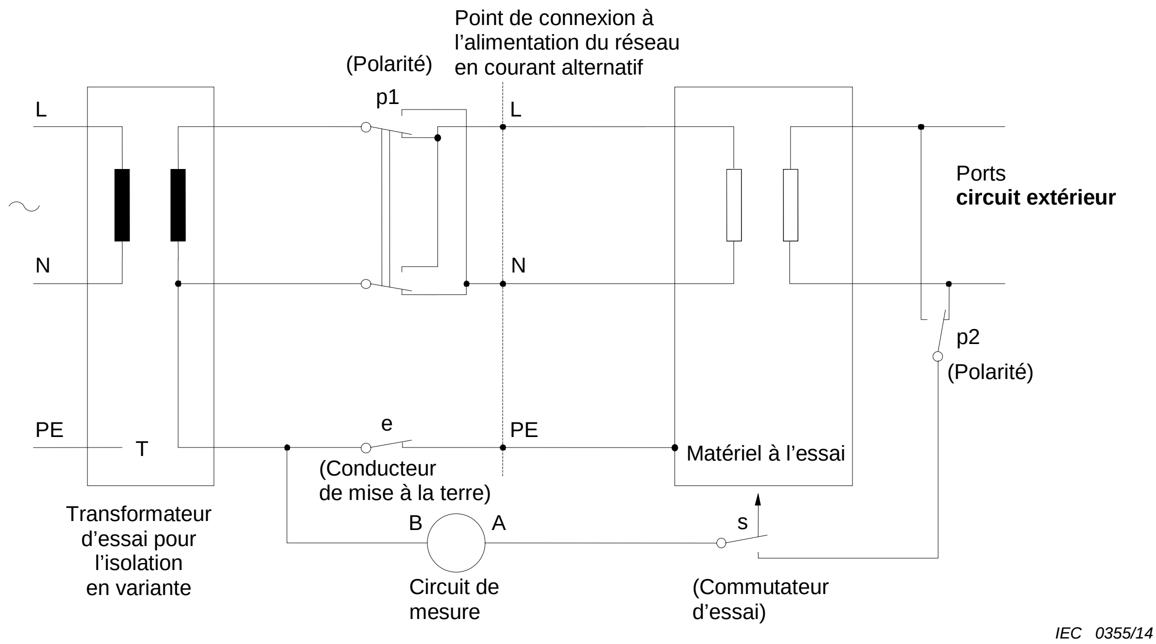


Figure 32 – Circuit d'essai pour le courant de contact d'équipement monophasé

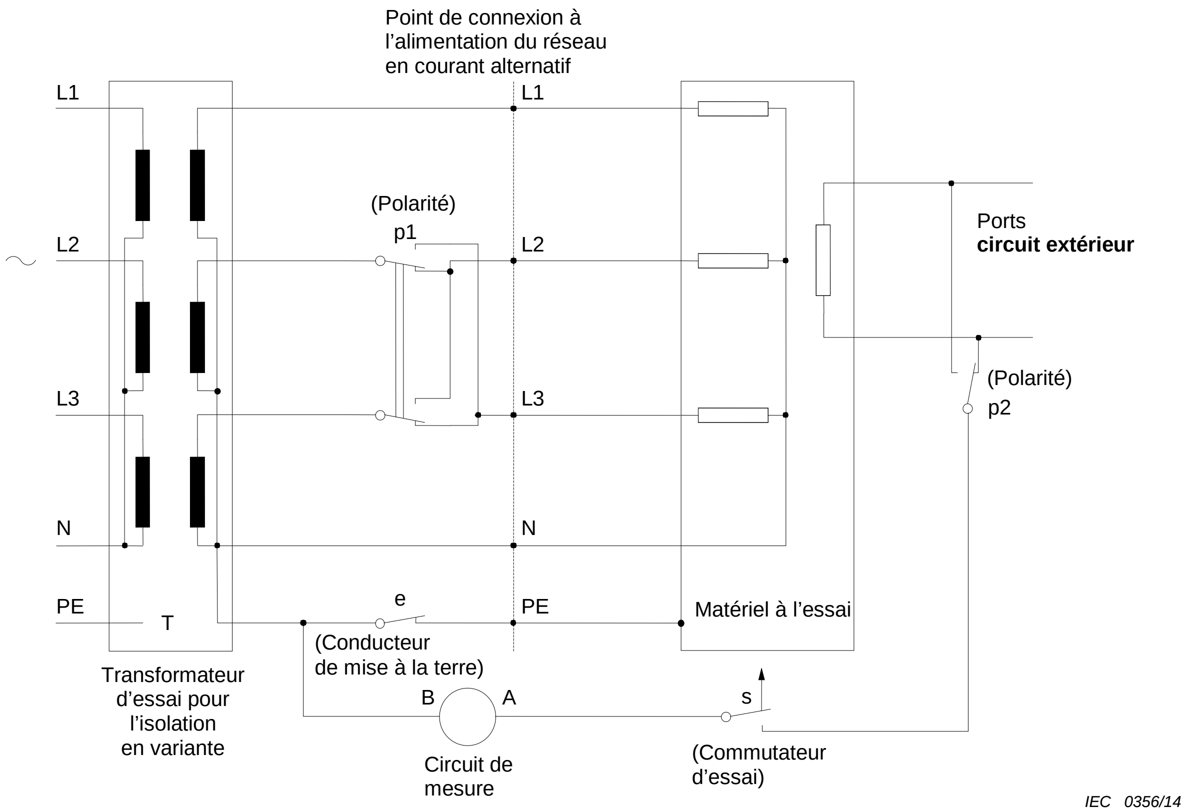


Figure 33 – Circuit d'essai pour le courant de contact d'équipement triphasé

5.7.7 Somme des courants de contact provenant de circuits externes

Les exigences ci-dessous spécifient dans quel cas un **conducteur de mise à la terre de protection** relié en permanence est nécessaire pour l'**équipement enfichable de type A** ou l'**équipement enfichable de type B**, au cas où la connexion au **réseau d'alimentation** viendrait à être interrompue.

Les exigences s’appliquent uniquement aux équipements avec des **circuits externes** comme indiqué dans le Tableau 14, numéros d’identification 1, 2, 3 et 4.

NOTE Ces types de **circuits externes** sont généralement des réseaux de télécommunication.

La somme des **courants de contact** provenant d’équipements à **circuits externes** multiples ne doit pas dépasser les limites de ES2 (voir Tableau 4).

Les abréviations suivantes sont utilisées:

– I_1: **courant de contact,** reçu d’autres équipements via un réseau, au niveau d’un **circuit externe** de l’équipement;

– $S(I_1)$: somme des **courants de contact** reçus d’autres équipements, au niveau de l’ensemble de ces **circuits externes** de l’équipement;

– 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 le courant venant de l’autre équipement ait une valeur connue 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 prévu pour 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 mm^2 en cas de protection mécanique ou à défaut 4,0 mm^2; et

– fournir un marquage conforme à 5.7.5 et à l'Article F.3.

2) Ce type d’équipement doit être conforme à 5.7.5. La valeur de I_2 doit être utilisée pour calculer la limite de 5 % du courant absorbé par phase spécifiée en 5.7.5.

La conformité avec le point a) est vérifiée par examen et, si nécessaire, par essai.

Si l’équipement est prévu pour une connexion permanente à la terre de protection 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 5, 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 venant d’un autre équipement d’une valeur connue 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 tout groupe 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 venant d'un autre équipement d'une valeur connue 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

Pour réduire la probabilité de blessures ou de dommages matériels résultant d'un incendie d'origine électrique survenant dans l'équipement, l'équipement doit être muni des protections spécifiées à l'Article 6.

6.2 Classification des sources de puissance (PS) et des sources potentielles d'incendie (PIS)

6.2.1 Généralités

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 pour 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 résistif**).

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

La classification de la source de puissance électrique doit être déterminée en mesurant la puissance maximale 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 la Figure 34 et la Figure 35.

6.2.2.2 Mesure de la puissance pour le cas de défaut de charge le plus défavorable

Avec référence à la Figure 34:

– *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);*

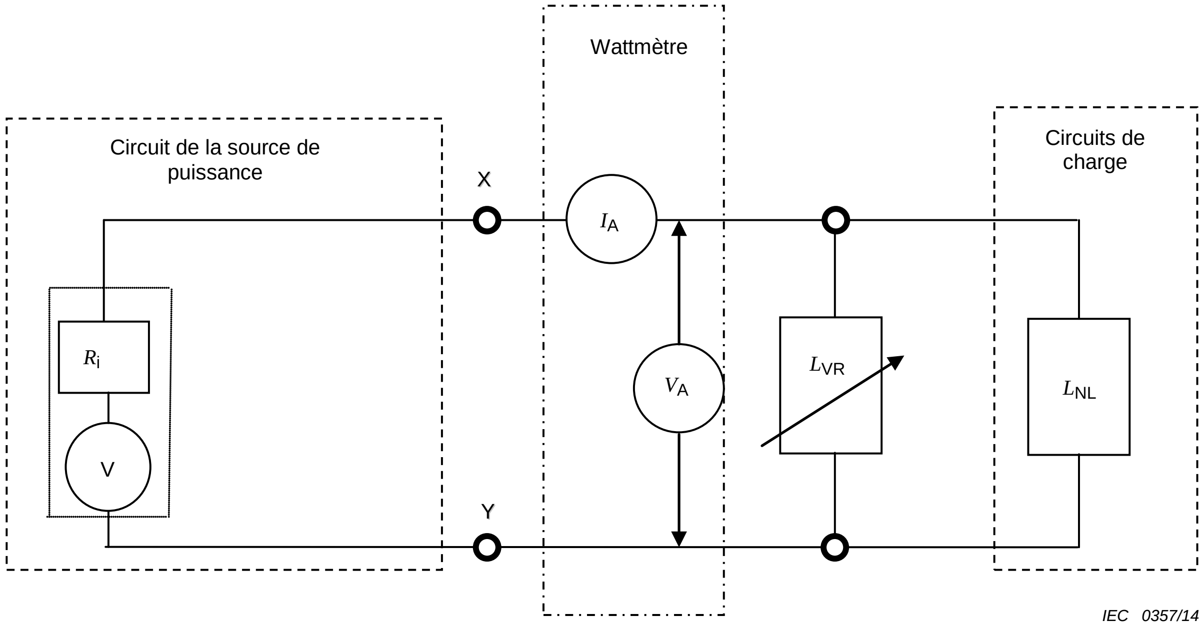
– *connecter une résistance variable, L_{VR} comme indiqué;*

– *ajuster la résistance variable, L_{VR}, pour une 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 de protection contre les surintensités fonctionne lors de l'essai, la mesure doit être répétée à 125 % de la valeur assignée du courant du dispositif de protection contre les surintensités.

Si un circuit de limitation de la puissance fonctionne lors de l'essai, la mesure doit être répétée au point juste en dessous du courant auquel le circuit de limitation de la puissance fonctionne.

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

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 34 – 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 le plus défavorable de la source de puissance

Avec référence à la Figure 35:

– *Aux points X et Y, insérer un wattmètre (ou un voltmètre, VA et un ampèremètre, IA).*

– *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 appropriés 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 classifier les circuits alimentés par la source de puissance conformément à 6.2.2.4, 6.2.2.5 ou 6.2.2.6.*

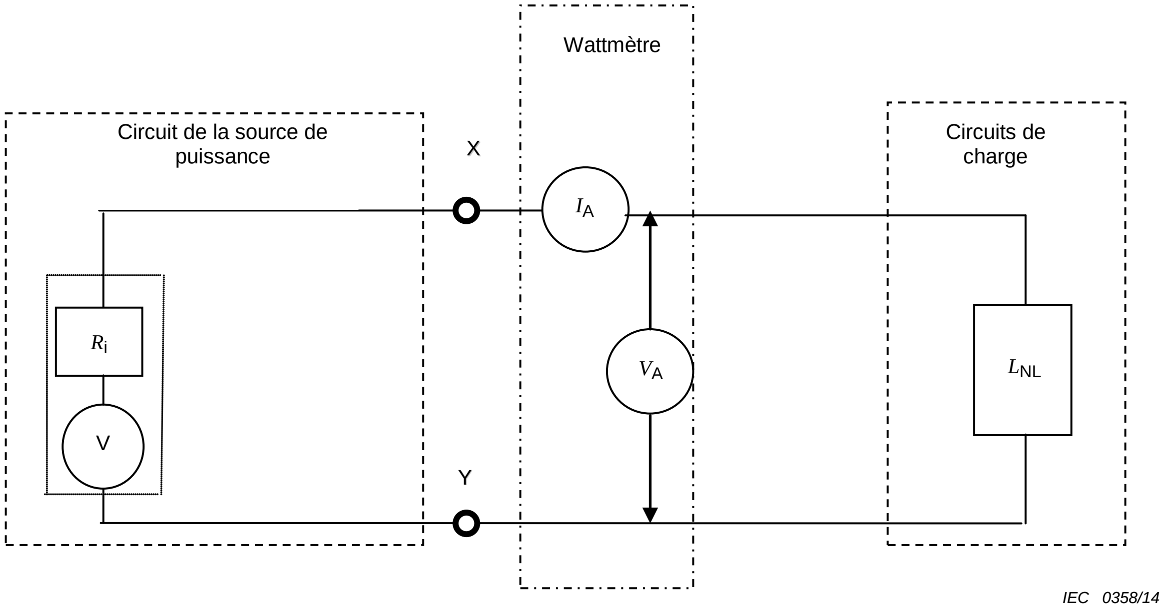
Si un dispositif de protection contre les surintensités fonctionne lors de l'essai, la mesure doit être répétée à 125 % de la valeur assignée du courant du dispositif de protection contre les surintensités.

Si le circuit de limitation de puissance fonctionne lors de l'essai, la mesure doit être répétée au point juste en dessous du courant auquel le circuit de limitation de puissance fonctionne.

Lorsque les essais sont répétés, il est admis qu'une résistance variable soit utilisée pour simuler le composant défaillant.

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 Des expériences peuvent être nécessaires pour identifier le premier défaut du composant qui produit l'énergie maximale.



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 35 – Mesure de la puissance dans le cas de défaut le plus défavorable de la source de puissance

6.2.2.4 PS1

PS1 est un circuit où la source de puissance (voir la Figure 36) mesurée conformément à 6.2.2, ne dépasse pas 15 W mesurés après 3 s.

La puissance disponible des **circuits externes**, décrite dans le Tableau 14, numéro d'identification 1 et 2, est considérée être égale à PS1.

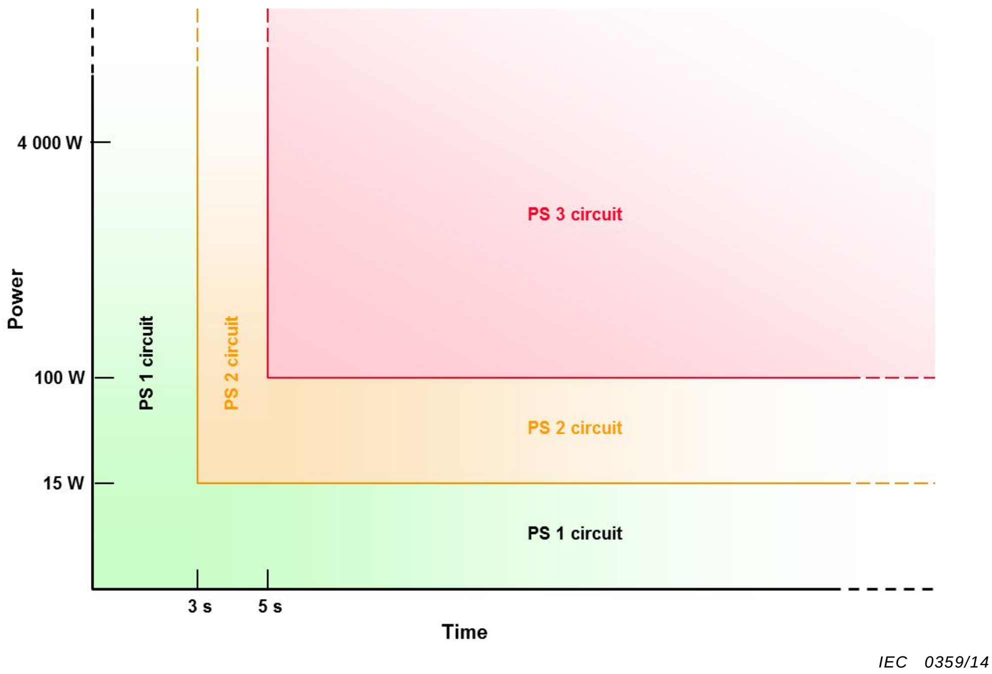
6.2.2.5 PS2

PS2 est un circuit où la source de puissance (voir la Figure 36) mesurée conformément à 6.2.2:

– dépasse les limites de PS1; et
– ne dépasse pas 100 W mesurée 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 36).



Légende

Anglais	Français
Power	Energie
PS1 circuit	Circuit PS1
PS2 circuit	Circuit PS2
PS3 circuit	Circuit PS3
Time	Temps

Figure 36 – 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 une zone (du circuit) qui présente les caractéristiques suivantes:

– une tension de circuit ouvert (mesurée après 3 s) aux bornes d'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 de la valeur efficace du courant mesuré (I_{eff}) dépasse 15 (soit, $V_p \times I_{eff} > 15$) dans chacun des cas suivants:
  - un contact, tel qu'un interrupteur ou un connecteur;
  - une terminaison, telle qu'une extrémité sertie, à ressort ou soudée;
  - l'ouverture d'un conducteur, tel qu'une piste de carte 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 supporter l'intégralité de la puissance.

Les connexions fiables sont les connexions considérées comme non ouvrables.

NOTE 2 Les exemples de connexions pouvant être considérées comme fiables sont:

– les trous métallisés et les pastilles sur une carte imprimée qui sont entièrement métallisées;
– les rivets/œillets tubulaires soudés;
– les sertissures usinées ou les connexions enroulées.

NOTE 3 D'autres moyens permettant d'éviter l'apparition d'une **source potentielle d'incendie causé par la formation d'un arc électrique** 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 en tenant compte de 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 résistif

La détermination d'une **source potentielle d'incendie causé par un phénomène résistif** s'effectue dans les **conditions normales de fonctionnement**, sauf spécification contraire.

Une **source potentielle d'incendie causé par un phénomène résistif** correspond à toute partie d'un circuit PS2 ou PS3 qui:

– dissipe plus de 15 W mesurés 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 puissance 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.

Une **source potentielle d’incendie causé par un phénomène résistif** est considérée comme inexistante dans un circuit PS1 à cause des limites de la source de puissance.

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 Actuellement, la présente norme ne spécifie aucune exigence relative aux liquides et poussières inflammables.

– les **matières combustibles** pour les composants et des autres parties à l’extérieur des **enveloppes ignifuges (contre le feu) (**y compris les **enveloppes électriques, les enveloppes mécaniques** et les parties décoratives), doivent avoir une **classe d’inflammabilité** 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**.

Ces exigences ne s’appliquent pas:

– aux parties ayant une taille inférieure à 1 750 mm^3;

– 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 apporter au feu, une contribution négligeable comme combustible, y compris les étiquettes, pieds de fixation, capuchons de clés, boutons et similaires.

6.3.2 Critères de 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.1.6 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 présentes 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 pour lequel la puissance disponible en régime permanent 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 en régime permanent de 4 000 W.

  - Les **équipements enfichables de type B** et les **équipements reliés en permanence** sont considérés comme n'excédant pas la valeur en régime permanent 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 (contre le feu)**. 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 en 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 en conditions de premier défaut dans les circuits PS2 et PS3

6.4.3.1 Généralités

Les exigences applicables aux **protections supplémentaires** nécessaires afin de réduire la probabilité d'inflammation en **conditions de premier défaut** dans les circuits PS2 et PS3 lorsque la puissance disponible ne dépasse pas 4 000 W (voir 6.4.1) sont spécifiées en 6.4.3.2.

6.4.3.2 Exigences

La probabilité d'inflammation peut être réduite en utilisant les **protections supplémentaires** suivantes, selon le cas:

– 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 résistif** comme spécifié en 6.4.7;

– utilisation de dispositifs de protection conformes aux spécifications de G.3.1 à G.3.4 ou aux normes composants CEI applicables pour ce type de dispositifs;

– utilisation des composants conformes à G.5.3 et G.5.4 ou aux normes composants CEI applicables;

– pour les composants associés au **réseau d'alimentation**, utilisation de composants conformes aux normes composants CEI applicables 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 connecteurs, 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 ci-dessous ne doit pas être utilisée comme une **protection**.

Les conducteurs d'une carte imprimée à **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 d'une carte imprimée qui n'a pas de **classe 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 décollement des conducteurs d'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 une inflammation 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 ponté 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 qu'un état stable ait été atteint, la température est mesurée immédiatement après l'interruption.*

NOTE 1 Voir B.1.6 pour plus de détails sur l'équilibre thermique.

Les températures d'inflammation spontanée des matériaux proches de la source de chaleur doivent être prises en compte.

NOTE 2 On peut observer un échauffement après l'interruption du courant, à cause de l'inertie thermique.

*Si la température est limitée par un fusible dans une **condition de premier défaut***

– *un fusible conforme à la série CEI 60127 doit s'ouvrir dans un délai de 1 s; ou*
– *un fusible non conforme à la série CEI 60127 doit s'ouvrir dans un délai de 1 s à trois reprises; ou*
– *le fusible doit satisfaire à l'essai suivant:*

*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 Critères de 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

Pour réduire la probabilité de propagation du feu des circuits PS2 aux **matériaux combustibles** à proximité, les circuits qui satisfont aux exigences de l'Annexe Q sont considérés comme des circuits PS2.

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 comme indiquée ci-dessous.

Pour les conducteurs et les dispositifs constituant une **PIS**, les spécifications suivantes s'appliquent:

– les cartes imprimées doivent être constituées de **matériaux de classe V-1** ou de **matériaux de classe VTM-1**;
– l'isolation et l'enrobage des fils doivent être conformes aux CEI 60332-1-2, CEI 60332-1-3, CEI 60332-2-2 ou CEI/TS 60695-11-21.

Tous les autres composants d'un circuit PS2 doivent:

– être montés sur des **matériaux de classe V-1** ou des **matériaux de classe VTM-1**; ou
– être composés d'un **matériau de classe V-2**, d'un **matériau de classe VTM-2** ou d'un **matériau 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
– ne pas s'enflammer pendant les **conditions de premier défaut** comme spécifié en 6.4.3.3; ou
– être conformes aux exigences de la norme composant CEI correspondante; ou
– être conformes à G.5.4 pour les moteurs; ou
– être conformes à G.5.3 pour les transformateurs; ou
– être dans une **enveloppe** étanche de 0,06 m^3 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 Critères de 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

La propagation du feu dans les circuits PS3 doit être contrôlée en appliquant toutes les **protections supplémentaires** suivantes:

– les conducteurs et dispositifs dans un circuit PS3 doivent satisfaire aux exigences de 6.4.5;

– 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 spécifications suivantes:

  - être constitués d'un **matériau de classe V-1**; ou
  - être conformes aux exigences d'inflammabilité de la norme composant CEI correspondante; ou
  - être montés sur des **matériaux de classe V-1** et avoir un volume inférieur ou égal à 1750 mm^3.

– utilisation d'une **enveloppe ignifuge (contre le feu)** telle que spécifiée en 6.4.8.

A l'intérieur des **enveloppes ignifuges (contre le feu)**, les **matériaux combustibles** qui ne font pas partie d'un circuit PS2 et PS3 doivent être conformes à l'essai d'inflammabilité de S.1 ou doivent être composés de **matériaux de classe V-2**, de **matériaux de classe VTM-2** ou de **matériaux cellulaires de classe HF-2**. Ces exigences ne s'appliquent pas:

– aux parties ayant une dimension inférieure à 1 750 mm^3;

– 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 pour systèmes pour air ou pour fluide, 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 cellulaire de classe HBF**.

Une **enveloppe ignifuge (contre le feu)** n'est pas nécessaire pour les composants et matériaux suivants:

– l'isolation et l'enrobage des fils conformes aux CEI 60332-1-2, CEI 60332-1-3, CEI 60332-2-2 ou CEI/TS 60695-11-21;

– les composants, y compris les connecteurs, conformes aux exigences de 6.4.8.2.1 qui remplissent une ouverture dans une **enveloppe ignifuge (contre le feu)**;

– les fiches et connecteurs qui font partie intégrante d'un câble d'alimentation ou d'un câble d'interconnexion, conformes à 6.5, G.4.1 et G.7;
– les moteurs conformes à G.5.4;
– les transformateurs conformes à G.5.3.

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

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 peuvent être remplies soit par une séparation par la distance (6.4.7.2), soit par une séparation à l'aide d'une barrière (6.4.7.3).

Les exigences de séparation d'une PIS à une **enveloppe ignifuge (contre le feu)** sont spécifiées en 6.4.8.4.

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 résistif** conformément à la Figure 37, à la Figure 38, à la Figure 39 et à la Figure 40.

Les matériaux de base 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**, de **matériaux de classe VTM-1** ou de **matériaux cellulaires de classe HF-1**.

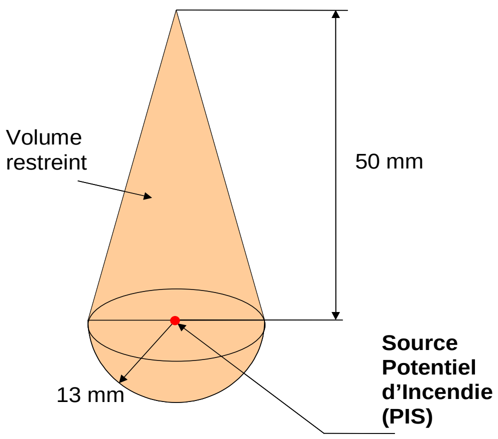
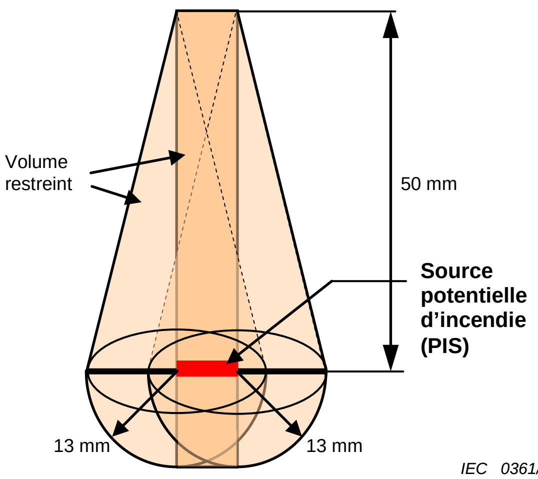


Figure 37 – Exigences minimales de séparation applicables à une source potentielle d'incendie causé par la formation d'un arc électrique



NOTE Cette figure peut être utilisée pour:

– une **source potentielle d'incendie causé par la formation d'un arc électrique** constituée de pistes ou de zones sur des cartes imprimées;

– les zones de composants d'une **source potentielle d'incendie causé par un phénomène résistif**. Les mesures sont réalisées à partir de l'élément de dissipation de puissance 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 la surface extérieure du composant est utilisée.

Figure 38 – Exigences étendues de séparation d'une source potentielle d'incendie

Lorsque le flux d'air à travers un circuit est mu par des appareils de ventilation, l'orientation verticale des volumes restreints décrits à la Figure 37, à la Figure 38 et à la Figure 40 doit être mise 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 être mis en rotation (incliné) autour de l'emplacement de la **source potentielle d'incendie** de 0° (orientation verticale indiquée à la Figure 39), à 45° dans la direction du flux d'air forcé.

Toutes données disponibles, y compris les données fournies par le fabricant, peuvent être utilisées pour déterminer la direction du flux d'air forcé lorsqu'elle n'est pas évidente. Le flux d'air qui résulte d'un mouvement dérivé d'une partie mobile qui n'est pas dédiée au mouvement d'air peut être ignoré.

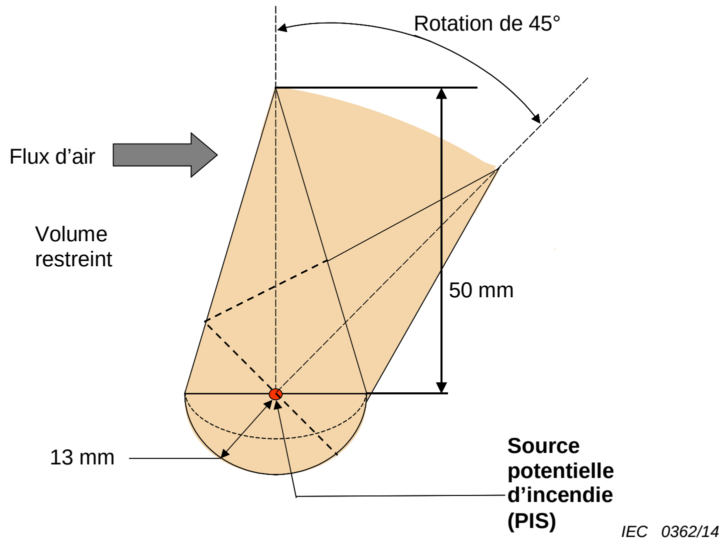


Figure 39 – Exigences de séparation en rotation causée par un flux d'air forcé

Lorsque la distance entre une **source potentielle d'incendie** et des **matériaux combustibles** est inférieure à la distance spécifiée à la Figure 37, à la Figure 38 et à la Figure 39 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 composant CEI correspondante; ou

  • être constitués de **matériaux de classe V-1**, **matériaux de classe VTM-1** ou **matériaux cellulaires de classe HF-1** ou être conformes à la CEI 60695-11-5. Les sévérités sont identifiées dans l'Article S.2.

6.4.7.3 Séparation par une barrière contre le feu

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 résistif** par une barrière contre le feu telle que définie au 6.4.8.2.1 (voir la Figure 40).

Les cartes imprimées ne sont pas considérées comme une barrière contre le feu pour 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 barrières contre le feu pour 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 une barrière contre le feu pour une **source potentielle d'incendie causé par un phénomène résistif** 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 cellulaire de classe HF-1**;

– dans le volume restreint, aucun matériau de classe assignée inférieure à la **classe V-1** ne doit être monté sur la même face de la carte imprimée que celle où se trouve la **source potentielle d'incendie causé par un phénomène résistif**;

– 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 aussi bien à chacune des faces de la carte imprimée qu'à ses couches internes.

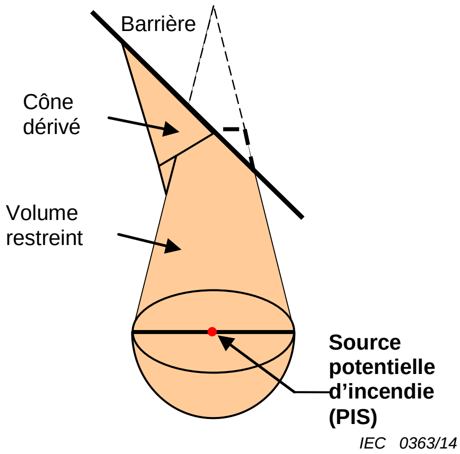


Figure 40a – Illustration montrant une barrière oblique

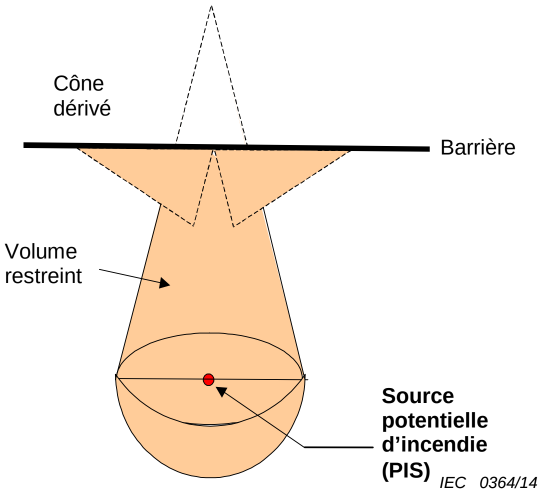


Figure 40b – Illustration montrant une barrière horizontale

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 barrière. Différentes formes de barrière peuvent engendrer différentes formes de flamme et donner lieu à des exigences différentes sur la barrière et la zone restreinte.

NOTE 2 Les dimensions sont identiques à la Figure 37 et à la Figure 38, mais, à l'exception de ce qui est exigé en 6.4.8.4, la distance entre la barrière et la **source potentielle d'incendie** n'est pas importante.

Figure 40 – Exigences sur la déviation de la barrière par rapport à une source potentielle d'incendie lorsqu'une barrière contre le feu est utilisée

6.4.7.4 Critères de conformité

La conformité est vérifiée par examen ou par mesure ou par les deux.

6.4.8 Enveloppes ignifuges (contre le feu) et barrières contre le feu

6.4.8.1 Généralités

La fonction de **protection** de l'**enveloppe ignifuge (contre le feu)** et de la barrière contre le feu consiste à freiner la propagation du feu à travers l'**enveloppe** ou la barrière.

L'**enveloppe ignifuge (contre le feu)** peut être l**'enveloppe** générale ou être à l'intérieur de celle-ci. L'**enveloppe ignifuge** (contre le feu) peut ne pas avoir une fonction exclusive, mais peut avoir d'autres fonctions en plus de celle d'**enveloppe ignifuge (contre le feu)**.

6.4.8.2 Propriétés du matériau des enveloppes ignifuges (contre le feu) et des barrières contre le feu

6.4.8.2.1 Exigences pour une barrière contre le feu

Une barrière contre le feu 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**.

6.4.8.2.2 Exigences pour une enveloppe ignifuge (contre le feu)

Pour les circuits où la puissance disponible ne dépasse pas 4 000 W (voir 6.4.1), l'**enveloppe ignifuge (contre le feu)** doit être conforme aux exigences de l'Article S.1.

Pour les circuits où la puissance disponible dépasse 4 000 W, l'**enveloppe ignifuge (contre le feu)** 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 (contre le feu)** ou à monter dans une telle ouverture doivent:

– être conformes aux exigences d'inflammabilité de la norme composant CEI correspondante; ou
– être constitués d'un **matériau de classe V-1**; ou
– satisfaire à l'Article S.1.

6.4.8.2.3 Critères de conformité

La conformité est vérifiée par examen des fiches techniques applicables ou par essai.

*La **classe d'inflammabilité du matériau** est vérifiée dans l'épaisseur significative la plus fine utilisée.*

6.4.8.3 Exigences de construction pour une enveloppe ignifuge (contre le feu) et une barrière contre le feu

6.4.8.3.1 Ouvertures dans les enveloppes ignifuges (contre le feu) et les barrières contre le feu

Les dimensions des ouvertures dans une **enveloppe ignifuge (contre le feu)** ou dans une barrière contre le feu 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 barrière contre le feu 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 à la Figure 41 et à la Figure 42.

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.

Lorsque le flux d'air forcé à travers une **source potentielle d'incendie** est mu par des appareils de ventilation, l'orientation verticale du volume décrit à la Figure 38 est mise en rotation (inclinée) autour de l'emplacement de la **source potentielle d'incendie** à partir de 0° (orientation verticale illustrée sur la Figure 38) à 45° dans la direction du flux d'air forcé (voir également la Figure 39).

6.4.8.3.2 Dimensions d'une barrière contre le feu

Une barrière contre le feu doit avoir des dimensions suffisantes pour éviter l'inflammation des bords de la séparation. Les bords des barrières contre le feu doivent s'étendre au-delà du cône de feu (voir la Figure 40).

6.4.8.3.3 Ouvertures sur le dessus et propriétés des ouvertures sur le dessus

Les propriétés des ouvertures sur le dessus d'une **enveloppe ignifuge (contre le feu)** et d'une barrière contre le feu doivent s'appliquer aux ouvertures situées au-dessus d'une **source potentielle d'incendie** comme indiqué sur la Figure 41.

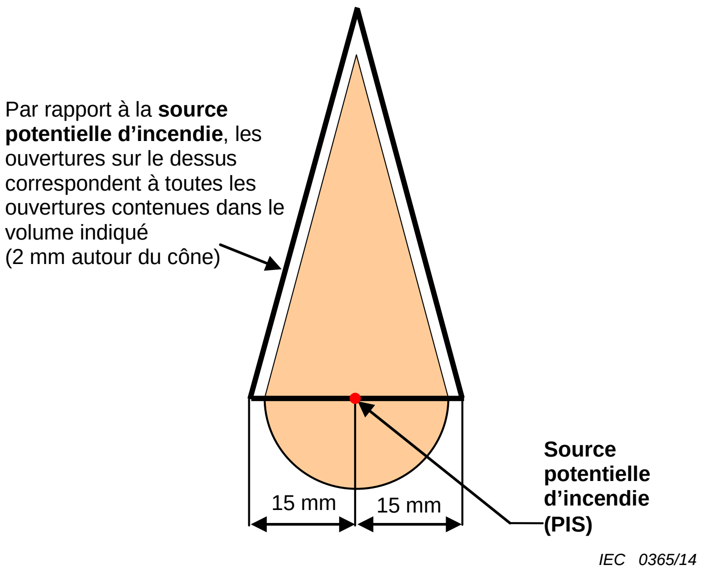
NOTE Toutes les ouvertures situées dans la zone indiquée sur la Figure 41 sont considérées comme des ouvertures sur le dessus, y compris les ouvertures latérales.

Les ouvertures qui aboutissent dans le volume défini à la Figure 41 *doivent être conformes à l'essai suivant.*

*L'essai est effectué à l'aide d'un brûleur aiguille, tel que spécifié dans 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 mm $\pm$ 1 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 de la Figure 37 et de la Figure 38.

Figure 41 – Ouvertures sur le dessus

Aucun essai n'est nécessaire à condition que les ouvertures ne dépassent pas:

– *5 mm dans toutes les dimensions; ou*

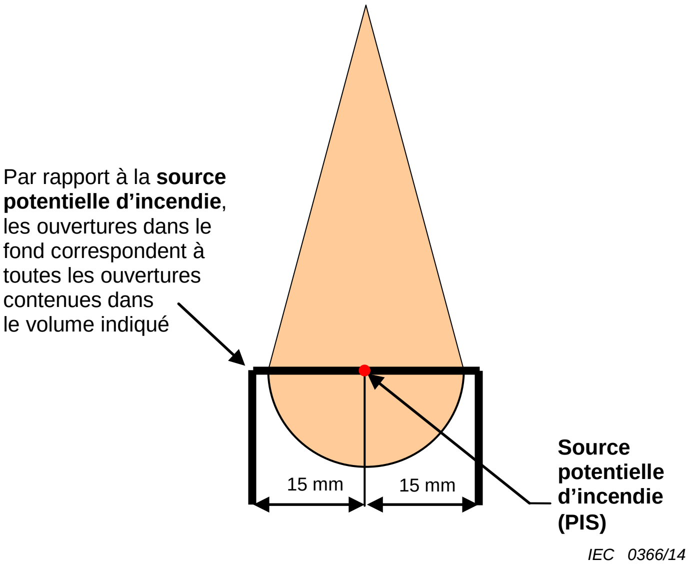
– *1 mm de largeur quelle que soit la longueur.*

6.4.8.3.4 Ouvertures dans le fond et propriétés des ouvertures dans le fond

Les propriétés des ouvertures dans le fond d'une **enveloppe ignifuge (contre le feu)** et d'une barrière contre le feu doivent s'appliquer aux ouvertures situées dans le volume indiqué sur la Figure 42.

NOTE Toutes les ouvertures situées dans la zone indiquée sur la Figure 42 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 de la Figure 37 et de la Figure 38.

Figure 42 – 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:

a) les ouvertures dans le fond ne dépassent pas:
   - 3 mm dans toutes les dimensions; ou
   - 1 mm de largeur quelle que soit la longueur;

b) sous des composants et des pièces satisfaisant aux exigences relatives aux **matériaux de classe V-1** ou aux **matériaux 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;

c) les dimensions de la maille des ouvertures dans le fond ne dépassent pas une surface de 2 mm par 2 mm pour un fil métallique ayant un diamètre d'au moins 0,45 mm.

d) les ouvertures dans le fond de l'**enveloppe** métallique sont conformes au Tableau 34.

Tableau 34 – Dimensions et espacement des trous dans le fond des enveloppes ignifuges (contre le feu) métalliques

	Trous circulaires		Ouvertures de formes différentes	
Epaisseur minimale du fond métallique mm	**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 (contre le feu)**. 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

6.4.8.3.5 Intégrité de l'enveloppe ignifuge (contre le feu)

Si une partie d'une **enveloppe ignifuge (contre le feu)** 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 ouvert par une **personne ordinaire**, doit satisfaire aux deux conditions suivantes:

   – il ne doit pas être séparable des autres parties de l'**enveloppe ignifuge (contre le feu)** 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 enlevée si une **protection par instructions** est fournie pour une dépose et une pose correctes de la porte ou du couvercle.

6.4.8.3.6 Critères de conformité

La conformité est vérifiée par examen des fiches techniques applicables et, le cas échéant, par essai.

6.4.8.4 Distances de séparation entre une source potentielle d'incendie et une enveloppe ignifuge (contre le feu) ou une barrière contre le feu

Une **enveloppe ignifuge (contre le feu)** ou une barrière contre le feu composée d'un **matériau combustible** doivent avoir:

– 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

– une distance de séparation minimale de 5 mm par rapport à une **source potentielle d'incendie causé par un phénomène résistif**.

Les distances inférieures sont autorisées sous réserve que la partie de l'**enveloppe ignifuge (contre le feu)** ou de la barrière contre le feu située à la distance de séparation nécessaire soit conforme à l'une des exigences suivantes:

– l'**enveloppe ignifuge (contre le feu)** ou la barrière contre le feu satisfait à l'essai au brûleur aiguille selon la CEI 60695-11-5. Les degrés de sévérité sont identifiés dans l'Article S.2. Après l'essai, le matériau de l'**enveloppe ignifuge (contre le feu)** ou de la barrière contre le feu ne doit présenter aucun trou dont la dimension est supérieure à celle autorisée en 6.4.8.3.3 ou en 6.4.8.3.4 selon le cas; ou

– l'**enveloppe ignifuge (contre le feu)** ou la barrière contre le feu sont composées d'un **matériau de classe V-0**.

6.5 Câblage interne et externe

6.5.1 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 ou égale à 0,5 mm^2, les méthodes d'essai des CEI 60332-1-2 et 60332-1-3 doivent être appliquées.

Pour les conducteurs dont la section est inférieure à 0,5 mm^2, les méthodes d'essai de la CEI 60332-2-2 doivent être appliquées.

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 la CEI 60332-1-2, la CEI 60332-1-3 ou la CEI 60332-2-2.

6.5.2 Critères de conformité

Le conducteur ou le câble isolé doit être acceptable s'il est conforme aux exigences de performance recommandées des normes applicables de la série CEI 60332 ou aux exigences de la CEI/TS 606954-11-21.

6.5.3 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 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 à puissance 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 à l'Article Q.1.

Les circuits servant à alimenter des dispositifs ou des composants externes qui sont conçus pour être utilisés dans le même local que l'EUT ne sont pas concernés par cette exigence. Voir 6.6 pour la connexion aux équipements secondaires.

Les circuits externes de câbles à double conducteurs tels que ceux décrits dans le Tableau 14 avec les numéros d'identification 1 et 2 et ayant un diamètre minimal de fil de 0,4 mm doivent avoir un courant limité à 1,3 A.

EXEMPLE 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 Q.1.2.

6.5.4 Critères de conformité

La conformité est vérifiée par essai, par examen et, lorsque nécessaire, selon les exigences de l'Annexe Q.

6.6 Protections contre les incendies dus à la connexion des équipements supplémentaires

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 ou doit être conforme à l'Article Q.1.

La conformité est vérifiée par examen ou par des mesures.

7 Blessures dues aux substances dangereuses

7.1 Généralités

Pour réduire la probabilité de blessure due à une exposition à des **substances dangereuses,** les équipements doivent être munis des **protections** spécifiées à l'Article 7.

NOTE Ces **protections** ne sont pas destinées à être les seuls moyens pour réduire la probabilité de telles blessures.

7.2 Réduction de l'exposition aux substances dangereuses

L'exposition aux **substances dangereuses** doit être réduite. La réduction de l'exposition aux **substances dangereuses** doit être contrôlée par le confinement des **substances 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 selon 4.4.4 à la suite desquels le conteneur ne doit présenter 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 On considère que la limite typique actuelle d'exposition à long terme à l'ozone est de 0,1 $\times 10^{-6}$ (0,2 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 équipement de protection individuelle (EPI)

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.

La conformité est vérifiée par examen des instructions ou des documents d'accompagnement.

7.5 Utilisation de protections par instructions et des instructions d'utilisation

Lorsqu'une **substance dangereuse** peut provoquer une blessure, des **protections par 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 et leurs circuits de protection

Les piles et les batteries ainsi que leurs circuits de protection doivent être conformes à l'Annexe M.

8 Blessures dues à un choc mécanique

8.1 Généralités

Pour réduire la probabilité de blessure due à une exposition à des dangers mécaniques**,** les équipements doivent être munis des **protections** spécifiées à l'Article 8.

NOTE 1 Dans certains cas, la personne est la source de l'énergie cinétique.

NOTE 2 Lorsque cela n'est pas spécifiquement mentionné dans l'Article 8, les termes "produits" et "équipements" incluent également les chariots, supports et éléments de transport.

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 35.

Tableau 35 – 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]
3a	Pales en plastique de ventilateur [a] Voir la Figure 44	$\frac{N}{15\ 000} + \frac{K}{2\ 400} \leq 1$	> MS1; et $\frac{N}{44\ 000} + \frac{K}{7\ 200} \leq 1$	> MS2
3b	Autres pales de ventilateur [a] Voir la Figure 43	$\frac{N}{15\ 000} + \frac{K}{2\ 400} \leq 1$	> MS1; et $\frac{N}{22\ 000} + \frac{K}{3\ 600} \leq 1$	> MS2
4	Desserrage, explosion ou implosion de parties	NA	NA	Voir [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 ≤1 kg montage ≤ 2 m [e]	Masse de l'équipement > 1 kg montage ≤ 2 m [e]	Tous équipements montés > 2 m

[a] Le facteur K est déterminé à partir de la formule $K = 6 \times 10^{-7}$ $(m\ r^2\ N^2)$, 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 d'une urgence hospitalière n'est pas nécessaire.

[c] L'expression "Peut provoquer une blessure" signifie que l'intervention d'un docteur ou d'une urgence hospitalière peut être nécessaire.

[d] Les équipements ayant les conceptions suivantes sont des exemples considérés comme équipement du type MS3:

– 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.

[e] Cette classification ne peut être utilisée que si les instructions d'installation du fabricant indiquent que l'équipement convient uniquement à un montage à des hauteurs ≤ 2 m.

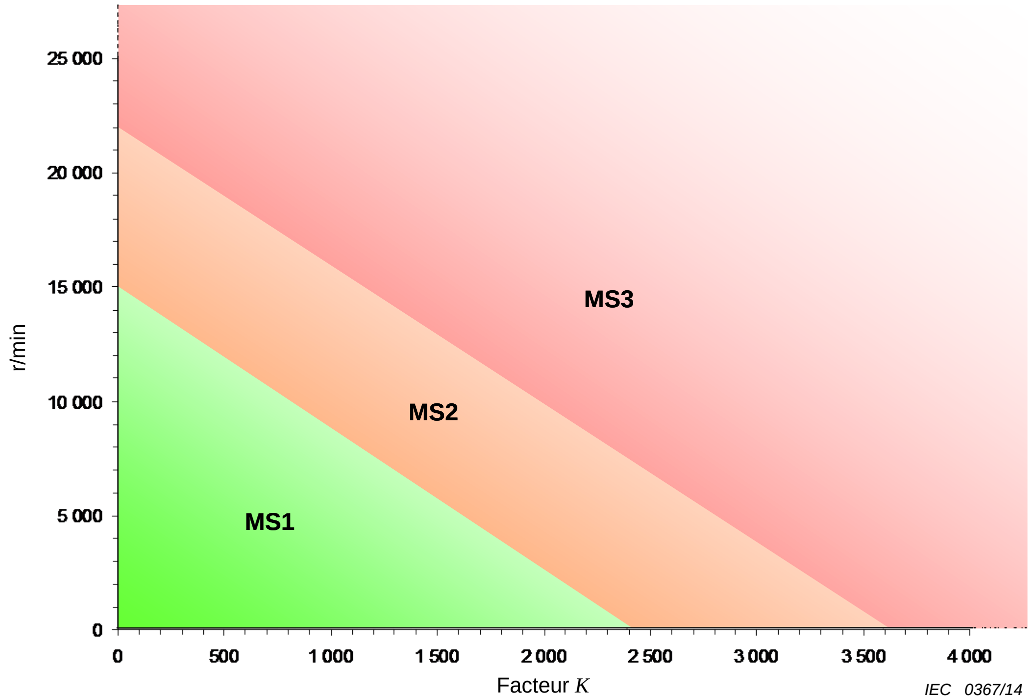


Figure 43 – Limites pour les pales mobiles de ventilateurs en matériaux autres que le plastique

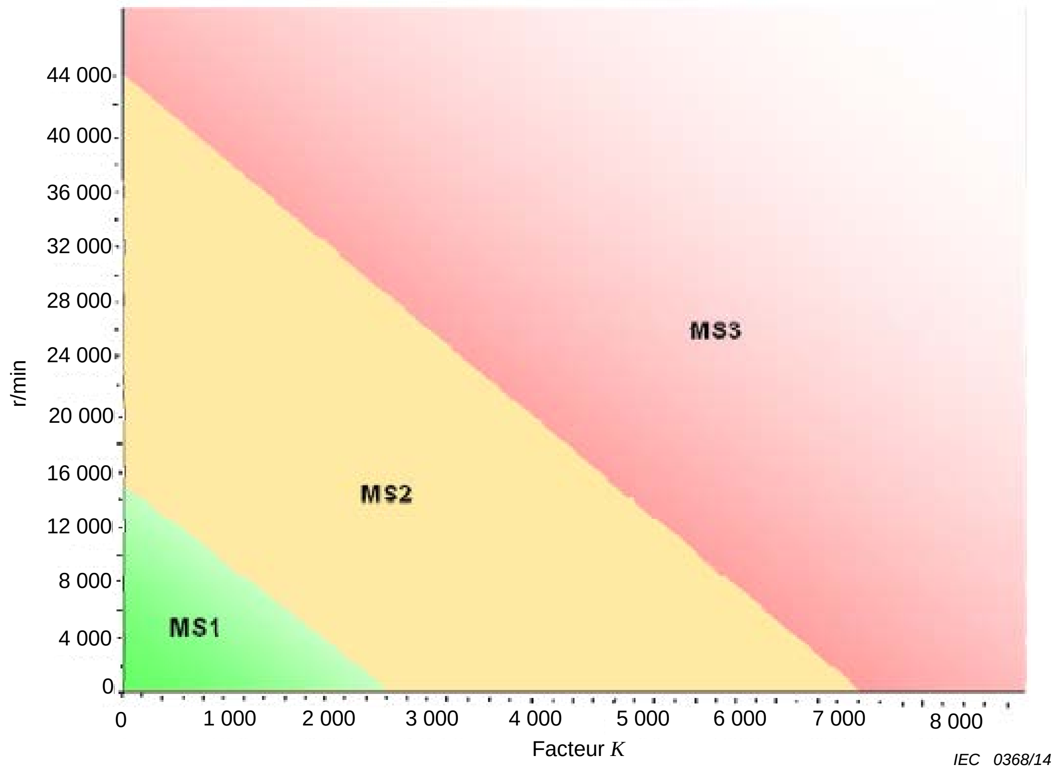


Figure 44 – Limites pour les pales mobiles de ventilateurs en matériaux plastiques

8.2.2 MS1

MS1 est une source d'énergie mécanique de classe 1 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**.

8.2.3 MS2

MS2 est une source d'énergie mécanique de classe 2 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.

8.2.4 MS3

MS3 est une source d'énergie mécanique de classe 3 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'énergie mécanique déclarée comme devant être traitée comme une source MS3 par le fabricant.

8.3 Protection contre les sources d'énergie mécanique

A l'exception de ce qui est indiqué ci-dessous, les exigences de **protection** pour les parties **accessibles** aux **personnes ordinaires**, aux **personnes averties** et aux **personnes qualifiées** sont données en 4.3.

Une **protection par instructions** doit être prévue pour MS2 qui ne soit pas évidente pour une **personne avertie** ou pour MS3 qui ne soit pas évidente pour une **personne qualifiée**.

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 s'éloigner involontairement de l'entretien des sources d'énergie de classe 2 ou classe 3.

8.4 Protections contre les parties avec arêtes vives et angles vifs

8.4.1 Exigences

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 sont spécifiées ci-dessous.

La classification des sources d'énergie doit être réalisée conformément à la ligne 1 du Tableau 35.

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 par instructions** doit être utilisée pour réduire le risque de contact involontaire conformément à l'Article F.5, à l'exception du fait que l'élément 3 est facultatif.

Les éléments de la **protection par instructions** doivent être comme suit:

– élément 1a: , CEI 60417-6043 (2011-01);
– élément 2: “Présence d’arêtes vives” ou texte équivalent;
– élément 3: facultatif;
– élément 4: “Ne pas toucher” ou texte équivalent.

8.4.2 Critères de conformité

Lorsqu’une arête ou un angle vif est tenu d'être ***accessible*** *pour le fonctionnement de l’équipement, la conformité est vérifiée par examen.*

Lorsqu’une arête ou un angle vif n'est pas tenu d'être ***accessible*** *pour le fonctionnement de l’équipement, la conformité est vérifiée par les essais appropriés 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

Les **protections** qui réduisent la probabilité de blessure par des parties mobiles de l’équipement (par exemple, les points de pincement, les engrenages et les parties qui peuvent commencer à bouger du fait d’un réenclenchement non prévu d’un dispositif de commande) sont spécifiées ci-dessous.

Les pales de ventilateur en plastique sont classées conformément à la ligne 3a du Tableau 35. Les autres pales de ventilateur sont classées conformément à la ligne 3b du Tableau 35. Les autres parties mobiles sont classées conformément à la ligne 2 du Tableau 35.

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 une expérience spécifique et un jugement d’ingénieur.

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.

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**.

Sauf spécification contraire, lorsqu’il existe une probabilité que des doigts, des bijoux, des vêtements, des cheveux, etc. soient pris dans des parties mobiles MS2 ou MS3, une **protection de l’équipement** doit être prévue pour éviter l’entrée de parties du corps ou leur coincement.

Dans le cas où une partie mobile MS2 est tenue d'être **accessible** à une **personne ordinaire** ou une partie mobile MS3 est tenue d'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 lorsqu’elle est exposée; et
– la partie mobile doit être protégée dans toute la mesure du possible; et
– une **protection par instructions** telle que donnée en 8.5.2 doit être utilisée; 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.

Les parties mobiles MS3:

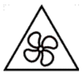
– uniquement **accessibles** à une **personne qualifiée**; et
– et dont la partie en mouvement n'est pas évidente (par exemple un dispositif à mouvement intermittent),

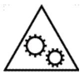
doivent disposer d'une **protection par instructions** telle que spécifiée en 8.5.2. Sauf si la partie mobile est disposée, située, enveloppée ou protégée de manière à ce qu'il soit peu probable d'entrer en contact avec les parties mobiles, un dispositif d'arrêt doit être placé de manière facilement visible et mis en évidence à environ 750 mm de la partie MS3.

8.5.2 Exigences relatives à la protection par instructions

Une **protection par instructions** doit être prévue pour réduire la probabilité d'un contact involontaire avec une partie mobile conformément à l'Article F.5, à l'exception du fait que l'élément 3 est facultatif.

Les éléments de la **protection par instructions** doivent être comme suit:

– élément 1a:  CEI 60417-6056 (2011-05) pour les pales mobiles de ventilateur
ou

 CEI 60417-6057 (2011-05) pour les autres parties mobiles

– élément 2: “Parties mobiles” ou “pale mobile de ventilateur” selon le cas, ou texte équivalent
– élément 3: facultatif
– élément 4: “Se tenir à l'écart des parties mobiles” ou “Se tenir à l'écart des pales de ventilateur” ou “Se tenir à l'écart de la zone de mouvement” selon le cas, ou texte équivalent.

Pendant l'entretien par une **personne ordinaire** au cours duquel il est nécessaire de retirer ou de contourner la **protection de l'équipement** contre l'accès à une partie mobile classée MS2, une **protection par instructions** doit être prévue pour:

– déconnecter la source d'énergie avant le retrait ou le contournement de la **protection de l'équipement**; et
– rétablir la **protection de l'équipement** avant de rétablir l'énergie.

8.5.3 Critères de conformité

L'accessibilité aux parties mobiles doit être vérifiée par examen, et si nécessaire, être évaluée conformément aux parties applicables de l'Annexe V.

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 m^3 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'ACCES DE L'OPERATEUR".

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

Les **protections d'équipement** pour la protection des personnes, y compris les enfants, sur les équipements conçus pour détruire mécaniquement différents supports au moyen de parties mobiles qui entraînent le support à l'intérieur de l'équipement sont spécifiées ci-dessous. 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, selon 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 par instructions contre les parties mobiles

Pour les équipements installés dans des emplacements que les enfants sont susceptibles de fréquenter, une **protection par instructions** doit être prévue conformément à l'Article F.5, à l'exception du fait que l'élément 3 est facultatif.

Les éléments de la **protection par instructions** doivent être comme suit:

- élément 1a: , CEI 60417-6057 (2011-05)
- élément 2: facultatif
- élément 3: facultatif
- élément 4: "l'équipement n'est pas destiné à être utilisé par des enfants" ou "cet équipement n'est pas un jouet" et "éviter que les mains, les vêtements et les cheveux ne touchent l'orifice d'alimentation du support" et "débrancher l'équipement lorsque celui-ci n'est pas utilisé pendant une période prolongée" ou texte équivalent.

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 ôte toutes les alimentations de puissance 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

Les dispositifs de destruction de supports sont soumis à essai en appliquant la sonde en coin de la Figure V.4 dans une direction quelconque par rapport à l'orifice:

– *avec une force maximale de 45 N pour un dispositif du type coupe en bande*

– *avec une force maximale de 90 N pour un dispositif du type coupe en travers.*

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 déchiquetage du support en longues bandes utilisant un mécanisme de déchiquetage à moteur. Un dispositif de destruction de supports à coupe en travers procède au déchiquetage du support de deux manières ou plus en petits morceaux (confettis) utilisant généralement un moteur plus puissant et un mécanisme de déchiquetage plus complexe.

*Toute **enveloppe** ou protection qui peut être enlevée ou ouverte par une **personne ordinaire** ou une **personne avertie** doit être enlevée ou ouverte avant l'application des sondes.*

8.5.4.2.5 Critères de conformité

La conformité est vérifiée conformément à V.1.2 et V.1.5. 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 Lampes à haute pression

8.5.5.1 Généralités

Le mécanisme de confinement pour les lampes à haute pression classées MS3 selon la ligne 4 du Tableau 35 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 du module de lampe, selon le cas.

8.5.5.2 Méthode 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 modules de 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 modules de lampes considérées comme des parties de classe MS3 uniquement pendant leur fonctionnement peuvent être soumises à l'essai séparément, ou normalement installées 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 tissu adhésif sombre (ou toute autre méthode adéquate) de taille appropriée 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 tissu adhésif sombre. 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 L'examen des débris de verre potentiels est plus facile si le tapis collant est de couleur bleu foncé.

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 répétables.

8.5.5.3 Critères de conformité

La conformité est vérifiée par examen physique, ou, si nécessaire, par les essais de 8.5.5.2.

Lors de la réalisation de l'essai conformément à 8.5.5.2, examiner les particules de verre se trouvant sur le tissu adhésif sombre, et:

- *aucune particule de verre dont la taille est inférieure à 0,8 mm sur l'axe le plus long ne doit être trouvée au-delà de 1 m de l'ouverture de **l'enveloppe**; et*
- *aucune particule de verre dont la taille est supérieure ou égale à 0,8 mm sur l'axe le plus long ne doit être trouvée.*

*Dans le cas des équipements professionnels pour lesquels il est peu probable que les particules soient à portée d'une **personne ordinaire**, il est admis de remplacer la valeur de 0,8 mm par 5 mm.*

8.6 Stabilité de l'équipement

8.6.1 Exigences

La classification des produits dans le but d'évaluer la stabilité de l'équipement doit être effectuée selon le Tableau 35, ligne 5.

Lorsque des unités sont fixées ensemble, la classe MS est déterminée par le poids total des unités. Si des unités sont destinées à être séparées pour relocalisation ailleurs, la classe MS est déterminée par le poids individuel.

Des unités individuelles qui sont conçues pour être fixées ensemble mécaniquement sur place et ne sont pas utilisées individuellement, ou un **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.

Les équipements doivent satisfaire aux exigences et essais spécifiés en 8.6.2, 8.6.3, 8.6.4 et 8.6.5 conformément au Tableau 36. Où “x” signifie que l'essai est applicable.

Tableau 36 – Présentation des exigences et essais

Type d'équipement		Type d'essai				
		Stabilité statique 8.6.2.2	**Force vers le bas** 8.6.2.3	**Déplacement** 8.6.3	**Lame de verre** 8.6.4	**Force horizontale** 8.6.5
MS1	Tous les équipements	Aucune exigence de stabilité				
MS2	Posé au sol			x		
	Non posé au sol	x				
	commandes ou affichages [a]				x	x
	Fixe [b]	Aucune exigence de stabilité				
MS3	Posé au sol	x	x	x		
	Non posé au sol	x				
	commandes ou affichages [a]	x			x	x
	Fixe [b]	Aucune exigence de stabilité				

[a] Equipements ayant les commandes d'utilisateur **accessibles** montées à l'avant et comportant des affichages à images mobiles .susceptibles d'être utilisés dans les environnements domestiques et analogues dans lesquels les équipements peuvent être **accessibles** aux enfants.

[b] Lorsque les équipements sont destinés à être installés par une **personne ordinaire,** les équipements munis d'un trou de vis ou d'autres moyens de fixation, pour la fixation à une table ou pour la protection en cas de séisme, ne sont pas considérés comme étant fixes. De telles fixations sont considérées comme des **protections supplémentaires.**

Lorsque des matériaux thermoplastiques sont impliqués dans la construction, les essais de stabilité correspondants doivent être réalisés après l'essai de relâchement des contraintes de l'Article T.8 lorsque l'équipement a refroidi et a atteint la température ambiante.

Les téléviseurs MS2 et MS3 doivent avoir une **protection par instructions** conformément à l'Article F.5, à l'exception du fait que la **protection par instructions** peut être incluse dans les instructions d'installation ou document d'accompagnement équivalent de l'équipement.

Les éléments de la **protection par instructions** doivent être comme suit:

– élément 1a: non disponible

– élément 2: "Danger d'instabilité" ou énoncé équivalent

– élément 3: "Le téléviseur peut tomber et causer des blessures corporelles graves ou la mort" ou texte équivalent

– élément 4: le texte ci-dessous ou texte équivalent

Ne jamais placer un téléviseur dans un endroit instable. Un téléviseur 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 du téléviseur.
- Utiliser uniquement les meubles qui peuvent soutenir le téléviseur de manière sécurisée.
- S'assurer que le téléviseur ne dépasse pas du bord du meuble qui le soutient.
- Ne pas placer le téléviseur sur des meubles hauts (par exemple, des armoires ou des bibliothèques) sans accrocher le meuble et le téléviseur à un support adapté.
- Ne pas placer le téléviseur sur un tissu ou d'autres matériaux qui peuvent se trouver entre le téléviseur et le meuble qui le soutient.
- Enseigner aux enfants les dangers de monter sur les meubles pour atteindre le téléviseur ou ses commandes.

Si un téléviseur existant est à déplacer, il convient d'appliquer les mêmes considérations que celles données ci-dessus.

8.6.2 Stabilité statique

8.6.2.1 Montage d'essai

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, sont tenus de contenir la quantité de substance, d'après leur capacité assignée, qui correspond aux conditions les plus défavorables.

Toutes les portes, tiroirs, roulettes, pieds réglables et autres accessoires, 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.*

Lorsque l'équipement est soumis à une maintenance périodique ou à un entretien régulier ou lorsqu'il est réparé sur son lieu d'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.*

Les essais de 8.6.2.2 et 8.6.2.3 doivent être effectués comme indiqué au Tableau 36.

8.6.2.2 Essai de stabilité statique

L'équipement 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. L'essai peut être appliqué à une hauteur inférieure ou égale à 1,5 m de la base de l'équipement. La force d'essai doit être interrompue si l'équipement reste stable après avoir été incliné de 10° par rapport à la verticale. En variante, l'équipement doit être incliné d'un angle inférieur ou égal à 10° par rapport à la verticale.

8.6.2.3 Essai de force vers le bas

L'équipement 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 comprise dans les 10° de l'horizontale d'au moins 125 mm sur au moins 200 mm, à une hauteur inférieure ou égale à 1 m de la base de l'équipement. La force de 800 N est appliquée par l'intermédiaire d'un outil d'essai adapté ayant une surface plate d'environ 125 mm par 200 mm. La force dirigée vers le bas est appliquée avec la totalité de la surface plate de l'outil d'essai en contact avec l'équipement; il n'est pas nécessaire que l'outil 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 n'ont vraisemblablement pas à être utilisés comme marche ou comme échelle.

8.6.2.4 Critères de conformité

L'équipement ne doit pas se renverser pendant les essais.

8.6.3 Essai de stabilité en mouvement

8.6.3.1 Exigences

L'équipement doit être stable lorsqu'il est déplacé.

La conformité est vérifiée par l'essai de 8.6.3.2. L'équipement ne doit pas se renverser pendant l'essai. Les équipements dont le diamètre minimal des roues est de 100 mm sont considérés comme satisfaisant aux exigences ci-dessus sans essai.

8.6.3.2 Méthode d'essai

L'équipement est incliné à un angle de 10° dans toute direction par rapport à sa 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 pendant l'essai au bord du support horizontal afin que le contact ne soit pas établi. 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°.

Les équipements censés être déplacés par des ***personnes ordinaires****, doivent avoir:*

– *toutes leurs portes et tous leurs tiroirs, n'ayant pas de moyen positif de retenue et qui peuvent être ouverts involontairement, et*
– *leurs roulettes, pieds réglables et autres parties analogues*

disposés dans toute combinaison entraînant la plus faible stabilité.

Les portes, tiroirs, etc. des équipements censés être déplacés par une ***personne avertie*** *ou une* ***personne qualifiée****, 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.

8.6.4 Essai de lame de verre

8.6.4.1 Exigences

L'équipement doit être construit de manière à ne pas glisser ou se renverser sur une surface d'appui en verre.

8.6.4.2 Méthode d'essai et critères de conformité

L'équipement est placé 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 l'essai, l'équipement ne doit pas glisser ou se renverser.

8.6.5 Essai de force horizontale et critères de conformité

L'équipement est placé 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:

- *une force horizontale extérieure égale à 13 % du poids de l'équipement ou 100 N, la valeur la plus faible étant retenue, est appliquée 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*
- *l'équipement doit être déplacé suivant tout angle d'inclinaison inférieur ou égal à 15° par rapport à la verticale; ou*
- *l'équipement est 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 15°.*

L'équipement ne doit pas se renverser au cours de l'essai.

8.7 Equipement monté sur un mur ou au plafond

8.7.1 Exigences

La classification des équipements dans le but d'évaluer les moyens de montage sur le mur est effectuée selon le Tableau 35, ligne 6.

Pour les équipements MS2 ou MS3:

- Si le fabricant spécifie un montage spécifique sur un mur ou au plafond, la combinaison du montage et de l'équipement doit être conforme à 8.7.2, Essai 1. Le matériel utilisé pour fixer le montage à l'équipement doit être fourni avec l'équipement ou décrit en détail dans les instructions d'utilisation (par exemple, la longueur des vis, le diamètre des vis, etc.).
- Si le fabricant ne spécifie pas un montage spécifique sur un mur ou au plafond, mais que l'équipement est livré avec toute pièce (par exemple un crochet ou une ouverture filetée) facilitant la fixation pour son montage, ces pièces doivent satisfaire à 8.7.2, Essai 2, selon le cas. Les instructions utilisateur doivent donner des conseils sur l'utilisation en toute sécurité des pièces considérées (par exemple, taille des vis y compris leur filetage et leur longueur, nombre de vis, etc.).
- Si l'équipement est équipé de pièces filetées pour fixation du dispositif de montage, les pièces filetées sans le dispositif de montage doivent de plus être conformes à 8.7.2, Essai 3.

NOTE Les essais concernent la vérification de la fixation du dispositif de montage à l'équipement et non la fixation au mur ou au plafond.

8.7.2 Méthodes d'essai

Si la construction implique des matériaux polymères, les essais doivent être réalisés après l'essai de relâchement des contraintes de l'Article T.8.

<u>Essai 1</u>

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, en plus du poids de l'équipement, est appliquée vers le bas au centre de gravité de l'équipement pendant 60 s. La force ajoutée doit:

- *être égale à trois fois le poids de l'équipement, ou*
- *être égale au poids de l'équipement plus 880 N,*

la valeur la plus faible étant retenue.

En outre, pour les équipements montés sur le mur, une force horizontale de 50 N est appliquée horizontalement pendant 60 s.

<u>Essai 2</u>

La force d'essai doit être équivalente à la plus faible des valeurs suivantes, divisée par le nombre de points de fixation dans le système de montage:

- *quatre fois le poids de l'équipement, ou*
- *deux fois le poids de l'équipement plus 880 N.*

Chaque point dans le système de montage doit être soumis à une force de cisaillement appliquée perpendiculairement à son axe central pendant 1 min. La force doit être appliquée dans quatre directions, une direction à la fois, à intervalle de 90°.

Chaque point dans le système de montage, un à la fois, doit être soumis à une force de poussée dirigée vers l'intérieur appliquée parallèlement à son axe central pendant 1 min.

Chaque point dans le système de montage, un à la fois, doit être soumis à une force de traction dirigée vers l'extérieur appliquée parallèlement à son axe central pendant 1 min.

<u>Essai 3</u>

Si la conception du système de montage repose sur des pièces filetées, un couple conforme aux valeurs données dans le Tableau 37 doit être appliqué à chaque partie filetée, un à la fois. Si une vis correspondante est fournie par le fabricant, elle doit être utilisée pour l'essai. En l'absence de vis correspondante fournie par le fabricant, même si un type de vis peut être recommandé dans les instructions d'utilisation, toute vis de même diamètre doit être utilisée pour l'essai.

Tableau 37 – Couple à appliquer aux vis

Diamètre nominal de vis mm	Couple Nm
Jusqu'à et y compris 2,8	0,4
de 2,8 jusqu'à et y compris 3,0	0,5
de 3,0 jusqu'à et y compris 3,2	0,6
de 3,2 jusqu'à et y compris 3,6	0,8
de 3,6 jusqu'à et y compris 4,1	1,2
de 4,1 jusqu'à et y compris 4,7	1,8
de 4,7 jusqu'à et y compris 5,3	2,0
de 5,3 jusqu'à et y compris 6,0	2,5

8.7.3 Critère de conformité

La conformité est vérifiée par examen et par les essais de 8.7.2, selon le cas. L'équipement ou ses dispositifs de montage associés ne doivent pas se détacher, et doivent rester mécaniquement intacts et sécurisés pendant l'essai.

8.8 Rigidité des poignées

8.8.1 Généralités

Une poignée dont la fonction déclarée par le fabricant est de soulever ou porter l'équipement doit satisfaire aux essais spécifiés en 8.8.2.

L'équipement est classifié conformément au Tableau 35, ligne 5.

Si l'équipement équipé de poignées est conçu ou fourni avec des instructions de levage ou de transport de plusieurs unités ensemble, la classe est déterminée en tenant compte du poids qu'il est possible de transporter.

8.8.2 Méthode d'essai et critères de conformité

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;*

NOTE Aucun essai ne s'applique aux équipements MS1 ayant uniquement une seule poignée.

– *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

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 doit être réduite. L'équipement est classifié selon le Tableau 35, 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 en **conditions normales de fonctionnement**, doivent être capables de supporter une traction de 20 N. La force de traction est à appliquer 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.*

Au cours de l'essai, les roues ou roulettes ne doivent pas être endommagées ou séparées de leurs moyens de fixation.

8.10 Chariots, supports et éléments de support semblables

8.10.1 Généralités

L'équipement doit être stable par rapport au chariot, support ou élément de support semblable. Les classifications MS du Tableau 35, 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 en **conditions normales de fonctionnement**, doivent être conformes à l'essai de force horizontale de 8.6.5.

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 8.6.3, 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 un équipement spécifique, mais conditionné et vendu séparément de l'équipement, doit être fourni avec une **protection par instructions**, conformément à l'Article F.5.

Les éléments de la **protection par instructions** doivent être comme suit:

– élément 1a: non disponible

– élément 2: “Attention” ou texte équivalent

– élément 4: “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)” ou texte équivalent

– élément 3: “Toute utilisation avec un autre équipement peut causer une instabilité entraînant des blessures” ou texte équivalent

Les éléments doivent figurer dans l’ordre 2, 4 et 3.

La **protection par instructions** doit être apposée sur le chariot, support ou élément de support ou incluse dans les instructions d’installation ou document d’accompagnement équivalent de l’équipement.

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 par instructions** conformément à l'Article F.5 et doivent comporter les éléments suivants:

– élément 1a: non disponible

– élément 2: “Attention” ou énoncé ou texte équivalent

– élément 4: “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)” ou texte équivalent

– élément 3: “Toute utilisation avec d’autres (chariots, supports ou éléments de support) peut causer une instabilité entraînant des blessures” ou texte équivalent

Les éléments doivent figurer dans l’ordre 2, 4 et 3.

La **protection par instructions** doit être apposée sur l’équipement ou incluse dans les instructions d’installation ou document d’accompagnement équivalent de l’équipement.

8.10.3 Essai de chargement de chariot, de support ou élément de support et critères de conformité

Un chariot, un support ou un élément de support doit être construit de telle manière que les déformations ou endommagements permanents pouvant entraîner des blessures chez une personne, ne se produisent pas lorsqu'il est 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 est à appliquer 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 est à appliquer 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, un chariot, un support ou un autre élément de support doit être construit 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 par le fabricant plus 440 N pour la surface censée supporter un affichage à images mobiles; ou*

– *quatre fois la charge prévue par le 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 est à appliquer pendant 1 min sur chaque surface d'appui, avec les autres surfaces non chargées.

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 est à appliquer à une partie du chariot ou du support et la méthode d'essai nécessite d'être telle que décrite en l'Article T.6. Cependant, un chariot, support ou élément de support en verre doit être soumis à essai conformément à 4.4.4.6.

8.10.5 Stabilité mécanique

Les chariots, supports ou éléments de support, y compris ceux posés au sol, doivent être soumis aux essais applicables décrits en 8.6.3 et 8.6.5 et, le cas échéant, en combinaison avec leurs équipements MS2 ou MS3 prévus.

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 8.6.3 et 8.6.5, 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 rack

8.11.1 Généralités

Ce paragraphe spécifie les exigences permettant au rail de glissière de réduire la probabilité de blessure en maintenant l'équipement monté sur rail de glissière (SRME – slide-rail mounted equipment) 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 SRME de glisser au-delà de l'extrémité des rails de glissière.

Les exigences ci-dessous s'appliquent aux moyens de montage des équipements SRME qui sont MS2 et MS3:

– installés sur rack, qui peuvent être rallongés sur glissière hors de ce dernier pour besoin d'installation, de fonctionnement ou d'entretien; et

– SRME qui s'étend sur toute la largeur du rack; et

– dont la position d'installation supérieure présente une hauteur supérieure à 1 m par rapport à la surface d'appui.

Les exigences ne s'appliquent pas aux

– sous-ensembles d'équipements; ou

– autres équipements fixés en place dans le rack; ou

– équipements non destinés à être entretenus lorsqu'ils sont rallongés sur rails de glissière.

Les moyens de montage mécaniques pour le SRME sont désignés comme constituant un rail de glissière. Le SRME peut être le produit réel configuré dans sa charge mécanique la plus défavorable ou une **enveloppe** représentative avec des poids permettant de simuler la charge la plus défavorable.

NOTE 1 Les rails de glissière incluent les glissières de support, les glissières de frottement ou d'autres moyens de montage équivalents.

NOTE 2 Les sous-ensembles du produit fini (par exemple, modules amovibles, tiroirs de composant, bacs d'alimentation à extraction des photocopieurs/imprimantes) ne sont pas considérés comme des équipements montés sur rail de glissière.

8.11.2 Exigences

La classification des produits dans le but d'évaluer la stabilité de l'équipement est à effectuer selon le Tableau 35, ligne 5.

NOTE Pour l'évaluation de la stabilité de l'équipement, voir 8.6.

Les rails de glissière doivent maintenir le SRME en place et doivent être munis de butées d'extrémité qui empêchent l'équipement SRME de glisser involontairement au-delà des moyens de montage.

Les rails de glissière doivent être installés sur un rack représentatif avec l'équipement SRME ou un montage équivalent, conformément aux instructions du fabricant.

Les rails de glissière et leurs moyens de montage doivent satisfaire aux essais de résistance mécanique de 8.11.3 et 8.11.4. A l'issue de chaque essai, les rails de glissière et le SRME peuvent être remplacés avant de réaliser l'essai suivant.

8.11.3 Essai de résistance mécanique

Avec les équipements SRME montés en position rallongée, une force supplémentaire au poids de l'équipement SRME est à appliquer vers le bas au centre de gravité pendant 1 min

La force supplémentaire appliquée aux rails de glissière doit être égale à la plus grande des deux valeurs suivantes:

– *50 % de la masse du SRME plus une force de 330 N,*

– *50 % de la masse du SRME, plus une masse supplémentaire, où cette dernière masse est égale à la masse de l'équipement SRME ou 530 N, selon la plus petite valeur.*

NOTE Cette force supplémentaire est censée prendre en compte les autres objets ou dispositifs pouvant être empilés au sommet de l'équipement SRME en position rallongée lors de l'installation d'un autre SRME.

Dans le cas d'étagères montées sur rail de glissière, l'étagère doit être soumise à essai avec un poids égal à 125 % du poids maximal destiné à être placé sur l'étagère.

Un marquage doit être apposé sur l'étagère pour indiquer le poids maximal qui peut lui être ajouté.

8.11.4 Essai de résistance mécanique, 250 N, y compris les butées d'extrémité

Une force statique de 250 N est appliquée latéralement, dans les deux directions au niveau de ou à proximité de l'extrémité du SRME munie des rails de glissière dans leur position entièrement rallongée (entretien) pendant 1 min. Il n'est pas nécessaire que le poids appliqué soit en contact total avec des surfaces irrégulières (par exemple, des surfaces ondulées ou courbes) mais il doit s'exercer à 30 mm de l'extrémité du SRME.

Pour vérifier par essai l'intégrité des butées d'extrémité, une force de poussée et de traction de 250 N est appliquée sur la face avant du SRME afin de tenter de faire sortir le SRME du rail de glissière. L'essai est réalisé avec le SRME dans la position entièrement rallongée (entretien) et dans la position d'installation (utilisation).

NOTE Des exigences supplémentaires pour un essai de force dynamique sur les butées d'extrémité sont en cours de développement.

8.11.5 Critères de 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 8.11.3 et 8.11.4 sont alors effectués.

A l'issue de chaque essai, l'équipement SRME et ses rails de glissière associés doivent rester fixés pendant un cycle complet de déplacement sur les rails de glissière. 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 SRME, et ce, afin de rentrer entièrement l'équipement SRME dans le rack.

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 SRME dans une position sécurisée et ne doivent pas permettre à l'équipement SRME 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 T.11.

9 Brûlure thermique

9.1 Généralités

Afin de réduire la probabilité de douleurs et de brûlure de la peau, l'équipement doit être muni des **protections** spécifiées dans l'Article 9.

NOTE Les brûlures thermiques dues à des sources d'énergie de radiofréquence (RF) constituent un cas spécial dans la présente norme. Elles sont contrôlées en limitant l'accessibilité au-dessus d'une fréquence spécifiée. Ces limites et conditions sont définies dans les notes [d] et [e] définies dans le Tableau 4.

9.2 Classifications des sources d'énergie thermique

9.2.1 Généralités

Les différentes sources d'énergie thermique et leurs limites dans les **conditions normales de fonctionnement,** dans les **conditions anormales de fonctionnement** et dans les **conditions de premier défaut** à une température ambiante normale de 25 °C sont spécifiées ci-dessous. Les limites et classifications de la température de contact concernant les différentes parties **accessibles** sont données dans le Tableau 38.

9.2.2 TS1

TS1 est une source d'énergie thermique de classe 1 avec des niveaux de température

– ne dépassant pas les limites de TS1 dans les **conditions normales de fonctionnement**; et
– ne dépassant pas les limites de TS2 dans
  - les **conditions anormales de fonctionnement**; ou
  - les **conditions de premier défaut**.

9.2.3 TS2

TS2 est une source d'énergie thermique de classe 2 où

– la température dépasse les limites de TS1; et
– dans les **conditions normales de fonctionnement,** les **conditions anormales de fonctionnement**. ou les **conditions de premier défaut**, la température ne dépasse pas les limites de TS2.

Aucune limite ne s'applique lorsque la défaillance de l'équipement est évidente.

9.2.4 TS3

TS3 est une source d'énergie thermique de classe 3 avec des niveaux dépassant les limites de TS2 appropriées du Tableau 38 dans les **conditions normales de fonctionnement** ou les **conditions anormales de fonctionnement**, ou dans les **conditions de premier défaut.**

9.2.5 Méthode d'essai et critères de conformité

Les essais thermiques sont réalisés dans des conditions de température ambiante telles que définies en B.1.6, sauf que la température ambiante doit être de 25^{-5}_{+0} *°C. Si l'essai est réalisé à une température s'écartant de 25° C, les résultats sont ajustés pour refléter une valeur 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****.*

9.2.6 Niveaux de température de contact

Tableau 38 – Limites de température de contact pour parties accessibles

	Parties accessibles [a]	Température maximale (T_{max}) °C			
		Métal [f]	Verre, porcelaine et matériaux vitreux	Plastique et caoutchouc [b]	Bois
TS1	Poignées, boutons, prises, etc., et surfaces externes tenus, touchés ou portés contre le corps en utilisation normale (> 1 min) [b, c]	48	48	48	48
	Poignées, boutons, prises, etc. et surfaces externes tenus pendant de courtes périodes ou touchés occasionnellement (> 10 s et < 1 min) [d]	51	56	60	60
	Poignées, boutons, prises, etc. et surfaces externes touchés occasionnellement pendant de très courtes périodes (>1 s et < 10 s) [d]	60	71	77	107
	Surfaces externes qui ne nécessitent pas d'être touchées pour le fonctionnement de l'équipement (< 1 s) [d]	70 [e]	80 [e]	94 [e]	140
TS2	Poignées, boutons, prises, etc., et surfaces externes tenus en utilisation normale (> 1 min) [c]	58	58	58	58
	Poignées, boutons, prises, etc. et surfaces externes tenus pendant de courtes périodes ou touchés occasionnellement (> 10 s et < 1 min) [d]	61	66	70	70
	Poignées, boutons, prises, etc. et surfaces externes touchés occasionnellement pendant de très courtes périodes < 10 s) [d]	70	81	87	117
	Surfaces externes qui ne nécessitent pas d'être touchées pour le fonctionnement de l'équipement (< 1 s) [d]	80 (100) [e]	90 (100) [e]	104	150
TS3	Supérieur aux limites de TS2				

[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 par instructions** conformément à 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 les parties en contact continu avec la peau, il convient de tenir compte des températures inférieures; voir le Guide 117 de la CEI.

[c] Des exemples de ces surfaces comprennent un combiné ou un casque de téléphone, la surface d'un ordinateur portable sur laquelle s'appuie la paume de la main et les surfaces qui nécessitent d'être touchées pour la déconnexion.

[d] La durée de contact doit être déterminée par le fabricant et doit être cohérente avec l'utilisation prévue conformément aux instructions de l'équipement.

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 du plastique et du caoutchouc est autorisé.

[e] Il est admis d'utiliser les valeurs entre les parenthèses pour les zones et les surfaces externes suivantes:

– 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 contrecolleuse, 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 par instructions** conforme à F.5 doit être prévue sur ou à proximité de la partie chaude.

Dans les **conditions anormales de fonctionnement** et les **conditions de premier défaut**, concernant d'autres zones et surfaces externes de l'équipement, une **protection principale de l'équipement** est exigée.

[f] Pour les surfaces extérieures métalliques qui sont recouvertes d'un matériau plastique ou de caoutchouc, dont l'épaisseur est au moins de 0,3 mm, la limite de température du plastique et du caoutchouc est autorisée.

9.3 Protection contre les sources d'énergie thermique

A l'exception de ce qui est indiqué ci-dessous, les exigences de protection pour les parties **accessibles** aux **personnes ordinaires**, aux **personnes averties** et aux **personnes qualifiées** sont données en 4.3.

Pour la protection d'une **personne ordinaire** contre TS2, il est admis de remplacer la **protection principale** par une **protection par instructions** conforme au 9.4.2 (voir condition [e] du Tableau 38).

Pour la protection d'une **personne ordinaire** ou d'une **personne avertie** contre TS3, il est admis que la **protection supplémentaire** soit remplacée par une **protection par instructions** conforme au 9.4.2. Les parties et surfaces classées TS3 doivent être équipées d'une **protection de l'équipement** ou d'une **protection par 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'énergie de classe 3 (voir la Figure 19).

9.4 Exigences pour les protections

9.4.1 Protection de l'équipement

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 38.

Les limites de température sont appliquées uniquement pour ces **conditions anormales de fonctionnement** lors desquelles l'équipement continue de fonctionner conformément aux instructions du fabricant et les **conditions anormales de fonctionnement** ne sont pas évidentes. Si l'équipement arrête de fonctionner, alors les limites ne sont pas applicables.

9.4.2 Protection par instructions

Une **protection par instructions** doit être prévue, conformément à F.5, à l'exception du fait que l'élément 3 est facultatif.

Les éléments de la **protection par instructions** doivent être comme suit:

– élément 1a: , CEI 60417-5041 (2002-10);
– élément 2: "ATTENTION" et "Surface chaude" ou énoncé ou texte équivalent;
– Élément 3: facultatif;
– Élément 4: "Ne pas toucher" ou texte équivalent.

10 Rayonnements

10.1 Généralités

Afin de réduire la probabilité d'effets douloureux et de blessure causés par des rayonnements laser, visibles, infrarouges, ultraviolet, rayon X et énergie acoustique, les équipements doivent être munis des **protections** spécifiées dans le présent article.

10.2 Classifications des sources d'énergie de rayonnement

10.2.1 Classification générale

Les classifications des sources d'énergie de rayonnement sont données dans le Tableau 39.

Tableau 39 – Classifications des sources d'énergie de rayonnement

Ligne	Catégorie	RS1	RS2	RS3
1	Lasers	Classe 1 [a]	Classe 1M, Classe 2, Classe 2M et Classe 3R (visible) [a]	Classe 3R (invisible), Classe 3B et Classe 4 [a]
2	Lampes et LED	Groupe exempt, RG-1 et RG-2 [b]		RG-3 [b]
3	Rayon X	≤ 36 pA/ kg à 50 mm [c]	> RS1 et ≤ 185 pA/ kg à 100 mm [d]	> RS2
4	Acoustique	≤ 85 dB(A)	> RS1 et ≤ 100 dB(A)	> RS2

[a] Les différentes classes sont définies dans la CEI 60825-1

[b] Les différentes classes sont définies dans la CEI 62471. Les applications à faible puissance utilisant des LED appartiennent au groupe exempt.

Les rayonnements UV des lampes fluorescentes et incandescentes universelles, avec des enveloppes en verre ordinaires, sont considérés comme RS1.

EXEMPLE Les LED RS1 sont celles utilisées comme:

- 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 1 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/m^2, 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).

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.

[c] 36 pA/ kg est égal à 5 µSv/h ou 0,5 mR/h. Cette valeur est cohérente avec la publication 60 de la Commission Internationale de Radioprotection (ICRP).

[d] 185 pA/ kg est égal à 25 µSv/h ou 2,5 mR/h.

La mesure 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 spécifiées ci-dessous.

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 1µSv/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 États-Unis, les conditions de mesure données dans la partie 1020 du titre 21 du code des règlements fédéraux des États-Unis sont les suivantes (pour les exigences complètes, voir les règlements ci-dessus).

Les mesures sont effectuées avec l'EUT 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 sont à simuler.

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'EUT 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.

10.2.2 RS1

RS1 est une source d'énergie de rayonnement de classe 1 qui

– ne dépasse pas les limites de la classe RS1 dans les
    - **conditions normales de fonctionnement,** et
    - **conditions anormales de fonctionnement** qui ne conduisent pas à une **condition de premier défaut**, et
    - **conditions de premier défaut** pour le rayonnement laser, visible, infrarouge, ultraviolet et rayon X; et

– ne dépasse pas les limites de RS2 dans les
    - **conditions de premier défaut** pour rayonnement acoustique.

10.2.3 RS2

RS2 est une source d'énergie de rayonnement de classe 2 qui ne dépasse pas les limites de RS2 dans les

– **conditions normales de fonctionnement**, et

– **conditions anormales de fonctionnement**, et

– **conditions de premier défaut**, et

n'est pas RS1.

10.2.4 RS3

RS3 est une source d'énergie de rayonnement de classe 3 qui dépasse les limites de RS2 dans les

– **conditions normales de fonctionnement**, ou

– **conditions anormales de fonctionnement**, ou

– **conditions de premier défaut**.

10.3 Protections contre le rayonnement laser

10.3.1 Exigences

Les équipements contenant un ou plusieurs lasers (y compris les diodes laser) doivent être conformes à la CEI 60825-1, à la CEI 60825-2 ou à la CEI 60825-12 suivant le cas.

Les diodes qui émettent une lumière cohérente doivent être traitées comme des rayonnements laser.

NOTE Dans la CEI 60825-1, ces diodes sont identifiées comme "diodes laser".

Sauf s'il est nécessaire que RS2 soit **accessible** pour le fonctionnement de l'équipement, le rayonnement laser émis par l'équipement ne doit pas dépasser RS1 dans les **conditions normales de fonctionnement**, les **conditions anormales de fonctionnement** et les **conditions de premier défaut**. Si RS2 nécessite d'être **accessible** pour le fonctionnement de l'équipement, l'équipement doit être muni d'une **protection par instructions** conformément à la CEI 60825-1.

À moins que l'équipement soit conforme à la CEI 60825-2, en présence d'un rayonnement laser RS3, un **outil** doit être nécessaire pour accéder à la partie concernée.

10.3.2 Critères de conformité

La conformité est déterminée par mesure ou par vérification de la fiche technique disponible du fabricant.

10.4 Protections contre le rayonnement visible, infrarouge et ultraviolet

10.4.1 Généralités

A l'exception de ce qui est indiqué ci-dessous, les exigences de protection relatives aux parties **accessibles** à des **personnes ordinaires**, des **personnes averties** et des **personnes qualifiées** sont données en 4.3.

Pour une **personne ordinaire** ou une **personne avertie**, une source de classe RS3 doit être contenue à l'intérieur de l'**enveloppe** des lampes et système de lampes ou à l'intérieur de l'**enveloppe** de l'équipement.

Si la source de classe RS3 est **accessible** à des **personnes qualifiées**, alors une **protection individuelle** (EPI) doit être exigée et une **protection par instructions** conforme au 10.4.2 doit être fournie.

Sauf s'il est nécessaire que RS2 soit **accessible** pour le fonctionnement de l'équipement, le rayonnement visible, infrarouge et ultraviolet **accessible** à une **personne ordinaire** ou une **personne avertie** ne doit pas dépasser la classe RS1 dans les **conditions normales de fonctionnement**, les **conditions anormales de fonctionnement** et les **conditions de premier défaut**. Si RS2 nécessite d'être **accessible** pour le fonctionnement de l'équipement, l'équipement doit être muni d'une **protection par instructions** conformément à la CEI/TR 62471-2.

Le matériau de l'**enveloppe** utilisée comme **protection** doit être opaque au rayonnement. Une **enveloppe** opaque qui satisfait à l'essai de l'Annexe T conformément au 4.4.4 est considérée comme une **protection renforcée**.

Le rayonnement UV émis au travers d'un verre ayant un affaiblissement de rayonnement ultraviolet de 90 % jusqu'à 400 nm est considéré comme de classe RS1. On considère qu'un verre d'une épaisseur de 2 mm a un tel affaiblissement.

Les matériaux qui comportent une **protection** et 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 fonction de **protection** reste efficace pendant la durée de vie de l'équipement. Il n'est pas nécessaire d'évaluer les métaux et les matériaux en verre et en céramique.

Les équipements incluant des sources d'énergie optique supérieures aux limites spécifiées dans la CEI 62471 dans la gamme de longueurs d'onde allant de 200 nm à 3 000 nm ayant une incidence sur le corps humain, doivent être munis des **protections** spécifiées dans le présent paragraphe.

En général, le rayonnement optique émis par les équipements 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**.

10.4.2 Protection par instructions

Si nécessaire, une **protection par instructions** doit être conforme à l'Article F.5.

Les éléments de la **protection par instructions** doivent être comme suit:

– élément 1a: symbole de rayonnement UV de la CEI 60417-6040 (2010-08) ; ou

symbole de rayonnement visible de la CEI 60417-6041 (2010-08) ;ou

symbole de rayonnement infrarouge de la CEI 60417-6151 (2012-02) 

– élément 2: “Lumière UV", "Lumière brillante” ou ‘’Lumière infrarouge’’ selon le cas, ou texte équivalent

– élément 3: “Risque de lésion de la peau ou des yeux” ou texte équivalent

– élément 4: “Débrancher l’énergie avant l’entretien” ou texte équivalent.

En variante, la déclaration de précaution relative aux groupes de risque RG-1 et RG-2 spécifiés dans la CEI/TR 62471-2 peut être utilisée comme **protection par instructions**.

Si la **protection** est un **verrouillage de sécurité**, une **protection par instructions** n’est pas nécessaire.

10.4.3 Critères de 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.

La conformité par rapport aux détériorations des matériaux du fait du rayonnement UV est vérifiée par les essais applicables de l’Annexe C.

10.5 Protections contre les rayons X

10.5.1 Exigences

Les rayons X qui sont émis par l’équipement ne doivent pas dépasser RS1 dans les **conditions normales de fonctionnement**, les **conditions anormales de fonctionnement** et les **conditions de premier défaut**.

Une **protection de l’équipement** est exigée entre RS2 ou RS3 et toutes les personnes.

Les portes et les couvercles qui assurent un rôle de **protection** et qui permettraient, lorsqu’ils sont ouverts, l’accès à une source de la classe RS2 ou RS3 pour une **personne qualifiée**, doivent comporter une **protection par instructions** fournie conformément à l'Article F.5.

10.5.2 Critères de conformité

La conformité est vérifiée par examen et, si nécessaire, par l’essai de 10.5.3.

10.5.3 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 mm^2 ou au moyen d'équipements de mesure d'autres types donnant des résultats équivalents.

Les mesures sont réalisées avec l'EUT 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/m^2, avec un champ blanc stable fourni par un générateur d'essai;*
– *pas plus de 12 claquages sur une période de 1 h;*
– *une résolution horizontale correspondant au moins à 1,5 MHz au centre, avec une dégradation verticale similaire.*

NOTE 2 Aux États-Unis et au Canada, une image intelligible est en synchronisation tout en couvrant 60 % de la surface de vision de l'écran.

10.6 Protections contre les sources d'énergie acoustique

10.6.1 Généralités

Les exigences de **protection** contre une exposition de longue durée à des niveaux excessifs de pression acoustique provenant de lecteurs de musique individuels étroitement accolés à l'oreille sont spécifiées ci-dessous. Les exigences relatives aux écouteurs et casques destinés à être utilisés avec des lecteurs de musique individuels sont aussi couvertes.

Un lecteur de musique individuel est un équipement portatif destiné à être utilisé par une **personne ordinaire**, qui:

– est conçu pour permettre à l'utilisateur d'écouter le contenu/l'enregistrement sonore ou audiovisuel; et
– utilise un dispositif d'écoute, tel que des casques ou écouteurs (oreillettes) qui peuvent être utilisés dans, sur ou autour des oreilles; et
– a un lecteur qui peut être porté sur le corps (d'une taille adaptée pour être transporté dans une poche de vêtement) et permet à l'utilisateur de se déplacer tout en l'utilisant de façon continue (par exemple, dans une rue, dans un métro, à l'aéroport, etc.

NOTE 1 Des exemples sont les lecteurs de CD ou de minidisques portables, les lecteurs audio MP3, les téléphones portables de type MP3, les PDA ou des équipements similaires.

Les lecteurs de musique individuels doivent satisfaire aux exigences ci-dessous.

NOTE 2 La protection contre les sources d'énergie acoustique provenant des applications de télécommunication est référencée dans le document UIT-T P.360.

Ces exigences sont applicables au mode audio (musique) ou vidéo uniquement.

Les exigences ne s’appliquent pas aux:

– matériels professionnels;

NOTE 3 Un matériel professionnel est un équipement vendu par des circuits commerciaux spéciaux. Tous les produits vendus par des magasins électroniques normaux sont considérés comme ne pas appartenir à la catégorie des matériels professionnels.

– appareils auditifs et autres appareils de sonorisation assistée;

– les types suivants de lecteurs de musique individuels analogiques:

  - récepteur radioélectrique longue distance (par exemple, un récepteur radioélectrique multibande ou mondial, ou à modulation d’amplitude), et
  - lecteur / enregistreur de cassettes;

NOTE 4 Cette exemption a été admise du fait que cette technologie n’est pratiquement plus utilisée et destinée à disparaître d’ici quelques années. Cette exemption n’est pas étendue à d’autres technologies.

– lecteur raccordé à un amplificateur externe qui ne permet à l’utilisateur de se déplacer au cours de son utilisation.

10.6.2 Classification

10.6.2.1 Limites de RS1

RS1 est une source d’énergie acoustique de classe 1 qui ne dépasse pas les éléments suivants:

– pour les équipements fournis comme un ensemble (lecteur avec son dispositif d’écoute), l’émission sonore L_{Aeq},T doit être ≤ 85 dB(A) en mode de lecture “bruit de simulation de programme” fixe décrit dans l'EN 50332-1.

– pour les équipements munis d’une prise électrique de sortie pour un dispositif d’écoute, la tension de sortie efficace non pondérée doit être ≤ 27 mV ou de 25 dB en dessous de la pleine échelle en mode de lecture “bruit de simulation de programme” fixe décrit dans l’EN 50332-1.

NOTE 1 Sauf spécification contraire, lorsque le terme émission sonore est utilisé en 10.6, L_{Aeq},T correspond au niveau de pression acoustique équivalent pondéré A sur une période de 30 s.

Pour ce qui concerne la musique, où la pression acoustique moyenne (longue durée L_{Aeq},T) mesurée sur la durée d’une chanson est inférieure à la moyenne produite par le bruit de simulation de programme, il n’est pas nécessaire d’utiliser l’avertissement tant que la pression acoustique moyenne de la chanson est inférieure à la limite de base de 85 dB(A). Dans ce cas, T devient la durée de la chanson.

NOTE 2 La musique classique a généralement une pression acoustique moyenne (longue durée L_{Aeq},T) bien inférieure au bruit de simulation de programme moyen. Par conséquent, si le lecteur peut analyser la chanson et la comparer au bruit de simulation de programme, il n’est pas nécessaire d’utiliser l’avertissement tant que la pression acoustique moyenne de la chanson est inférieure à la limite de base de 85 dB(A).

Par exemple, si le lecteur est réglé sur le bruit de simulation de programme à 85 dB(A), mais que le niveau musical moyen de la chanson n’est que de 65 dB(A), il n’est pas nécessaire d’utiliser un avertissement ou de demander un acquittement tant que le niveau acoustique moyen de la chanson n’est pas supérieur à la limite de base de 85 dB(A).

Pour les équipements conçus ou destinés à être de façon évidente utilisés par des enfants, les limites spécifiées dans les normes applicables relatives aux jouets peuvent s’appliquer.

NOTE 3 En Europe, les exigences correspondantes données dans l'EN 71-1:2011, 4.20 et les méthodes d’essai et distances de mesure associées s’appliquent.

10.6.2.2 Limites de RS2

RS2 est une source d'énergie acoustique de classe 2 qui ne dépasse pas les éléments suivants:

- pour les équipements fournis comme un ensemble (lecteur avec son dispositif d'écoute), l'émission sonore L_{Aeq},T doit être ≤ 100 dB(A) en mode de lecture "bruit de simulation de programme" fixe décrit dans l'EN 50332-1.
- pour les équipements munis d'une prise électrique de sortie pour un dispositif d'écoute, la tension de sortie efficace non pondérée doit être ≤ 150 mV ou de 10 dB en dessous de la pleine échelle en mode de lecture "bruit de simulation de programme" fixe décrit dans l'EN 50332-1.

10.6.2.3 Limites de RS3

RS3 est une source d'énergie acoustique de classe 3 qui dépasse les limites de RS2.

10.6.3 Méthodes de mesure

Toutes les commandes de volume doivent être réglées au maximum pendant les essais.

Les mesures doivent être réalisées conformément à l'EN 50332-1 ou à l'EN 50332-2 selon le cas.

10.6.4 Protection des personnes

A l'exception de ce qui est indiqué ci-dessous, les exigences de protection pour les parties **accessibles** aux **personnes ordinaires**, aux **personnes averties** et aux **personnes qualifiées** sont données en 4.3.

NOTE 1 La commande de volume n'est pas considérée comme une **protection**.

Entre une source de classe RS2 et une **personne ordinaire**, il est admis que la **protection principale** soit remplacée par une **protection par instructions** conformément à l'Article F.5, sauf que la **protection par instructions** doit être apposée sur l'équipement, sur l'emballage ou dans le manuel d'instruction. En variante, la **protection par instructions** peut être indiquée sur l'affichage de l'équipement en cours d'utilisation.

Les éléments de la **protection par instructions** doivent être comme suit:

- élément 1: le symbole  de la CEI 60417-6044 (2011-01)
- élément 2: "Pression acoustique élevée" ou formulation équivalente
- élément 3: "Risque de détérioration de l'audition" ou formulation équivalente.
- élément 3: facultatif
- élément 4: " Ne pas écouter à des niveaux de volume élevés pendant des périodes prolongées" ou formulation équivalente.

Une **protection de l'équipement** doit éviter toute exposition d'une **personne ordinaire** à une source d'énergie RS2 sans action physique intentionnelle de la **personne ordinaire** et doit revenir automatiquement à un niveau de sortie ne dépassant pas RS1 en cas de mise hors tension.

L'équipement doit prévoir un moyen permettant d'informer de manière effective l'utilisateur sur l'augmentation de la pression acoustique lorsque l'équipement fonctionne avec une émission sonore dépassant RS1. Tout moyen utilisé doit être acquitté par l'utilisateur avant d'activer un mode de fonctionnement qui autorise une émission sonore dépassant RS1. L'acquittement n'a pas besoin d'être répété plus d'une fois toutes les 20 h d'écoute cumulées.

NOTE 2 Des exemples de ce type de moyen comprennent les signaux visuels ou sonores. L'action de l'utilisateur est toujours requise.

NOTE 3 Les 20 h d'écoute correspondent aux heures d'écoute cumulées, indépendamment de la fréquence et du temps pendant lequel le lecteur de musique individuel a été mis hors tension.

Une **personne qualifiée** ne doit pas être exposée de manière non intentionnelle à RS3.

10.6.5 Exigences relatives aux dispositifs d'écoute (casques, écouteurs, etc.)

10.6.5.1 Dispositifs d'écoute passifs avec fils à entrée analogique

Avec une émission de pression acoustique de 94 dB(A) L_{Aeq}, la tension d'entrée du "bruit de simulation de programme" fixe décrit dans l'EN 50332-1 doit être ≥ 75 mV.

Cette exigence s'applique à tout mode de lecture musicale dans lequel les casques peuvent fonctionner, y compris tout réglage disponible (par exemple, une commande de niveau de volume intégrée, une fonction acoustique supplémentaire telle que l'égalisation, etc.).

NOTE Les valeurs de 94 dB(A) et 75 mV correspondent à 85 dB(A) et 27 mV ou 100 dB(A) et 150 mV.

10.6.5.2 Dispositifs d'écoute avec fils à entrée numérique

Avec tout dispositif, lisant le "bruit de simulation de programme" fixe décrit dans l'EN 50332-1, l'émission sonore $L_{\text{Aeq},T}$ du dispositif d'écoute doit être ≤ 100 dB(A).

Cette exigence s'applique à tout mode de lecture musicale dans lequel les casques peuvent fonctionner, y compris tout réglage disponible (par exemple, une commande de niveau de volume intégrée, une fonction acoustique supplémentaire telle que l'égalisation, etc.).

10.6.5.3 Dispositifs d'écoute sans fil

En mode sans fil,

– avec tout dispositif de lecture et de transmission, lisant le bruit de simulation de programme fixe décrit dans l'EN 50332-1; et

– conforme aux normes d'émission sans fil, pour lesquelles il existe une norme d'interface hertzienne qui spécifie le niveau acoustique équivalent; et

– avec des réglages de volume et de son dans le dispositif de réception (par exemple, une commande de niveau de volume intégrée, une fonction acoustique supplémentaire telle que l'égalisation, etc.) établis pour la combinaison des positions permettant d'optimiser l'émission sonore mesurée pour le bruit de simulation de programme mentionné ci-dessus,

l'émission sonore $L_{\text{Aeq},T}$ du dispositif d'écoute doit être ≤ 100 dB(A).

10.6.5.4 Méthode de mesure

Les mesures doivent être réalisées conformément à l'EN 50332-2 selon le cas.

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, vidéoprojecteurs, 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, radiomessageurs, répondeurs téléphoniques, postes téléphoniques (avec et sans fil)

Cette liste n'est pas à considérer 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

S'il est évident qu'un essai particulier n'est 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 examinés 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.

B.1.5 Conformité par examen 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, plutôt que d'effectuer les **essais de type** spécifiés.

B.1.6 Conditions de mesure de la température

Le montage de mesure de l'essai doit reproduire les conditions d'installation de l'équipement les plus sévères. 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.

Les mesures sont réalisées avec l'EUT fonctionnant à la tension d'alimentation la plus défavorable (voir B.2.3).

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.

Pour les essais devant être poursuivis jusqu'à l'obtention de températures en régime constant, l'équilibre thermique est considéré comme atteint si l'échauffement ne varie pas de plus de 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 comme atteint si l'échauffement ne varie pas de plus de 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 ± 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 **tensions assignées** multiples;

– les valeurs extrêmes des **plages de tensions assignées**; et

– la tolérance sur la **tension assignée** telle que déclarée par le fabricant.

Sauf déclaration par le fabricant d'une tolérance plus grande, la tolérance minimale 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. Il est admis que l'équipement qui, selon le fabricant, ne peut être raccordé qu'à un système d'alimentation électrique conditionné (par exemple, une UPS, c'est-à-dire une alimentation sans interruption) soit muni d'une tolérance plus petite si cet équipement est aussi accompagné d'instructions spécifiant une telle restriction.

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 14, sous les numéros d'identification 1 et 2.

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 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'EUT;

– les charges dues à d'autres unités d'équipement prévues par le fabricant afin de tirer du courant de l'EUT;

– 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'Article E.1;

– 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 que dans 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.

Le courant ou la puissance absorbé(e) mesuré(e) dans les **conditions normales de fonctionnement**, mais à la **tension assignée** ou à chaque extrémité de chaque **plage de tensions assignées**, ne doit pas dépasser le **courant assigné** ou la **puissance assignée** de plus de 10 %.

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**;*
– *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***
  - *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,*
  - *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.*

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 spécifiées;

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 utile 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_{amb} – T_{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 et décharge de la batterie dans les conditions normales de fonctionnement

Dans les **conditions normales de fonctionnement**, les conditions de charge et de décharge de la **batterie** 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/m^2, 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.

A l'exception des spécifications ci-dessous, il n'existe pas d'exigences concernant le blocage des ouvertures placées au fond de l'équipement.

Par ailleurs, les équipements à ouvertures de ventilation susceptibles d'être utilisés sur un support souple (tel que literie, couvertures, etc.), doivent être conformes à l'un des éléments suivants:

– les ouvertures sur le fond, les côtés et à l'arrière de l'équipement sont à recouvrir en même temps. Les surfaces extérieures ne doivent pas dépasser les limites de TS2 du Tableau 38.
– une **protection par instructions** doit être prévue conformément à l'Article F.5, à l'exception du fait que l'élément 3 est facultatif.

  Les éléments de la **protection par instructions** doivent être comme suit:

  • élément 1: non disponible
  • élément 2: “Ne pas couvrir les ouvertures de ventilation” ou formulation équivalente
  • élément 3: facultatif
  • élément 4: “Cet équipement n'est pas destiné à être utilisé sur un support souple (tel que literie, couvertures, etc.).” ou formulation équivalente.

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 en E.2.

B.3.8 Critères de 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 défaut, le critère de conformité de B.4.8 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, y compris **l'isolation fonctionnelle**, sont étudiés afin de déterminer les **conditions de premier défaut** qui peuvent être raisonnablement escomptées et qui:

– peuvent contourner une **protection**; ou
– conduisent à la mise en service d'une **protection supplémentaire**; ou
– affectent autrement la sécurité de l'équipement.

Les **conditions de premier défaut** suivantes doivent être prises en considération:

– une **condition anormale de fonctionnement** 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 limiteurs de courant sur circuit intégré conformes à l'Article G.9, 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 G.3.1 à G.3.4, 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 B.1.6.

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 Critères de conformité

La conformité est vérifiée soit en inspectant et en examinant les données disponibles, soit en procédant à l'essai conformément à G.5.4.

B.4.4 Isolation fonctionnelle

B.4.4.1 Distances dans l'air pour l'isolation fonctionnelle

À moins que la **distance dans l'air** pour l'**isolation fonctionnelle** ne soit conforme:

– à la **distance dans l'air** pour l'**isolation principale** telle que spécifiée en 5.4.2; ou

– à l'essai de rigidité diélectrique du Tableau 26 pour l'**isolation principale;**

les **distances dans l'air** pour l'**isolation fonctionnelle** doivent être court-circuitées.

B.4.4.2 Lignes de fuite pour l'isolation fonctionnelle

À moins que la **ligne de fuite** pour l'**isolation fonctionnelle** ne soit conforme:

– à la **ligne de fuite** pour l'**isolation principale** telle que spécifiée en 5.4.3; ou

– à l'essai de rigidité diélectrique de 5.4.9.1 pour l'**isolation principale;**

la **ligne de fuite** pour l'**isolation fonctionnelle** doit être court-circuitée.

B.4.4.3 Isolation fonctionnelle sur les cartes imprimées revêtues

À moins que **l'isolation fonctionnelle** ne soit conforme

– à la distance de séparation indiquée dans le Tableau G.13; ou

– à l'essai de rigidité diélectrique indiqué en 5.4.9.1 pour l'**isolation principale;**

l'**isolation fonctionnelle** sur une carte imprimée revêtue doit être court-circuitée.

B.4.5 Court-circuit et interruption des électrodes dans les tubes et les semi-conducteurs

Les électrodes dans les tubes électroniques et les broches des dispositifs semi-conducteurs doivent être court-circuitées ou, le cas échéant, interrompues. Interrompre une broche à la fois ou toute paire de broches connectée ensemble l'une 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 60730-1:2010, Articles 15, 17, J.15 et J.17;
– thermistances CTP fournissant l'action de type 2.AL spécifiée dans la CEI 60730-1;
– résistances conformes aux essais cités en 5.5.6;
– condensateurs conformes à la CEI 60384-14 et évalués selon 5.5.2 de la présente norme;
– composants d’isolation (par exemple, optocoupleurs et transformateurs) conformes aux exigences pour ces composants à l’Annexe G pour l’**isolation renforcée**; et
– d’autres composants qui servent de **protection** conformes aux exigences correspondantes de l’Annexe G ou aux exigences de sécurité de la norme CEI de composant correspondante.

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 Critères de conformité pendant et après des conditions de premier défaut

Pendant et après une ***condition de premier défaut*** *une partie* ***accessible*** *ne doit pas dépasser la classe d’énergie correspondante telle que spécifiée en 5.3, 8.3, 9.3, 10.3, 10.4.1, 10.5.1 et 10.6.4 pour la personne concernée en fonction du danger en question. Pendant et après des* ***conditions de premier défaut****, toute flamme à l’intérieur de l’équipement doit s’éteindre dans un délai de 10 s et aucune partie environnante ne doit s’enflammer. Toute partie présentant des flammes doit être considérée comme une* ***PIS****.*

B.4.9 Charge et décharge de la batterie dans les conditions de premier défaut

Dans les **conditions de premier défaut**, les conditions de charge et de décharge de la batterie doivent satisfaire aux exigences de l’Annexe M le cas échéant.

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, telles que spécifiées par le fabricant des lampes.

NOTE 1 Les lampes fluorescentes et incandescentes à usage général, 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 agissent généralement comme 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 [a] [b]	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	**Classe 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 sont à effectuer sur des éprouvettes dont l'épaisseur n'est pas supérieure aux épaisseurs réelles.

[b] La face de l'échantillon exposée au rayonnement UV est tenue d'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 **classe 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 et critères de conformité

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, tel 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 des 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 de corps noir de 63 °C ± 3 °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 W/m^2 à 340 nm et une température du panneau noir de 63 °C ± 3 °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. Ne pas confondre l'arrosage à l'eau et 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 4892-4 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. Ne pas confondre l'arrosage à l'eau et 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.

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:

– l'impulsion du circuit 1 est représentative des tensions induites dans les lignes téléphoniques et les câbles coaxiaux dans les longues suites de câbles, provoquées par la foudre sur leur blindage de mise à la terre;

– l'impulsion de circuit 2 est représentative 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;

– l'impulsion du circuit 3 est représentative des tensions induites dans les câbles d'antenne, provoquées par les décharges de foudre au sol, à proximité.

NOTE Pendant ces essais, appliquer des mesures de précaution extrêmes 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 1 et 2 du Tableau D.1, est utilisé pour générer des impulsions, le condensateur C_1 étant chargé initialement à la tension U_c.

Le circuit 1 du Tableau D.1 produit des impulsions 10/700 μs (10 μs de temps de montée virtuel, 700 μs de temps virtuel à mi-hauteur) destinées à simuler les transitoires dans les **circuits externes** comme indiqué dans le Tableau 14, sous les numéros d'identification 1, 2, 3, 4 et 5.

Le circuit 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 à mi-hauteur) destinées à simuler les transitoires dans les systèmes de distribution d'alimentation.

Les formes d'ondes de l'impulsion sont celles dans les conditions de circuit ouvert et peuvent être différentes en 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 15) et la forme d'impulsion (par exemple, 1,2 μs de temps de montée virtuel, 50 μs de temps virtuel à mi-hauteur 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 dans l'air*** *peuvent être déconnectés pendant cet essai.*

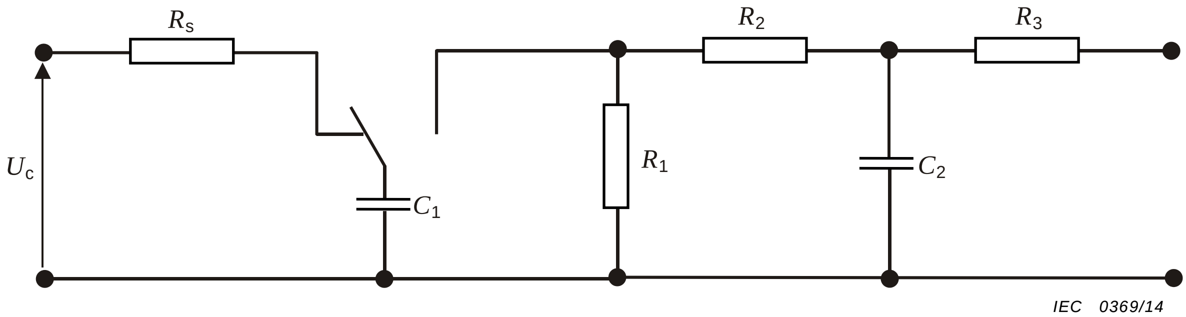


Figure D.1 – Générateur de tension de choc de 1,2/50 µs et 10/700 µs

D.2 Générateur d'essai de l'interface d'antenne

Le circuit de la Figure D.2, utilisant les valeurs de composants dans le circuit 3 du Tableau D.1, est utilisé pour produire des impulsions, le condensateur C_1 étant chargé initialement à la tension U_c.

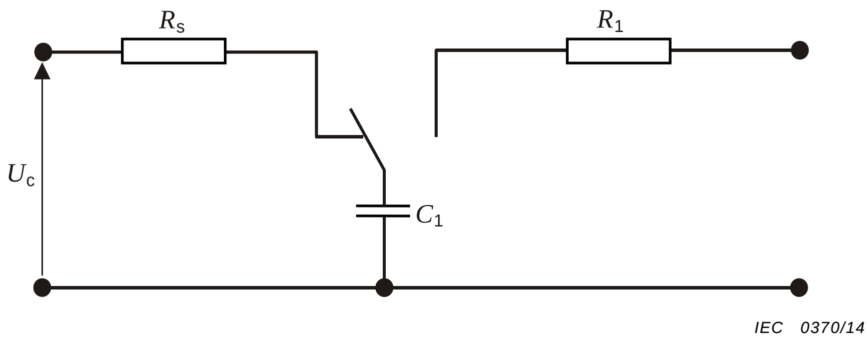
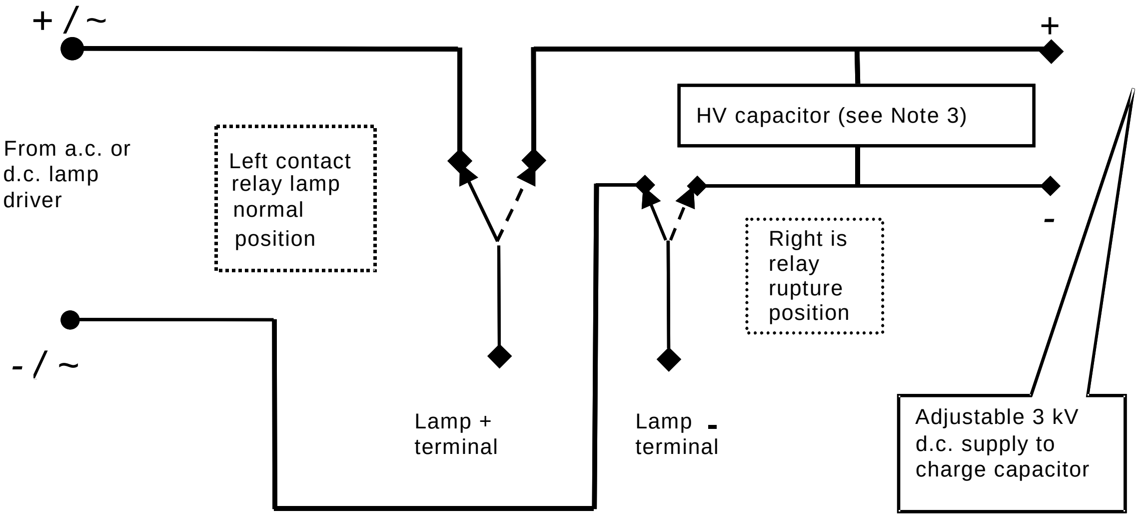


Figure D.2 – Circuit du générateur d'essai pour interface d'antenne

Tableau D.1 – Valeurs des composants pour la Figure D.1 et la Figure D.2

	Impulsion d'essai	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 MΩ	1 nF	-	1 kΩ	-	-
D'autres générateurs d'essai peuvent être fournis sous réserve qu'ils donnent le même résultat. NOTE Les circuits 1 et 2 sont basés sur la recommandation K.44 de l'UIT-T								

D.3 Générateur d'impulsions électronique



Légende

Anglais	Français
From a.c. or c.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 peut généralement être utilisé comme le point de départ pour la charge d'essai.

NOTE 2 Le relais est de type défibrillateur à double pôle de 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 µF 5 kV.

Figure D.3 – Exemple de générateur d'impulsions électronique

Annexe E
(normative)

Conditions d'essai pour les équipements comprenant des amplificateurs audio

E.1 Conditions normales de fonctionnement des amplificateurs audio

Les équipements contenant un amplificateur audio doivent fonctionner en utilisant une source de signal audio sinusoïdal 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.

L'équipement doit fonctionner de manière à fournir 1/8 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 bande passante du bruit provenant du signal d'essai doit être limitée par un filtre dont la caractéristique est décrite dans la Figure E.1.

Si un écrêtage visible ne peut pas être atteint, la puissance maximale qu'il est possible d'atteindre doit être considérée comme la **puissance de sortie non écrêtée**.

Lors de la classification des signaux audio (voir Tableau E.1), l'équipement doit fonctionner pour fournir la **puissance de sortie non écrêtée** maximale sur son **impédance de charge assignée**. La charge est retirée et la classe de source d'énergie électrique est déterminée à partir de la tension de sortie en circuit ouvert qui en résulte.

Les commandes de tonalité doivent être réglées à mi plage.

De plus, toutes les conditions suivantes doivent être considérées comme des **conditions normales de fonctionnement**:

– L'**impédance de charge assignée** la plus défavorable ou le haut-parleur réel, lorsqu'il est fourni, est connectée à la sortie de l'amplificateur.
– Toutes les voies d'amplificateur fonctionnent en même temps.
– Les organes ou instruments similaires qui possèdent un générateur de tonalités ne doivent pas être mis en fonctionnement avec le signal de 1 000 Hz mais, à la place, 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.
– 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 multivoies, contenant des voies ne pouvant pas être mises en fonctionnement de manière indépendante, ces voies en question doivent être chargées en utilisant l'**impédance de charge assignée** au niveau de puissance de sortie qui correspond, par conception, à 1/8 de la **puissance de sortie non écrêtée** du ou des voies d'amplificateur réglables.
– Lorsqu'il n'est pas possible de réaliser un fonctionnement continu, l'amplificateur doit fonctionner au niveau maximal de puissance de sortie qui permet le fonctionnement continu.

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

Classe	Tension du signal audio V efficace	Exemples de protections entre la source d'énergie et une personne ordinaire	Exemple de protections entre la source d'énergie et une personne avertie
ES1	Entre 0 et 71	Aucune **protection** nécessaire	Aucune **protection** nécessaire
ES2	Supérieure à 71 et inférieure à 120	Bornes isolées [a] Marquage ISO 7000, symbole 0434a (2004-01) ou symbole 0434b (2004-01) **Protection par instructions** pour les pièces de borne non isolées et les fils dénudés [b]	Aucune **protection** nécessaire
ES3	Supérieure à 120	Connecteurs conformes aux exigences de la CEI 61984 et marqé avec le symbole CEI 60417-6042 (2010-11)	

[a] Les bornes qui n'ont pas de parties conductrices **accessibles** après avoir installé les fils en conformité avec les instructions.

[b] Une **protection par instructions** indiquant que les bornes ou les fils non isolés en contact peuvent provoquer une sensation déplaisante.

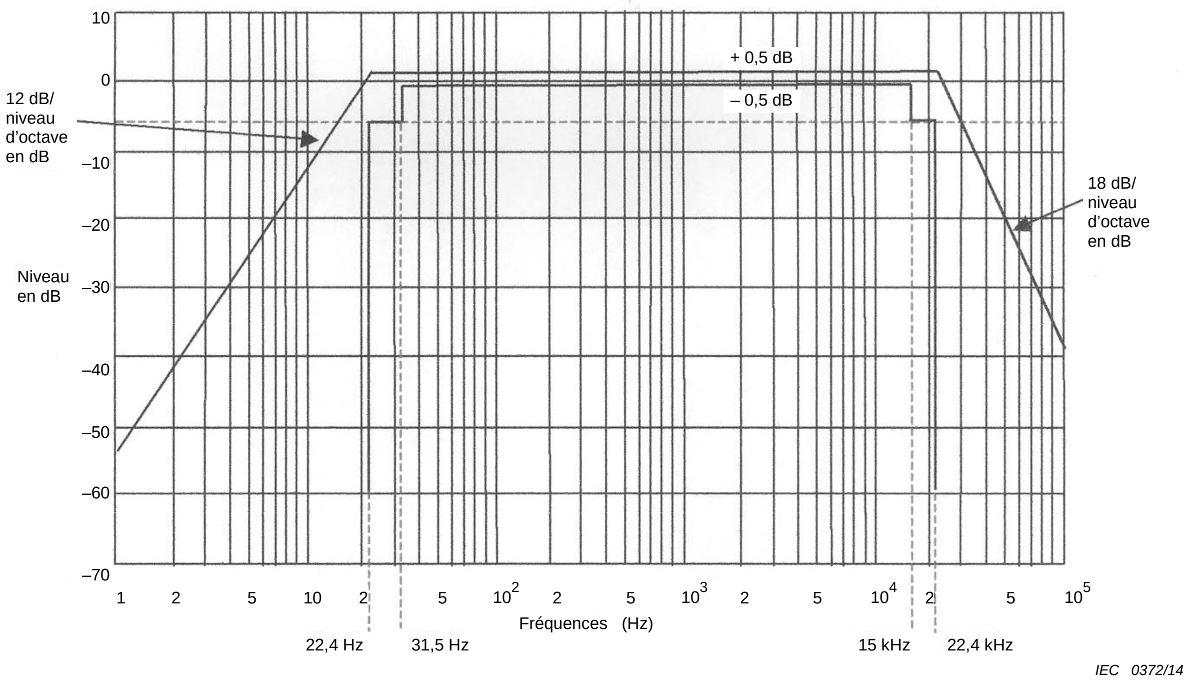


Figure E.1 – Filtre passe-bande pour la mesure du bruit en bande large

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**.

Annexe F
(normative)

Marquages des équipements, instructions et protections par instructions

F.1 Généralités

La présente annexe spécifie les marquages des équipements, les instructions et les **protections par 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 par 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 présente norme, il s'applique également aux instructions et aux éléments requis d'une **protection par instructions**.

NOTE 2 Pour des exemples de marquage, voir le Tableau F.1.

Des précautions doivent être prises de manière à ce que les marquages et les instructions supplémentaires qui ne sont pas exigés par la présente norme, ne contredisent pas ceux exigés par la présente norme.

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 placés sur l'équipement qu'ils soient exigés par la présente norme ou non, doivent être conformes à la CEI 60417, à l'ISO 3864-2, à l'ISO 7000 ou à l'ISO 7010, s'ils sont disponibles. En l'absence de symboles adéquats, il est admis que le fabricant crée des symboles graphiques spécifiques.

F.2.3 Critères de 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 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 en rack ou sur un panneau qui pèsent plus de 18 kg, les marquages peuvent être placés sur toute surface devenant visible après avoir retiré l'équipement du rack 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.

La conformité est vérifiée par examen.

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.

La conformité est vérifiée par examen.

F.3.3 Marquages de caractéristiques assignées des équipements

F.3.3.1 Équipement avec connexion directe au réseau d'alimentation

Si un appareil est fourni avec un moyen de connexion directe au **réseau d'alimentation**, il doit être marqué avec une caractéristique électrique assignée, telle que spécifiée de F.3.3.3 à F.3.3.6.

F.3.3.2 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 caractéristique électrique assignée. Cependant, tout marquage de **puissance assignée** ou de **courant assigné** doit être conforme à B.2.5.

F.3.3.3 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 des caractéristiques assignées de la tension de l'équipement. Si un symbole est utilisé pour identifier les équipements à courant continu ou à courant alternatif, le symbole ∼, CEI 60417-5032 (2002-10) doit être utilisé pour le courant alternatif et le symbole ⎓ , CEI 60417-5031 (2002-10) 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.3.3.4 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
– tout 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.3.3.5 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.3.3.6 Courant assigné ou puissance assignée

Le **courant assigné** ou la **puissance assignée** de l'équipement doit être marqué sur l'équipement.

Pour les équipements triphasés, le **courant assigné** ou la **puissance assignée** est le courant ou la puissance d'une phase.

NOTE 1 B.2.5 établit des critères sur la manière dont le **courant assigné** ou la **puissance assignée** est mesuré.

NOTE 2 Il n'est pas nécessaire de mentionner plus d'un chiffre significatif pour le **courant assigné** ou la **puissance assignée**.

NOTE 3 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** à d'autres équipements, le **courant assigné** ou la **puissance assignée** de l'équipement doit 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.3.3.7 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.3.3.8 Critères de 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 par 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.

F.3.5 Marquages des bornes et dispositifs de fonctionnement

F.3.5.1 Marquages des prises et socles de prises de courant des appareils reliés au réseau d'alimentation

Si une sortie d'appareil connectable au **réseau d'alimentation** en conformité avec la CEI 60320-2-2 est fournie avec l'équipement, la **tension assignée** et le courant ou la puissance assigné(e) doivent être marqués à proximité de la sortie de l'appareil.

Si le socle de prise de courant du **réseau d'alimentation** est configuré conformément à la CEI/TR 60083 ou une norme nationale pertinente, le courant ou la puissance assigné(e) doit être marqué. Si la tension du socle de raccordement est la même que la tension du **réseau d'alimentation**, il n'est pas nécessaire de marquer la tension.

F.3.5.2 Marquage d'identification de la position de l'interrupteur

La position d'un interrupteur de déconnexion ou d'un disjoncteur doit être identifiée. Une telle identification peut comprendre des mots, des symboles ou un indicateur lumineux.

Si un symbole est utilisé, il doit être conforme à la CEI 60417.

F.3.5.3 Marquages d'identification et de caractéristiques assignées des fusibles de rechange

Si un fusible est remplaçable par une **personne ordinaire** ou une **personne avertie**, le marquage d'identification d'un fusible de rechange adéquat doit être apposé à proximité du porte-fusible. L'identification doit comprendre le courant assigné du fusible et, au besoin, les points suivants:

– si le fusible requiert un pouvoir de coupure spécifique nécessaire à la fonction de **protection**, le symbole approprié qui indique le pouvoir de coupure;
– si le fusible peut être remplacé par un fusible de tension assignée différente, la tension assignée du fusible;
– si le fusible est un fusible temporisé, et si la temporisation est nécessaire à la fonction de **protection**, le symbole approprié qui indique la temporisation.

Si un fusible est remplaçable par une **personne ordinaire**, les codages des fusibles concernés doivent être expliqués dans les instructions fournies à l'utilisateur.

Si un fusible n'est pas remplaçable par une **personne ordinaire** ou une **personne avertie**:

– le marquage d'identification d'un fusible de rechange adéquat doit être apposé à proximité du fusible ou doit être fourni dans les instructions d'entretien;
– si le fusible se trouve ou est susceptible de se trouver dans le neutre de l'alimentation du **réseau**, une **protection par instructions** doit stipuler que le fusible est dans le neutre, et que le **réseau d'alimentation** doit être déconnecté afin d'éteindre les conducteurs de phase.

Si un fusible n'est pas conçu pour être remplaçable, le marquage de ses caractéristiques assignées n'est pas nécessaire.

F.3.5.4 Marquage d'identification de la batterie de rechange

Si une batterie peut être remplacée par une **batterie** remplaçable de type incorrect, une **protection par instructions** doit être prévue conformément à l'Article F.5.

F.3.5.5 Emplacement du marquage de bornes

Les marquages de bornes spécifiés en F.3.6.1 et F.3.6.2.2 ne doivent pas être placés sur les vis, les joints amovibles ou d'autres parties pouvant être déplacées lorsque les conducteurs sont connectés.

F.3.5.6 Critères de conformité

La conformité est vérifiée par examen.

F.3.6 Marquages d'équipements liés à leur classification

F.3.6.1 Équipement de classe I

F.3.6.1.1 Borne conductrice de mise à la terre de protection

La borne prévue pour la connexion de l'**équipement de classe I** au **conducteur de mise à la terre de protection** de l'installation, doit être identifiée par le symbole , CEI 60417-5019 (2006-08).

Une borne prévue pour la connexion d'un sous-ensemble de classe I (par exemple, une alimentation), ou un composant (par exemple, un bloc de connexion), au **conducteur de mise à la terre de protection** de l'équipement, peut être identifiée soit par le symbole , CEI 60417-5019 (2006-08), soit par le symbole , CEI 60417-5017 (2006-08).

F.3.6.1.2 Borne du conducteur neutre

Pour les **équipements reliés en permanence**, la borne, s'il y en a une, prévue exclusivement pour la connexion au conducteur neutre du **réseau d'alimentation**, doit être identifiée par la lettre majuscule "N".

F.3.6.1.3 Bornes conductrices de liaison de protection

Il n'est pas nécessaire d'identifier les bornes des **conducteurs de liaison de protection**.

Si de telles bornes sont identifiées, elles doivent être identifiées par le symbole de terre , CEI 60417-5017 (2006-08). Toutefois, une borne de composant ou une borne de câblage de liaison équipotentielle sortant d'un socle de connecteur déjà marqué du symbole , CEI 60417-5019 (2006-08) est acceptable comme identification d'une borne de **conducteur de liaison de protection**.

F.3.6.2 Équipement de classe II

F.3.6.2.1 Marquage des équipements de classe II

Les **équipements de classe II** sans connexion de **terre fonctionnelle** doivent porter le symbole CEI 60417-5172 (2003-02).

Les **équipements de classe II** avec connexion de **terre fonctionnelle** doivent porter le symbole CEI 60417-6092 (2011-10).

Les symboles ci-dessus ne doivent pas être utilisés pour les **équipements de classe I**.

Les équipements assurant la mise à la terre de protection à d'autres équipements ne peuvent pas être considérés comme des **équipements de classe II**.

Pour les **équipements de classe II** fournis avec un cordon de **réseau d'alimentation** disposant d'un conducteur équipé d'une isolation verte et jaune qui n'est utilisé que pour assurer une connexion à la **terre fonctionnelle,** il n'existe pas d'exigences autres que celles spécifiées en 4.6 concernant la terminaison de ce conducteur à l'extrémité de l'équipement.

F.3.6.2.2 Marquage des bornes de terre fonctionnelle

Les bornes pour fils électriques à utiliser uniquement pour la connexion de la **terre fonctionnelle** doivent être marquées du symbole , CEI 60417-5020 (2002-10). Ces bornes ne doivent porter ni le symbole CEI 60417-5017 (2006-08) ni le symbole CEI 60417-5019 (2006-08).

Cependant, ces symboles peuvent être utilisés sur une borne pour fils électriques prévue pour un composant (par exemple, un bloc de connexion) ou un sous-ensemble.

F.3.6.3 Critères de conformité

La conformité est vérifiée par examen.

F.3.7 Marquage de l'indice IP de l'équipement

Si l'équipement est conçu pour un indice différent de IPX0, il doit porter le numéro IP correspondant au degré de protection contre la pénétration d'eau, conformément à la CEI 60529.

La conformité est vérifiée par examen.

F.3.8 Marquage de la sortie de l'alimentation électrique externe

La sortie en courant continu (c.c.) d'une alimentation externe doit porter les caractéristiques assignées de la tension, les caractéristiques assignées du courant et la polarité.

La sortie en courant alternatif (c.a) d'une alimentation externe doit porter les caractéristiques assignées de la tension, les caractéristiques assignées du courant et la fréquence si elle est différente de la fréquence d'entrée.

La conformité est vérifiée par examen et mesure.

F.3.9 Durabilité, lisibilité et permanence des marquages

En général, tous les marquages devant figurer sur l'équipement doivent être résistants et lisibles, et doivent être aisément discernables dans les conditions normales d'éclairage.

Sauf spécification contraire, il n'est pas nécessaire que les **protections par instructions** soient en couleur. Si une **protection par instructions** est en couleur, la couleur doit être conforme à la série de normes ISO 3864. Il n'est pas nécessaire que les marquages gravés ou moulés soient dans des couleurs contrastées, à condition qu'ils soient lisibles et aisément discernables dans les conditions normales d'éclairage.

Les marquages imprimés ou tramés doivent également être permanents.

La conformité est vérifiée par examen. L'état permanent est déterminé par les essais décrits en F.3.10.

F.3.10 Essai déterminant la permanence des marquages

F.3.10.1 Généralités

Chaque marquage imprimé ou tramé exigé doit être soumis à essai. Toutefois, si la fiche technique d'une étiquette certifie la conformité aux exigences d'essai, il n'est pas nécessaire d'effectuer l'essai.

F.3.10.2 Procédure d'essai

L'essai consiste à frotter le marquage à la main sans appliquer une force importante pendant 15 s avec un chiffon imbibé d'eau, et sur un deuxième échantillon, ou à un emplacement différent, avec un chiffon imbibé d'essence minérale pendant 15 s, comme spécifié en F.3.10.3.

F.3.10.3 Essence minérale

L'essence minérale est de l'hexane réactif contenant au moins 85 % de n-hexane.

NOTE La désignation "n-hexane" correspond à la nomenclature chimique pour un hydrocarbure à chaîne droite ou "normal". Cette essence minérale est ensuite identifiée comme hexane réactif (CAS # 110-54-3) selon la certification de l'ACS (American Chemical Society).

F.3.10.4 Critères de conformité

Le marquage doit rester lisible après chaque essai. Si le marquage est apposé sur une autre étiquette, l'étiquette ne doit pas se corner et ne doit pas être détachable à la main.

F.4 Instructions

Lorsqu'une information concernant la sécurité est exigée conformément à la présente norme, cette information doit figurer dans les instructions d'installation ou les instructions de première utilisation. Cette information doit être disponible avant l'installation et la première utilisation de l'équipement.

Les équipements destinés à être utilisés dans des lieux non susceptibles de recevoir des enfants et qui sont évalués à l'aide de la sonde d'essai articulée de la Figure V.2, doivent comporter les indications suivantes ou des indications équivalentes dans les instructions destinées à l'utilisateur.

NOTE 1 Cette conception d'équipements s'applique d'ordinaire aux équipements commerciaux ou industriels prévus pour être installés dans des lieux n'accueillant normalement que des adultes.

Cet équipement ne convient pas à une utilisation dans des lieux pouvant accueillir des enfants.

NOTE 2 Voir également le Guide ISO/CEI 37, Instructions d'emploi pour les produits présentant un intérêt pour les consommateurs.

Dans toute la mesure du possible, les instructions doivent comprendre les informations suivantes.

– Des indications pour assurer une installation et interconnexion correctes et sans danger de l'équipement.
– Pour les équipements prévus uniquement pour une utilisation dans une **zone à accès limité**, les instructions doivent en faire mention.
– S'il est prévu que l'équipement soit fixé sur place, les instructions doivent expliquer comment parvenir à fixer solidement l'équipement.

– Pour les équipements audio comportant des bornes classées comme bornes ES3 conformément au Tableau E.1, ainsi que pour les autres équipements qui comportent des bornes marquées en conformité avec F.3.6.1.1, les instructions doivent exiger que les fils externes connectés à ces bornes doivent être installés par une **personne qualifiée**, ou qu'ils doivent être connectés au moyen de câbles ou de cordons déjà préparés et conçus pour éviter tout contact avec un circuit ES3.

– Si une borne de terre de protection est utilisée comme **protection**, les instructions doivent exiger que le **conducteur de mise à la terre de protection** de l'équipement soit connecté au **conducteur de mise à la terre de protection** de l'installation (par exemple, au moyen d'un cordon d'alimentation connecté à un socle de prises de courant avec connexion à la terre).

– Pour les équipements comprenant un **conducteur de mise à la terre de protection**, parcouru par un courant qui dépasse les limites ES2 citées en 5.2.2.2, l'équipement doit comporter une **protection par instructions** conforme à 5.7.5.

– Les symboles graphiques apposés sur l'équipement et utilisés comme une **protection par instructions** doivent être expliqués.

– Si un **équipement relié en permanence** n'est pas équipé d'un interrupteur d'alimentation coupant tous les pôles du **réseau**, les instructions d'installation doivent stipuler qu'un interrupteur d'alimentation coupant tous les pôles du **réseau** conforme à l'Annexe L doit être ajouté à l'installation électrique du bâtiment.

– Si un composant ou un module remplaçable prévoit une fonction de **protection**, l'identification d'un module ou d'un composant de rechange approprié doit figurer dans les instructions destinées aux **personnes ordinaires**, aux **personnes averties** ou aux **personnes qualifiées**, le cas échéant.

La conformité est vérifiée par examen.

F.5 Protections par instructions

Sauf spécification contraire dans la présente norme, une **protection par instructions** comprend les éléments 1a ou 2, ou les deux, ainsi que les éléments 3 et 4. Si un symbole adéquat n'est pas disponible pour l'élément 1a, le marquage de l'élément 1b peut alors être apposé sur l'équipement.

Sauf spécification contraire dans la présente norme, l'emplacement de la **protection par instructions** doit être comme suit:

– le marquage complet de la **protection par instructions** doit figurer sur l'équipement, ou

– l'élément 1a ou l'élément 2, ou les deux, doivent être apposés sur l'équipement et la totalité de la **protection par instructions** doit figurer dans le texte du document d'accompagnement. Si l'on utilise uniquement l'élément 2, le texte doit être précédé par le terme “Avertissement” ou “Attention” ou formulation similaire.

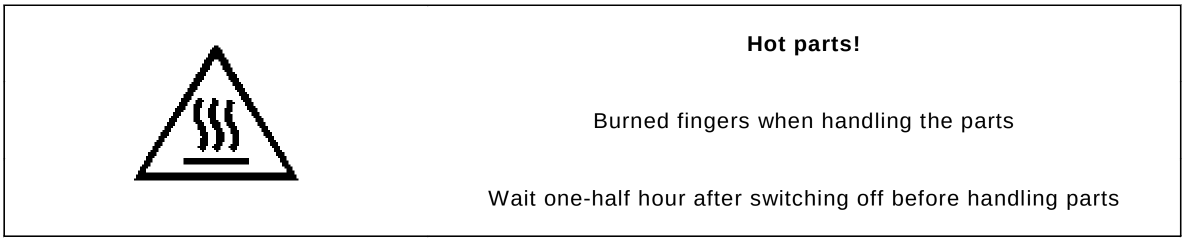
Tout élément de **protection par instructions** placé sur l'équipement doit être visible par la personne avant une exposition potentielle aux pièces de source d'alimentation de classe 2 ou 3 et situé le plus près possible des pièces de source d'énergie.

Les éléments 1a, 1b, 2, 3 et 4 sont spécifiés dans le Tableau F.1.

Tableau F.1 – Description et exemples d'éléments de protection mise en place sous forme d'instructions

Élément	Description	Exemple
1a	Symbole permettant d'identifier la nature de la source d'énergie de classe 2 ou 3 ou les conséquences pouvant résulter de la source d'énergie de classe 2 ou 3.	
1b	Symbole ou ensemble de symboles tels que l'ISO 7000-0434 (2004-01) et l'ISO 7000-1641 (2004-01) faisant référence au texte du document d'accompagnement. Ces symboles peuvent être combinés.	
2	Texte identifiant la nature de la source d'énergie de classe 2 ou 3 ou les conséquences pouvant résulter de la source d'énergie, ainsi que l'emplacement de la source d'énergie.	**Pièces à haute température !**
3	Texte décrivant les conséquences possibles d'un transfert d'énergie de la source d'énergie à une partie du corps.	La manipulation des pièces provoque des brûlures aux doigts
4	Texte décrivant l'action de **protection** nécessaire afin d'éviter le transfert d'énergie vers une partie du corps.	Attendre une demi-heure après la mise hors tension avant de manipuler les pièces
Le symbole destiné aux éléments 1a et 1b doivent provenir de la CEI 60417, de l'ISO 3864-2, de l'ISO 7000, de l'ISO 7010 ou d'une norme équivalente.		

La Figure F.1 montre un exemple de disposition des quatre éléments qui contient une **protection par instructions** complète. D'autres dispositions sont également acceptables pour le positionnement des éléments.

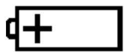
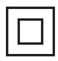


IEC 0373/14

Figure F.1 – Exemple de protection par instructions

Pour des exemples de marquages, d'instructions et de **protections par instructions**, voir le Tableau F.2.

Tableau F.2 – Exemples de marquages, d'instructions et de protections mises en place sous forme d'instructions

Caractéristique assignée	**Exemple**
Tension en courant continu assignée	48 V c.c. 48 V ⎓
Tension en courant alternatif assignée	230 V ~ 230 V ~ ±10 % 100/120/220/240 V c.a. 100-250 V c.a.
Tension triphasée assignée	400 Y/230 V 3Ø 208 Y/120 V triphasé 208 Y/120 V 3 ~
Fréquence assignée	50-60 Hz 50/60 Hz
Courant assigné	1 A
Instruction	**Exemple**
Positionnement de la **pile**, CEI 60417-5002 (2002-10)	
Courant alternatif, CEI 60417-5032 (2002-10)	~
Courant continu, CEI 60417-5031 (2002-10)	⎓
Equipement de **classe II**, CEI 60417-5172 (2003-02)	
Attention, ISO 7000, 0434a ou 0434b (2004-01)	
Tension dangereuse, CEI 60417-5036 (2002-10)	
Terre; masse, CEI 60417-5017 (2006-08)	
Terre de protection; CEI 60417-5019 (2006-08)	

Annexe G
(normative)

Composants

G.1 Interrupteurs

G.1.1 Généralités

Les exigences relatives aux interrupteurs dans des circuits PS3 sont spécifiées ci-dessous.

Un interrupteur peut être soumis à l'essai séparément ou au sein de l'équipement.

G.1.2 Exigences

Les interrupteurs utilisés en tant que **dispositifs de déconnexion** doivent être conformes aux exigences de l'Annexe L.

Un interrupteur ne doit pas être incorporé à un cordon d'alimentation du **réseau d'alimentation**.

Un interrupteur doit satisfaire à toutes les spécifications suivantes:

– satisfaire aux exigences de la CEI 61058-1:2008, notamment:
  - 10 000 cycles de fonctionnement (voir 7.1.4.4 de la CEI 61058-1:2008);
  - l'interrupteur doit être adapté à une utilisation dans l'environnement de **degré de pollution** dans lequel il est utilisé, généralement un environnement de **degré de pollution 2** (voir 7.1.6.2 de la CEI 61058-1:2008);
  - l'interrupteur doit avoir pour le fil incandescent une température de 850 °C (voir 7.1.9.3 de la CEI 61058-1:2008);
  - pour les interrupteurs du **réseau d'alimentation** utilisés dans les téléviseurs à écran cathodique, la vitesse d'ouverture et de fermeture du contact doit être indépendante de la vitesse de manœuvre;

    NOTE Ceci est provoqué par l'existence d'un courant d'appel élevé dû à la bobine de démagnétisation.

  - les caractéristiques de l'interrupteur en ce qui concerne les valeurs assignées et la classification (voir la CEI 61058-1) doivent être conformes à la fonction de l'interrupteur dans les **conditions normales de fonctionnement**, comme suit:
    – les valeurs assignées de l'interrupteur (voir Article 6 de la CEI 61058-1:2008);
    – la classification de l'interrupteur en fonction de:
      - la nature de l'alimentation (voir 7.1.1 de la CEI 61058-1:2008);
      - le type de charge commandé par l'interrupteur (voir 7.1.2 de la CEI 61058-1:2008);
      - la température ambiante de l'air (voir 7.1.3 de la CEI 61058-1:2008);

    La conformité est vérifiée conformément à la CEI 61058-1:2008.

– l'interrupteur doit être conçu de sorte qu'il n'atteigne pas des températures excessives dans les **conditions normales de fonctionnement**;

  La conformité est vérifiée en position de marche selon les spécifications de 16.2.2 d), l) et m) de la CEI 61058-1:2008, à l'exception du fait que le courant est la somme du courant de l'équipement et du courant maximal fourni à d'autres équipements, s'il existe

– un interrupteur de **réseau d'alimentation** contrôlant les socles de prises de courant d'autres équipements doit résister à l'essai d'endurance selon 17.2 de la CEI 61058-1:2008, avec une charge supplémentaire selon la Figure 9 de la CEI 61058-1:2008. Le courant assigné total de la charge additionnelle doit correspondre au marquage apposé sur les socles de prises de courant. Le courant de surcharge crête de la charge additionnelle doit avoir une valeur conforme à celle indiquée dans le Tableau G.1.

Tableau G.1 – Courant de surcharge crête

Courant assigné A	**Courant de surcharge crête** A
jusqu'à et y compris 0,5	20
jusqu'à et y compris 1,0	50
jusqu'à et y compris 2,5	100
Supérieur à 2,5	150

G.1.3 Méthode d'essai et critères de conformité

Les essais de la CEI 61058-1:2008 doivent être appliqués avec les modifications indiquées en G.1.2.

*Après les essais, l'interrupteur ne doit présenter aucun dommage au niveau de l'**enveloppe**, ni aucun relâchement des connexions électriques ou des fixations mécaniques.*

G.2 Relais

G.2.1 Exigences

Les exigences relatives aux relais compris dans un circuit PS3 sont spécifiées ci-dessous.

Le relais peut être soumis à l'essai séparément ou au sein de l'équipement.

Pour la résistance à la chaleur et au feu, voir l'Article 16 de la CEI 61810-1:2008.

Un relais doit être conforme aux exigences de la CEI 61810-1:2008, en prenant en compte ce qui suit:

– les matériaux doivent être conformes à 6.4.5.2 ou satisfaire à l'essai du fil incandescent à 750 °C ou à l'essai du brûleur-aiguille;

– 10 000 cycles de fonctionnement pour l'endurance (voir 5.5 de la CEI 61810-1:2008) et pendant l'essai d'endurance électrique (voir l'Article 11 de la CEI 61810-1:2008), aucune défaillance temporaire ne doit survenir;

NOTE Une défaillance temporaire constitue un événement devant être supprimé pendant l'essai au plus tard après un cycle de mise sous tension supplémentaire sans aucune influence externe (voir Article 11 de la CEI 61810-1:2008).

– le relais doit être adapté à une utilisation dans des conditions de pollution applicables (voir l'Article 13 de la CEI 61810-1:2008);

– pour les relais du **réseau d'alimentation**, la vitesse d'ouverture et de fermeture des contacts doit être indépendante du débit d'augmentation de la tension de la bobine;

– les caractéristiques du relais en ce qui concerne les valeurs assignées et la classification (voir la CEI 61810-1) doivent être appropriées à la fonction du relais dans les **conditions normales de fonctionnement**, comme suit:

  • tension de la bobine assignée et plage de tensions assignées de la bobine (voir 5.1 de la CEI 61810-1:2008);

- charge de contact assignée et type de charge (voir 5.7 de la CEI 61810-1:2008);
- relais à courant alternatif ou courant continu (voir 5.3 de la CEI 61810-1:2008);
- la température de l'air ambiant et les limites inférieure et supérieure de température (voir 5.8 de la CEI 61810-1:2008);
- seules les catégories de technologie de relais RT IV et RT V doivent être considérées comme satisfaisant à un environnement au **degré de pollution** 1; par exemple, le relais satisfait à 5.4.8 de la présente norme (voir 5.9 de la CEI 61810-1:2008);

– la rigidité diélectrique (voir 10.3 de la CEI 61810-1:2008), sauf que la tension d'essai, doit être la tension d'essai requise spécifiée en 5.4.9.1 de la présente norme;

– les **distances dans l'air** conformes au Tableau 15 de la présente norme, si la **tension de tenue requise** (dénommée tension de tenue aux chocs dans la CEI 61810-1) dépasse 12 kV;

– les **lignes de fuite** conformes au Tableau 18 de la présente norme, si la **tension de service efficace** (dénommée tension efficace dans la CEI 61810-1) dépasse 500 V;

– l'**isolation réalisée avec un isolant solide** conformément à 13.3 de la CEI 61810-1:2008 ou au 5.4.4 de la présente norme.

La conformité est vérifiée conformément à la CEI 61810-1 et aux exigences de la présente norme.

G.2.2 Essai de surcharge

Un relais doit supporter l'essai suivant:

Le contact du relais est soumis à un essai de surcharge. Cet essai consiste à appliquer 50 cycles de fonctionnement à un rythme de 6 à 10 cycles par minute, ouvrant et fermant 150 % du courant imposé dans l'application, et sauf dans le cas où un contact actionne une charge moteur, l'essai est réalisé avec le rotor du moteur en position bloquée. Après l'essai, le relais doit toujours être fonctionnel.

G.2.3 Relais contrôlant les socles de raccordement d'autres équipements

*Un relais raccordé au **réseau d'alimentation** contrôlant les socles de raccordement d'autres équipements doit supporter l'essai d'endurance de l'Article 11 de la CEI 61810-1:2008, avec une charge supplémentaire égale à la charge totale marquée sur les socles de prises de courant de raccordement à d'autres équipements.*

G.2.4 Méthode d'essai et critères de conformité

*Pour les relais raccordés au **réseau d'alimentation**, les essais de la CEI 61810-1 et de la présente norme doivent être appliqués avec les modifications indiquées dans l'Article G.2 de la présente norme.*

*Après les essais, le relais ne doit présenter aucune détérioration au niveau de l'**enveloppe**, aucune réduction des **lignes de fuite** et des **distances dans l'air**, ni aucun relâchement des connexions électriques ou des fixations mécaniques.*

G.3 Dispositifs de protection

G.3.1 Disjoncteurs thermiques

G.3.1.1 Exigences

Une **protection par disjoncteur thermique** doit être conforme aux exigences a) et b) ou c).

NOTE Dans la CEI 60730-1, un "disjoncteur thermique" est un "coupe-circuit thermique".

a) Lorsqu'il est soumis à essai en tant que composant séparé, le **disjoncteur thermique** doit satisfaire aux exigences et aux essais de la série CEI 60730, dans toute la mesure du possible:

   – le **disjoncteur thermique** doit être à action de type 2 (voir 6.4.2 de la CEI 60730-1:2010);

   – le **disjoncteur thermique** doit fournir au moins une micro-interruption, de type 2.B (voir 6.4.3.2 et 6.9.2 de la CEI 60730-1:2010);

   – le **disjoncteur thermique** doit avoir un mécanisme à déclenchement libre par lequel l'application continuelle du défaut ne peut pas empêcher les contacts de s'ouvrir (type 2.E) (voir 6.4.3.5 de la CEI 60730-1:2010);

   – le nombre de cycles d'action automatique doit être au moins de:

     • 3 000 cycles pour un **disjoncteur thermique** à réarmement automatique utilisé dans les circuits qui ne sont pas interrompus lorsque l'équipement est éteint (voir 6.11.8 de la CEI 60730-1:2010);

     • 300 cycles pour un **disjoncteur thermique** à réarmement automatique utilisé dans les circuits qui sont interrompus lorsque l'équipement est éteint et pour un **disjoncteur thermique** sans réarmement automatique, et qui peuvent être réarmés à la main depuis l'extérieur de l'équipement (voir 6.11.10 de la CEI 60730-1:2010);

     • 30 cycles pour un **disjoncteur thermique** sans réarmement automatique et qui ne peut pas être réarmé à la main depuis l'extérieur de l'équipement (voir 6.11.11 de la CEI 60730-1:2010);

   – le **disjoncteur thermique** doit être soumis à l’essai comme s’il était conçu pour supporter une période longue de contrainte électrique entre les parties isolantes (voir 6.14.2 de la CEI 60730-1:2010);

   – le **disjoncteur thermique** doit être conforme aux exigences de conditionnement pour une durée d'utilisation prévue d'au moins 10 000 h (voir 6.16.3 de la CEI 60730-1:2010);

   – la distance d’ouverture des contacts et la distance entre les bornes et les fils électriques des contacts, doivent être conformes à 13.1.4 et 13.2 de la CEI 60730-1:2010.

b) Les caractéristiques du **disjoncteur thermique**, en ce qui concerne

   – les valeurs assignées du **disjoncteur thermique** (voir Article 5 de la CEI 60730-1:2010);

   – la classification du **disjoncteur thermique** en fonction de:

     • la nature de l'alimentation (voir 6.1 de la CEI 60730-1:2010);

     • le type de charge à contrôler (voir 6.2 de la CEI 60730-1:2010);

     • le degré de protection procuré par les **enveloppes** contre la pénétration de corps solides et de poussières (voir 6.5.1 de la CEI 60730-1:2010);

     • le degré de protection procuré par les **enveloppes** contre les effets nuisibles dus à la pénétration d'eau (voir 6.5.2 de la CEI 60730-1:2010);

     • l'environnement de pollution pour lequel le **disjoncteur thermique** est approprié (voir 6.5.3 de la CEI 60730-1:2010);

     • la limite maximale de température ambiante (voir 6.7 de la CEI 60730-1:2010);

   doivent être appropriées à l’application de l’équipement.

c) Lorsqu'il est soumis à essai comme une partie de l'équipement, le **disjoncteur thermique** doit:

   – comprendre au moins une micro-interruption, conformément à la CEI 60730-1, qui supporte une tension d'essai correspondant à 13.2 de la CEI 60730-1:2010; et

   – avoir un mécanisme à déclenchement libre par lequel l'application continuelle du défaut ne peut pas empêcher les contacts de s'ouvrir; et

– être conditionné pour 300 h lorsque l'équipement fonctionne dans les **conditions normales de fonctionnement** à une température ambiante de 30 °C ou à la température ambiante maximale spécifiée par le fabricant, selon celle des deux températures qui est la plus élevée; et

– être soumis à un nombre de cycles de fonctionnement automatique comme indiqué au point a) pour un **disjoncteur thermique** soumis à essai en tant que composant séparé, en estimant les conditions de défaut pertinentes.

G.3.1.2 Méthode d'essai et critères de conformité

La vérification du ***disjoncteur thermique*** *est effectuée par examen et par mesure conformément aux spécifications d'essai de la série CEI 60730. L'essai est effectué sur trois éprouvettes.*

Au cours de l'essai, aucun arc électrique entretenu ne doit survenir. Après l'essai, le ***disjoncteur thermique*** *ne doit présenter aucun relâchement des connexions électriques ou des fixations mécaniques.*

G.3.2 Coupe-circuit thermiques

G.3.2.1 Exigences

Un coupe-circuit thermique utilisé comme **protection** doit être conforme à l'exigence a) ou b) ci-dessous.

a) Lorsqu'il est soumis à essai en tant que composant séparé, le coupe-circuit thermique doit satisfaire aux exigences de la CEI 60691.

   Les caractéristiques du coupe-circuit thermique, en ce qui concerne

   – les conditions ambiantes (voir Article 5 de la CEI 60691:2002);

   – les conditions électriques (voir 6.1 de la CEI 60691:2002);

   – les conditions thermiques (voir 6.2 de la CEI 60691:2002);

   – les valeurs assignées du coupe-circuit thermique (voir l'Article 8 b) de la CEI 60691:2002);

   – l'aptitude au scellement ou l'utilisation en présence de liquides d'imprégnation ou de solvants de nettoyage (voir l'Article 8 c) de la CEI 60691:2002),

   doivent être appropriées à l'utilisation dans l'équipement dans les **conditions normales de fonctionnement** et dans les **conditions de premier défaut**.

   La rigidité diélectrique du coupe-circuit thermique doit satisfaire aux exigences de 5.4.9.1 de la présente norme sauf aux bornes de la coupure (parties en contact) et entre les broches et les connexions des contacts, pour lesquels 10.3 de la CEI 60691:2002 s'applique.

b) Lorsqu'il est soumis à essai comme une partie de l'équipement, le coupe-circuit thermique doit être:

   – vieilli pendant 300 h à une température correspondant à la température ambiante du coupe-circuit thermique lorsque l'équipement fonctionne dans les **conditions normales de fonctionnement** à une température ambiante de 30 °C ou à la température ambiante maximale spécifiée par le fabricant, selon celle des deux températures qui est la plus élevée; et

   – soumis à des **conditions de premier défaut** de l'équipement qui déclenchent le coupe-circuit thermique. Pendant l'essai, il ne doit survenir aucun arc électrique entretenu; et

   – capable de supporter deux fois la tension aux bornes de la coupure et présenter une résistance d'isolement au moins égale à 0,2 MΩ, mesurée en présence d'une tension égale à deux fois la tension aux bornes de la coupure.

G.3.2.2 Méthode d'essai et critères de conformité

Si un coupe-circuit thermique est soumis à essai comme composant séparé conformément à G.3.2.1 a) ci-dessus, la conformité est vérifiée selon les spécifications d'essai de la CEI 60691, par examen et mesure.

Si un coupe-circuit thermique est soumis à essai comme partie intégrante de l'équipement selon G.3.2.1 b) ci-dessus, la conformité est vérifiée par examen et par les essais spécifiés dans l'ordre indiqué. L'essai est effectué trois fois. Le coupe-circuit thermique est remplacé, en partie ou en totalité, après chaque essai.

Lorsque le coupe-circuit ne peut pas être remplacé, en partie ou en totalité, il convient de remplacer l'intégralité de la pièce du composant comprenant le coupe-circuit thermique (par exemple, un transformateur).

Aucun défaut n'est autorisé.

G.3.3 Thermistances CTP

Les thermistances CTP utilisées comme **protections** doivent être conformes aux Articles 15, 17, J.15 et J.17 de la CEI 60730-1:2010.

En ce qui concerne les thermistances CTP:

– dont la puissance dissipée dépasse 15 W à sa tension maximale à une température ambiante de 25 °C ou autrement spécifiée par le fabricant pour l'état déclenché, déterminé dans la CEI 60738-1:2009, 3.38; et
– d'une dimension de 1750 mm^3 ou plus; et
– situées dans un circuit PS2 ou PS3;

l'enrobage ou l'enveloppe doit être constitué(e) d'un **matériau de classe V-1** ou équivalent.

NOTE L'état déclenché signifie l'état dans lequel les thermistances CTP sont décalées vers un état de résistance élevée à une température donnée.

La conformité est vérifiée par examen.

G.3.4 Dispositifs de protection contre les surintensités

A l'exception des dispositifs couverts par G.3.5, les dispositifs de protection contre les surintensités utilisés comme **protection** doivent être conformes aux normes CEI correspondantes.

La conformité est vérifiée par examen.

G.3.5 Dispositifs de protection non mentionnés de G.3.1 à G.3.4

G.3.5.1 Exigences

De tels dispositifs de protection (par exemple, des résistances fusibles, des coupe-circuits à fusible non normalisés dans la série CEI 60127 ou des coupe-circuit miniatures) doivent avoir des caractéristiques assignées suffisantes, y compris le pouvoir de coupure.

Un marquage doit être apposé à proximité des dispositifs de protection non réutilisables, tels que les coupe-circuits à fusible, pour permettre leur remplacement correct.

G.3.5.2 Méthode d'essai et critères de conformité

La conformité est vérifiée par examen et par un essai de **condition de premier défaut** *tel que spécifié dans l'Article B.4.*

L'essai est effectué trois fois. Aucun défaut n'est autorisé.

G.4 Connecteurs

G.4.1 Exigences relatives aux distances dans l'air et aux lignes de fuite

La **distance dans l'air** et la **ligne de fuite** entre la surface isolante extérieure 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 dans l'air** et la **ligne de fuite** entre la surface isolante extérieure 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 dans l'air** et la **ligne de fuite** peuvent être conformes 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
  - nécessite d'être à sa place dans les **conditions normales de fonctionnement**, et
  - est fourni avec une **protection par instructions** pour remplacer le sous-ensemble retiré.

Les essais de 5.3.2 s'appliquent à ce type de connecteurs après le retrait du sous-ensemble.

G.4.2 Connecteurs du réseau d'alimentation

Les connecteurs du **réseau d'alimentation** énumérés dans la CEI/TR 60083 ou conformes à l'une des normes suivantes (série CEI 60309, série CEI 60320, CEI 60906-1 ou CEI 60906-2), sont considérés comme acceptables sans une évaluation ultérieure.

G.4.3 Connecteurs autres que les connecteurs de réseau d'alimentation

Les connecteurs autres que les connecteurs de **réseau d'alimentation** doivent être conçus de sorte que la forme de la fiche ne permette vraisemblablement pas une insertion dans le socle de raccordement au **réseau d'alimentation** ou une prise d'appareil.

EXEMPLE Les connecteurs conformes à cette exigence sont ceux dont la construction est conforme à la CEI 60130-2, à la CEI 60130-9, à la CEI 60169-3 ou à la CEI 60906-3. Un exemple de connecteur non conforme aux exigences est la fiche appelée "fiche banane". Les fiches audio standard de 3,5 mm ne sont pas supposées pouvoir être insérées dans le socle de prise de courant du **réseau d'alimentation.**

La conformité est vérifiée par examen.

G.5 Composants bobinés

G.5.1 Isolation des fils dans des composants bobinés

G.5.1.1 Généralités

Le présent article s'applique aux composants bobinés comprenant une **isolation principale**, une **isolation supplémentaire** ou une **isolation renforcée**.

G.5.1.2 Protection contre les contraintes mécaniques

Lorsque deux fils de bobinage ou un fil de bobinage et un autre fil sont en contact à l'intérieur d'un composant bobiné et se croisent avec un angle compris entre 45° et 90° et sont soumis à la tension de l'enroulement, l'une des conditions suivantes s'applique:

– une protection contre les contraintes mécaniques doit être prévue. Cette protection peut être obtenue, par exemple, en fournissant une séparation physique sous la forme d'un manchon isolant ou d'un matériau en feuille, ou en utilisant le double du nombre de couches d'isolants requis sur le fil de bobinage; ou

– le composant bobiné satisfait aux essais d'endurance de G.5.2.

De plus, si la construction ci-dessus assure l'**isolation principale**, l'**isolation supplémentaire** ou l'**isolation renforcée**, les composants bobinés finis doivent satisfaire à l'**essai individuel de série** pour la rigidité diélectrique conformément à 5.4.9.1.

G.5.1.3 Méthode d'essai et critères de conformité

La conformité est vérifiée par 5.4.4.1 et, si nécessaire, par G.5.2. Si les essais de l'Annexe J sont requis, ils ne sont pas répétés si les fiches techniques des matériaux confirme la conformité.

G.5.2 Essai d'endurance

G.5.2.1 Exigences générales d'essai

Lorsque requis par G.5.1.2, trois échantillons du composant bobiné sont soumis 10 fois aux cycles d'essai suivants:

– *les échantillons sont soumis à l'essai à la chaleur de G.5.2.2. À la suite de l'essai, les échantillons redescendent à la température ambiante.*

– *les échantillons sont ensuite soumis à l'essai de vibration de G.15.3.4.*

– *Les échantillons sont ensuite soumis à l'épreuve hygroscopique de 5.4.8 pendant deux jours.*

Les essais décrits ci-dessous sont effectués avant le démarrage des 10 cycles et après chaque cycle.

L'essai de rigidité diélectrique décrit en 5.4.9.1 est effectué.

*À la suite de l'essai de rigidité diélectrique, l'essai de G.5.2.3 est effectué sur les composants bobinés qui sont alimentés par le **réseau d'alimentation**, à l'exception de l'alimentation à découpage.*

G.5.2.2 Essai à la chaleur

Selon le type de classification thermique de l'isolation, les échantillons sont maintenus dans une enceinte thermique pour une combinaison de temps et de température spécifiée dans le Tableau G.2. Les 10 cycles sont effectués dans la même combinaison.

La température dans l'enceinte thermique doit être maintenue avec une tolérance de ±5 °C.

Tableau G.2 – Température d'essai et durée d'essai (jours) par cycle

Classification thermique	**Classe 105 (A)**	**Classe 120 (E)**	**Classe 130 (B)**	**Classe 155 (F)**	**Classe 180 (H)**	**Classe 200 (N)**	**Classe 220 (R)**	**Classe 250 -**
Température d'essai °C	**Durée d'essai pour l'essai de G.5.2**							
290								4 jours
280								7 jours
270								14 jours
260							4 jours	
250							7 jours	
240						4 jours	14 jours	
230						7 jours		
220					4 jours	14 jours		
210					7 jours			
200					14 jours			
190				4 jours				
180				7 jours				
170				14 jours				
160			4 jours					
150		4 jours	7 jours					
140		7 jours						
130	4 jours							
120	7 jours							

Les classes sont liées à la classification des matériaux isolants électriques et des EIS (systèmes d'isolation électriques) conformément à la CEI 60085. Les désignations alphabétiques assignées sont données entre parenthèses.

Le fabricant doit spécifier la durée de l'essai ou la température d'essai.

G.5.2.3 Composants bobinés alimentés à partir du réseau d'alimentation

*Un circuit d'entrée est connecté à une source de tension d'essai égale à au moins 1,2 fois la **tension assignée**, et de fréquence double de la **fréquence assignée** pendant 5 min. Aucune charge n'est reliée au transformateur. Pendant l'essai, les enroulements à plusieurs fils, s'il y en a, sont reliés en série.*

*On peut utiliser une fréquence d'essai plus élevée; la durée de mise sous tension, en minutes, est alors égale à 10 fois la **fréquence assignée** divisée par la fréquence d'essai, mais pas inférieure à 2 min.*

*La tension d'essai est initialement réglée à la **tension assignée** et progressivement augmentée jusqu'à 1,2 fois la valeur initiale, puis maintenue pendant la durée spécifiée. Si pendant l'essai, un changement de courant non linéaire se produit de manière incontrôlable, cela est considéré comme une rupture entre les spires du bobinage.*

G.5.2.4 Critères de conformité

*Pour les composants bobinés alimentés par le **réseau d'alimentation**, il ne doit pas y avoir de claquage de l'isolation entre les spires du bobinage, entre des enroulements d'entrée et de* *sortie, entre des enroulements d'entrée ou de sortie adjacents, ou entre les bobinages et tout noyau conducteur.*

G.5.3 Transformateurs

G.5.3.1 Généralités

Les transformateurs doivent satisfaire à l'une des exigences suivantes:

– soit aux exigences citées en G.5.3.2 et G.5.3.3;

– soit aux exigences de la CEI 61204-7, s'il s'agit d'un transformateur pour alimentation basse tension;

– soit aux exigences de la CEI 61558-1 et des parties applicables de la CEI 61558-2, avec les additions et les limites suivantes:

  - les valeurs limites pour ES1 spécifiées dans la présente norme s'appliquent (voir 5.2.2.2),
  - pour les **tensions de service** supérieures à 1 000 V en valeur efficace, voir 18.3 de la CEI 61558-1:2005, en application de la tension d'essai spécifiée en 5.4.9.1,
  - l'essai de surcharge selon G.5.3.3.

– soit aux exigences de la CEI 61558-2-16 pour les transformateurs à alimentation à découpage.

NOTE Des exemples de parties pertinentes de la CEI 61558-2 sont:

– CEI 61558-2-1: Transformateurs de séparation;

– CEI 61558-2-4: Transformateurs d'isolement;

– CEI 61558-2-6: Transformateurs d'isolement de sécurité.

G.5.3.2 Isolation

G.5.3.2.1 Exigences

L'isolation des transformateurs doit satisfaire aux exigences suivantes.

Les enroulements et les parties conductrices des transformateurs doivent être traités comme des parties intégrantes des circuits auxquels ils sont connectés, le cas échéant. L'isolation entre ces éléments doit satisfaire aux exigences pertinentes de l'Article 5 et satisfaire aux essais de rigidité diélectrique pertinents, conformément à l'utilisation de l'isolation dans l'équipement.

Des mesures de précaution doivent être prises pour éviter une réduction en deçà des valeurs minimales requises pour les **distances dans l'air** et les **lignes de fuite** qui fournissent une **isolation principale**, une **isolation supplémentaire** ou une **isolation renforcée**, par

– le déplacement des enroulements ou de leurs spires;

– le déplacement du câblage interne ou des fils pour les connexions externes;

– le déplacement excessif de parties d'enroulements ou de câblage interne, en cas de rupture des fils adjacents aux connexions ou de desserrage des connexions;

– le pontage de l'isolation par des fils, vis, rondelles ou pièces similaires, s'ils venaient à se desserrer ou se défaire.

Deux fixations indépendantes ne sont pas supposées se détacher simultanément.

Les spires d'extrémité de tous les enroulements doivent être fixées par des moyens efficaces.

Les exemples suivants représentent des formes de construction acceptables (il existe d'autres formes de construction acceptables):

– des enroulements isolés les uns des autres placés sur des supports séparés d'un même noyau, avec ou sans bobines;
– des enroulements disposés sur une bobine unique avec une paroi de séparation, lorsque soit la bobine et la paroi de séparation sont pressées ou moulées en une seule pièce, soit la paroi de séparation rapportée comporte une protection intermédiaire ou un recouvrement sur le joint entre la bobine et la paroi de séparation;
– des enroulements concentriques sur une bobine en matière isolante sans rebords ou sur une isolation appliquée sous forme de feuilles minces sur le noyau du transformateur;
– une isolation est prévue entre les enroulements sous forme d'une feuille isolante s'étendant au-delà des spires terminales de chaque couche;
– des enroulements concentriques séparés par un écran conducteur mis à la terre, qui consiste en une feuille métallique qui s'étend sur toute la largeur des enroulements avec une isolation appropriée entre chaque enroulement et l'écran. L'écran conducteur et son conducteur de sortie ont une section suffisante pour garantir qu'en cas de défaillance de l'isolation, le dispositif de protection contre les surcharges ouvre le circuit avant que l'écran ne soit détruit. Le dispositif de protection contre les surcharges peut être une pièce du transformateur.

Si un transformateur est doté d'un écran relié à la terre pour des raisons de protection, il doit satisfaire à l'essai spécifié en 5.6.6 entre l'écran relié à la terre et la borne de terre du transformateur.

Aucun essai de rigidité diélectrique ne s'applique à l'isolation entre un enroulement et le noyau ou l'écran, à condition que le noyau ou l'écran soit complètement enveloppé ou encapsulé et qu'il n'y ait pas de connexion électrique avec le noyau ou l'écran. Cependant, les essais entre les enroulements comprenant des bornes demeurent applicables.

G.5.3.2.2 Critères de conformité

La conformité est vérifiée par examen, par des mesures, et par essai le cas échéant.

G.5.3.3 Essais de surcharge du transformateur

G.5.3.3.1 Conditions d'essai

Si les essais sont effectués dans des conditions simulées sur le banc, ces conditions doivent comprendre tout dispositif de protection pouvant protéger le transformateur dans l'équipement complet.

Les transformateurs pour les blocs d'alimentation à découpage sont soumis à essai au sein du bloc d'alimentation complet ou de l'équipement complet. Les charges d'essai sont appliquées à la sortie du bloc d'alimentation.

Chacun des enroulements, isolés du ***réseau d'alimentation****, d'un transformateur linéaire ou d'un transformateur à ferrorésonance est chargé tour à tour, les autres enroulements isolés du* ***réseau d'alimentation*** *étant chargés entre zéro et leur charge maximale spécifiée pour obtenir l'effet d'échauffement maximal.*

La sortie d'une alimentation à découpage est chargée pour obtenir l'effet d'échauffement maximal dans le transformateur.

Lorsqu'une ***condition de surcharge*** *ne peut pas se produire ou n'est pas susceptible de provoquer une défaillance de la* ***protection****, les essais ne sont pas effectués.*

G.5.3.3.2 Critères de conformité

Les températures maximales des enroulements ne doivent pas dépasser les valeurs indiquées dans le Tableau G.3 lorsqu'elles sont relevées conformément aux spécifications de B.1.6 et déterminées comme suit:

- *avec une protection contre les surintensités externe: en cours de fonctionnement, afin de déterminer la durée écoulée avant que la protection contre les surintensités ne se mette à fonctionner, il est possible de consulter une fiche technique du dispositif de protection contre les surintensités indiquant le délai de déclenchement par rapport aux caractéristiques du courant;*
- *avec un **disjoncteur thermique** à réarmement automatique, comme montré dans le Tableau G.3 et après 400 h;*
- *avec un **disjoncteur thermique** à réarmement manuel: en cours de fonctionnement;*
- *pour les transformateurs à limiteurs de courant: après stabilisation de la température.*

Si la température des enroulements d'un transformateur avec un noyau en ferrite, mesurée comme spécifié en B.1.6, dépasse 180 °C, elle doit être à nouveau soumise à essai à la valeur maximale de la température ambiante assignée ($T_{amb} = T_{ma}$), et non telle que calculée selon B.2.6.3.

*Les enroulements isolés du **réseau d'alimentation**, qui dépassent les limites de température mais qui deviennent des circuits ouverts, ou alors qui nécessitent un remplacement du transformateur, ne constituent pas un échec de cet essai, à condition que le transformateur reste conforme à B.4.8.*

Pendant l'essai, le transformateur ne doit pas émettre de flammes ou métal fondu.

Tableau G.3 – Limites de température pour les enroulements de transformateurs et de moteurs (à l'exception de l'essai de surcharge sur moteur en marche)

Méthode de protection	Température maximale °C Classe 105 (A)	Classe 120 (E)	Classe 130 (B)	Classe 155 (F)	Classe 180 (H)	Classe 200 (N)	Classe 220 (R)	Classe 250 -
Protection par impédance interne ou externe	150	165	175	200	225	245	265	295
Protection par dispositif de protection fonctionnant pendant la première heure	200	215	225	250	275	295	315	345
Protection par tout dispositif de protection:								
– maximum après la première heure	175	190	200	225	250	270	290	320
– moyenne arithmétique pendant la deuxième heure et pendant la 72e heure [a]	150	165	175	200	225	245	265	295

Les classes sont liées à la classification des matériaux isolants électriques et des EIS (systèmes d'isolation électriques) conformément à la CEI 60085. Les désignations alphabétiques assignées sont données entre parenthèses.

[a] La moyenne arithmétique des températures est déterminée comme suit:

Le graphique de température en fonction du temps (voir la Figure G.1), alors que l'alimentation du transformateur est ouverte et fermée de façon cyclique, est tracé pour la période d'essai étudiée. La moyenne arithmétique des températures (t_A) est déterminée par la formule:

$$t_A = \frac{t_{max} + t_{min}}{2}$$

où

t_{max} est la moyenne des valeurs maximales,

t_{min} est la moyenne des valeurs minimales.

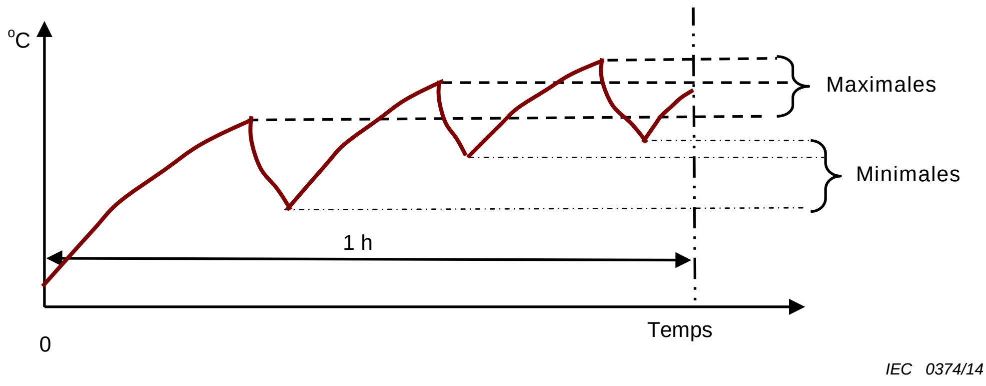


Figure G.1 – Détermination de la moyenne arithmétique des températures

G.5.3.3.3 Autre méthode d'essai

Le transformateur est placé sur une planche de bois recouverte d'une seule couche de ***papier mousseline*** *et le transformateur, à son tour, est recouvert d'une seule couche d'****étamine*** *jusqu'à l'une des occurrences suivantes:*

– *le dispositif de protection contre les surcharges fonctionne,*

– *l'enroulement devient un circuit ouvert,*

– *la charge ne peut plus être augmentée sans atteindre une condition de court-circuit ou de repli.*

Le transformateur est ensuite chargé jusqu'à un point juste avant l'occurrence de la situation applicable ci-dessus et fonctionne pendant 7 h.

*Pendant l'essai, le transformateur ne doit pas émettre de flammes ou métal fondu. L'**étamine** ne doit ni se carboniser ni s'enflammer*

*Si la tension du transformateur dépasse ES1, la **protection principale** ou la **protection renforcée** fournie dans le transformateur doit supporter l'essai de rigidité diélectrique spécifié en 5.4.9.1, le cas échéant, après son refroidissement jusqu'à la température ambiante.*

G.5.4 Moteurs

G.5.4.1 Exigences générales

Les moteurs c.c. alimentés par des circuits PS2 ou PS3 isolés du **réseau d'alimentation** c.a. doivent satisfaire aux essais cités enG.5.4.5, G.5.4.6 et G.5.4.9. Les moteurs c.c. qui fonctionnent normalement de manière intrinsèque dans des conditions de rotor bloqué, tels que les moteurs pas à pas, ne sont pas soumis à essai et il n'est pas nécessaire que les moteurs c.c. uniquement utilisés pour la propulsion d'air et dans lesquels le composant de propulsion d'air est directement couplé à l'arbre du moteur satisfassent à l'essai de G.5.4.5.

Tous les autres moteurs alimentés par des circuits PS2 ou PS3 doivent être conformes aux essais de surcharge spécifiés en G.5.4.3 et G.5.4.4 et, le cas échéant, aux essais spécifiés en G.5.4.7, G.5.4.8 et G.5.4.9.

Cependant, les moteurs suivants ne sont pas soumis à l'essai spécifié en G.5.4.3:

– les moteurs qui sont utilisés pour le traitement de l'air uniquement et pour lesquels le composant de propulsion d'air est directement couplé à l'arbre du moteur, et

– les moteurs à bague de déphasage dont les valeurs de courant à rotor bloqué et de courant à vide ne diffèrent pas de plus de 1 A et dont le rapport ne dépasse pas 2/1.

G.5.4.2 Conditions d'essai de surcharge du moteur

*Sauf spécification contraire, pendant l'essai, l'équipement fonctionne à la **tension assignée** ou à la tension la plus élevée de la **plage de tensions assignées**.*

Les essais sont effectués soit dans l'équipement, soit dans des conditions simulées sur le banc. Des échantillons séparés peuvent être utilisés pour les bancs d'essai. Les conditions simulées comprennent:

– *tout dispositif de protection capable de protéger le moteur dans l'équipement complet, et*

– *l'utilisation de tout moyen de montage pouvant servir de dissipation de chaleur au bâti du moteur.*

*Les températures des enroulements sont mesurées selon les spécifications de B.1.6. Lorsque des thermocouples sont utilisés, ils sont appliqués à la surface des enroulements du moteur. Le relevé de températures s'effectue à la fin de la période d'essai, si cela est spécifié dans l'essai; sinon, après stabilisation de la température ou au moment du fonctionnement des fusibles, des **disjoncteurs thermiques**, des dispositifs de protection du moteur et équivalents.*

Pour les moteurs entièrement enveloppés et protégés par impédance, les températures sont relevées par les thermocouples appliqués au carter du moteur.

Lorsque les moteurs qui ne possèdent pas de protection thermique interne sont soumis à essai dans des conditions simulées sur le banc, la température de l'enroulement mesurée est ajustée de manière à prendre en compte la température ambiante à laquelle le moteur se trouve normalement au sein de l'équipement.

G.5.4.3 Essai de surcharge en fonctionnement et critères de conformité

Un essai de surcharge en fonctionnement est effectué en faisant fonctionner le moteur dans les ***conditions normales de fonctionnement****. La charge est alors augmentée de sorte que le courant soit augmenté par étapes progressives adéquates, la tension d'alimentation étant maintenue à sa valeur d'origine. Lorsque des conditions stables sont établies, la charge est à nouveau augmentée. La charge est ainsi augmentée de manière progressive par étapes appropriées, mais sans atteindre une condition de rotor bloqué (voir G.5.4.4), jusqu'à ce que le dispositif de protection contre les surcharges se mette en marche.*

La conformité est vérifiée en mesurant les températures des enroulements du moteur pendant chaque période stable. Les températures mesurées ne doivent pas dépasser les valeurs données dans le Tableau G.4.

Tableau G.4 – Limites de température pour les essais de surcharge en fonctionnement

Température maximale °C							
Classe 105 (A)	**Classe 120 (E)**	**Classe 130 (B)**	**Classe 155 (F)**	**Classe 180 (H)**	**Classe 200 (N)**	**Classe 220 (R)**	**Classe 250 -**
140	155	165	190	215	235	255	275
Les classes sont liées à la classification des matériaux isolants électriques et des EIS (systèmes d'isolation électriques) conformément à la CEI 60085. Les désignations alphabétiques assignées sont données entre parenthèses.							

G.5.4.4 Essai de surcharge à rotor bloqué

G.5.4.4.1 Méthode d'essai

Un essai de surcharge à rotor bloqué est effectué en démarrant à la température ambiante.

La durée de l'essai est la suivante:

– *un moteur protégé par une impédance inhérente ou externe est mis en fonctionnement à rotor bloqué pendant 15 jours, sauf si les enroulements du moteur atteignent une température constante, auquel cas l'essai est interrompu si la température constante n'est pas supérieure à celle spécifiée dans le Tableau 10 pour le système d'isolation utilisé;*

– *un moteur équipé d'un dispositif de protection à réarmement automatique est mis en fonctionnement à rotor bloqué pendant 18 jours;*

– *un moteur équipé d'un dispositif de protection à réarmement manuel est mis en fonctionnement à rotor bloqué pendant 60 cycles, le dispositif de protection étant réarmé dès que possible après chaque fonctionnement, afin qu'il reste fermé, mais toutefois pas avant que 30 s ne se soient écoulées;*

– *un moteur équipé d'un dispositif de protection non réarmable est mis en fonctionnement jusqu'à ce que le dispositif fonctionne.*

G.5.4.4.2 Critères de conformité

La conformité est vérifiée en mesurant les températures à intervalles réguliers pendant les trois premiers jours pour les moteurs équipés d'un dispositif de protection par impédance inhérente ou externe, ou d'un dispositif de protection à réarmement automatique, ou pendant *les dix premiers cycles pour un moteur équipé d'un dispositif de protection à réarmement manuel, ou au moment de la mise en fonctionnement pour un dispositif de protection non réarmable. Les températures mesurées ne doivent pas dépasser les valeurs données dans le Tableau 3.*

Durant l'essai, les dispositifs de protection doivent fonctionner de manière fiable sans causer de dommages permanents au moteur, tels que:

- *un dégagement de fumée ou de flammes important ou prolongé;*
- *une rupture électrique ou mécanique d'un des composants associés tel qu'un condensateur ou un relais de démarrage;*
- *un écaillage, une fragilisation ou une carbonisation de l'isolation;*
- *une détérioration de l'isolation.*

Une décoloration de l'isolation peut se produire, mais une carbonisation ou une fragilisation telles que l'isolation s'écaille ou que le matériau se détache en frottant l'enroulement avec le pouce ne sont pas acceptables.

A l'issue de la période spécifiée pour la mesure de la température, le moteur doit supporter l'essai de rigidité diélectrique de 5.4.9.1 après que l'isolation s'est refroidie pour atteindre la température ambiante avec les tensions d'essai réduites à 0,6 fois les valeurs spécifiées.

NOTE La poursuite de l'essai sur un dispositif de protection à réarmement automatique au-delà de 72 h, ainsi que sur un dispositif de protection à réarmement manuel au-delà de 10 cycles, est uniquement destinée à démontrer la capacité du dispositif à lancer et interrompre le courant à rotor bloqué sur une longue durée.

G.5.4.5 Surcharge en fonctionnement pour les moteurs c.c.

G.5.4.5.1 Exigence

L'essai cité en G.5.4.5.2 est effectué uniquement s'il existe une possibilité de surcharge après examen ou révision de la conception. Par exemple, il n'est pas nécessaire de réaliser l'essai lorsque les circuits d'entraînement électroniques maintiennent un courant sensiblement constant.

S'il est difficile d'obtenir des mesures de température précises, parce que le moteur est de petite taille ou qu'il est de conception non classique, la méthode de G.5.4.5.3 peut être utilisée à la place.

G.5.4.5.2 Méthode d'essai et critères de conformité

Le moteur est mis en marche dans les ***conditions normales de fonctionnement****. La charge est alors augmentée de sorte que le courant soit augmenté par étapes progressives adéquates, la tension d'alimentation étant maintenue à sa valeur d'origine. Lorsque des conditions stables sont établies, la charge est à nouveau augmentée. La charge est alors augmentée par étapes progressives appropriées, soit jusqu'à ce que le dispositif de protection contre les surcharges se mette en marche, l'enroulement devenant alors un circuit ouvert, soit jusqu'à ce que la charge ne puisse plus être augmentée sans atteindre une condition de rotor bloqué.*

Les températures des enroulements du moteur sont mesurées pendant chaque période stable. Les températures mesurées ne doivent pas dépasser les valeurs indiquées au Tableau G.4.

Après l'essai, si la tension du moteur dépasse ES1, la ***protection principale*** *ou la* ***protection renforcée*** *fournie dans le moteur doit supporter l'essai de rigidité diélectrique de 5.4.9.1 après refroidissement à la température ambiante, mais avec les tensions d'essai réduites à 0,6 fois les valeurs spécifiées.*

G.5.4.5.3 Autre méthode

*Le moteur recouvert d'une seule couche d'étamine est placé sur une planche de bois recouverte d'une seule couche de **tissu d'emballage.** Le moteur est alors chargé graduellement jusqu'à l'une des occurrences suivantes:*

- *le dispositif de protection contre les surcharges fonctionne,*
- *l'enroulement devient un circuit ouvert,*
- *la charge ne peut plus être augmentée sans atteindre une condition de rotor bloqué,*

Le moteur est ensuite chargé jusqu'à un point juste avant l'occurrence de la situation applicable ci-dessus et fonctionne pendant 7 h.

*Pendant l'essai, le moteur ne doit émettre aucune flamme ni métal fondu. L'**étamine** ne doit ni se carboniser ni s'enflammer.*

*À la suite de l'essai, si la tension du moteur dépasse ES1, la **protection principale** ou la **protection renforcée** fournie dans le moteur doit supporter l'essai de rigidité diélectrique cité en 5.4.9.1 après que la température du moteur soit redescendue à la température ambiante, mais avec des tensions d'essai réduites à 0,6 fois les valeurs spécifiées.*

G.5.4.6 Surcharge à rotor bloqué pour les moteurs c.c.

G.5.4.6.1 Exigence

Les moteurs doivent satisfaire à l'essai spécifié en G.5.4.6.2.

S'il est difficile d'obtenir des mesures de température précises, parce que le moteur est de petite taille ou de conception non classique, la méthode décrite en G.5.4.6.3 peut être utilisée à la place.

G.5.4.6.2 Méthode d'essai et critères de conformité

Le moteur est mis en marche à la tension utilisée dans son application et avec son rotor bloqué pendant 7 h ou jusqu'à ce que des conditions stables soient établies, la condition la plus longue étant retenue. Cependant, si l'enroulement du moteur s'ouvre ou si le moteur est mis hors tension en permanence, l'essai est interrompu.

La conformité est vérifiée en mesurant les températures des enroulements du moteur pendant l'essai. Les températures mesurées ne doivent pas dépasser les valeurs données dans le Tableau G.3.

À la suite de l'essai, si la tension du moteur dépasse ES1, et après refroidissement à température ambiante, le moteur doit supporter l'essai de rigidité diélectrique de 5.4.9.1, mais avec des tensions d'essai réduites à 0,6 fois les valeurs spécifiées.

G.5.4.6.3 Autre méthode

*Le moteur recouvert d'une seule couche d'**étamine** est placé sur une planche de bois recouverte d'une seule couche de **tissu d'emballage.***

Le moteur est ensuite mis en marche à la tension utilisée dans son application et avec son rotor bloqué pendant 7 h ou jusqu'à ce que des conditions stables soient établies, la condition la plus longue étant retenue. Cependant, si l'enroulement du moteur s'ouvre ou si le moteur est mis hors tension en permanence, l'essai est interrompu.

*Pendant l'essai, le moteur ne doit émettre aucune flamme ni métal fondu. L'**étamine** ne doit ni se carboniser ni s'enflammer.*

À la suite de l'essai, si la tension du moteur dépasse ES1, et après que la température du moteur soit redescendue à la température ambiante, le moteur doit supporter l'essai de rigidité diélectrique cité en 5.4.9.1 mais avec des tensions d'essai réduites à 0,6 fois les valeurs spécifiées.

G.5.4.7 Méthode d'essai et critères de conformité pour les moteurs équipés de condensateurs

Les moteurs pourvus de condensateurs déphaseurs sont soumis à essai dans des conditions de rotor bloqué, avec le condensateur en état de court-circuit ou de circuit ouvert (en retenant la solution la plus défavorable).

L'essai en court-circuit n'est pas effectué si le condensateur est conçu de telle sorte que, en cas d'échec, il ne reste pas en état de court-circuit.

La conformité est vérifiée en mesurant les températures des enroulements du moteur après l'essai. Les températures mesurées ne doivent pas dépasser les valeurs du Tableau G.3.

G.5.4.8 Méthode d'essai et critères de conformité pour les moteurs triphasés

Les moteurs triphasés sont soumis à essai dans les ***conditions normales de fonctionnement****, avec une phase déconnectée, sauf si les commandes du circuit empêchent l'application de la tension au moteur lorsque l'une ou plusieurs des phases d'alimentation manquent.*

L'effet produit par d'autres charges et circuits au sein de l'équipement peut nécessiter une mise à l'essai du moteur au sein de l'équipement et avec les trois phases d'alimentation déconnectées l'une après l'autre.

La conformité est vérifiée en mesurant les températures des enroulements du moteur pendant l'essai. Les températures mesurées ne doivent pas dépasser les valeurs du Tableau G.3.

G.5.4.9 Méthode d'essai et critères de conformité pour les moteurs série

Les moteurs série sont mis en fonctionnement à une tension équivalente à 1,3 fois la tension assignée du moteur pendant 1 min avec la charge la plus petite possible.

À la suite de l'essai, les enroulements et les connexions ne doivent pas s'être desserrés et toutes les ***protections*** *applicables doivent rester effectives.*

G.6 Isolation des fils

G.6.1 Généralités

Les exigences suivantes s'appliquent à tous les fils comprenant les fils dans les composants bobinés (voir également l'Article G.5), fils de sortie et analogues dont l'isolant fournit une **isolation principale**, une **isolation supplémentaire** ou une **isolation renforcée**.

NOTE 1 Pour l'isolation prévue en plus de l'isolation sur le fil de bobinage, voir 5.4.4.

Si la **valeur de crête de la tension de service** ne dépasse pas ES2, aucune exigence de dimensions ou de construction ne s'applique.

Si la **valeur de crête de la tension de service** dépasse ES2, l'une des spécifications suivantes s'applique:

a) Il n'existe pas d'exigence de dimension ou de construction pour l'**isolation principale** qui ne se trouve pas en situation de contrainte mécanique (provenant, par exemple, de la tension de l'enroulement). Pour l'**isolation principale** qui se trouve en situation de contrainte mécanique, b) ou c) s'applique.

NOTE 2 Cette exception ne s'applique pas à l'**isolation supplémentaire** ou l'**isolation renforcée**.

b) Pour l'**isolation principale**, l'**isolation supplémentaire** ou l'**isolation renforcée**, l'isolant sur le fil doit:

– avoir une seule couche d'une épaisseur d'au moins 0,4 mm; ou

– satisfaire à 5.4.4.6 et à l'Annexe J.

c) Le fil de bobinage doit satisfaire à l'Annexe J. Le nombre minimal de couches superposées de ruban enroulé en spirale ou de couches d'isolation extrudées doit être le suivant:

– pour une **isolation principale**: une couche;

– pour une **isolation supplémentaire**: deux couches;

– pour une **isolation renforcée**: trois couches.

Pour l'isolation entre deux fils de bobinage adjacents, une couche sur chaque conducteur est considérée comme suffisante pour fournir une **isolation supplémentaire**.

Un ruban enroulé en spirale avec un chevauchement maximal de 50 % est considéré comme constituant une couche. Un ruban enroulé en spirale avec un chevauchement supérieur à 50 % est considéré comme constituant deux couches.

Un ruban enroulé en spirale doit être scellé et doit satisfaire aux essais a), b) ou c) de 5.4.4.5.

NOTE 3 Pour les fils isolés par un processus d'extrusion, le scellement est inhérent au processus.

Le fil de bobinage doit satisfaire à un **essai individuel de série** pour l'essai de rigidité diélectrique, en utilisant l'essai spécifié en J.3.2.

G.6.2 Isolation d'enroulement avec de l'émail à base de solvant

L'émail à base de solvant n'est pas considéré fournir une **isolation supplémentaire** ou une **isolation renforcée**, quelles que soient les circonstances.

L'émail à base de solvant est considéré comme une **isolation principale** lorsque toutes les conditions suivantes sont réunies:

– l'isolation fournit une **isolation principale** dans un composant bobiné entre un **circuit externe** et un circuit interne fonctionnant en ES2 et ES1;

– l'isolation présente sur tous les conducteurs est constituée d'émail conforme aux exigences d'un fil de bobinage de niveau 2 tel qu'indiqué dans la série de normes CEI 60317 avec l'**essai individuel de série** effectué à la tension la plus élevée du Tableau 26 et du Tableau 27;

– le composant fini est soumis à un **essai de type** de la rigidité diélectrique (entre les enroulements et entre les enroulements et le noyau, voir G.5.3.2.1), conformément à 5.4.9.1;

– le composant fini est soumis à des **essais individuels de série** de la rigidité diélectrique (entre les enroulements et entre les enroulements et le noyau, voir G.5.3.2.1), conformément à 5.4.9.2.

À l'exception des spécifications de 4.3.2.3, le noyau du composant bobiné ci-dessus ne doit pas être **accessible** à une **personne ordinaire**.

G.7 Câbles d'alimentation réseau

G.7.1 Généralités

Un câble d'alimentation **réseau** doit être gainé et conforme aux spécifications suivantes, selon le cas:

– si la gaine est en caoutchouc, elle est en caoutchouc synthétique et le câble ne nécessite pas d'être plus léger qu'un câble souple gainé de caoutchouc ordinaire, conformément à la CEI 60245-1 (désignation 60245 IEC 53);

– si la gaine est en PVC:

- pour les équipements comprenant un **câble d'alimentation fixé à demeure** et dont la masse ne dépasse pas 3 kg, le câble ne nécessite pas d'être plus léger qu'un câble souple gainé en PVC léger, conformément à la CEI 60227-1 (désignation 60227 IEC 52);
- pour les équipements comprenant un **câble d'alimentation fixé à demeure** et dont la masse dépasse 3 kg, le câble ne nécessite pas d'être plus léger qu'un câble souple gainé en PVC ordinaire, conformément à la CEI 60227-1 (désignation 60227 IEC 53);

NOTE 1 Il n'existe pas de limite pour la masse de l'équipement si l'équipement est prévu pour une utilisation avec un câble d'alimentation non fixé à demeure.

- pour les équipements comprenant un câble d'alimentation non fixé à demeure, le câble ne nécessite pas d'être plus léger qu'un câble souple gainé en PVC léger, conformément à la CEI 60227-1 (désignation 60227 IEC 52);
- pour les câbles blindés des **équipements mobiles**, l'essai de flexion de 3.1 de la CEI 60227-2:2003;

NOTE 2 Bien que les câbles blindés ne soient pas couverts par le domaine d'application de la CEI 60227-2, les essais de flexion appropriés de la CEI 60227-2 sont utilisés.

– d'autres types de câble peuvent être utilisés s'ils possèdent des propriétés électromécaniques et de sécurité au feu similaires à celles susmentionnées.

NOTE 3 Lorsque des normes nationales ou régionales existent, elles peuvent être utilisées pour démontrer la conformité aux alinéas ci-dessus.

Pour les **équipements enfichables de type A** ou les **équipements enfichables de type B** qui disposent d'une mise à la terre de protection, un **conducteur de mise à la terre de protection** doit être inclus dans le câble d'alimentation du **réseau d'alimentation**. Pour tous les autres équipements, en cas de fourniture d'un cordon d'alimentation du **réseau d'alimentation** sans un **conducteur de mise à la terre de protection**, un câble **conducteur de mise à la terre de protection** doit être également fourni.

Les équipements destinés à être utilisés par des musiciens sur scène (par exemple, les instruments de musique et les amplificateurs) doivent avoir:

– une entrée conforme à la CEI 60320-1 pour leur branchement au **réseau d'alimentation** par l'intermédiaire d'un ensemble de câbles non fixés à demeure; ou

– un moyen de fixation protégeant le câble du **réseau d'alimentation** lorsqu'il n'est pas utilisé (par exemple, un compartiment, des crochets ou des pinces).

La conformité est vérifiée par examen. Pour les câbles avec écran, les dommages sur la protection sont acceptables à condition que:

– *pendant l'essai de flexion, l'écran ne soit pas en contact avec un conducteur, et*

– *après l'essai de flexion, l'échantillon supporte l'essai de rigidité diélectrique entre l'écran et tous les autres conducteurs.*

G.7.2 Section

Les câbles d'alimentation **réseau** doivent comporter des conducteurs avec des sections équivalentes à celles spécifiées dans le Tableau G.5 (voir également 5.6.3).

Tableau G.5 – Tailles des conducteurs

Courant assigné de l'équipement [a]	Tailles minimales des conducteurs	
A jusqu'à et y compris	**Section** mm^2	**AWG ou kcmil** [section en mm^2] [e]
3	0,5 [b]	20 [0,5]
6	0,75	18 [0,8]
10	1,00 (0,75) [c]	16 [1,3]
16	1,50 (1,0) [d]	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 mm^2] [e]
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 notes [b], [c] et [d]. Cependant, certains pays ont précisé qu'ils n'acceptaient pas toutes les valeurs indiquées dans ce tableau, en particulier les valeurs concernées par les notes [b], [c] et [d].

NOTE 2 Pour les courants plus élevés, voir la série CEI 60364.

[a] Le **courant assigné** comprend les courants des socles de prises de courant alimentant d'autres équipements en électricité du **réseau d'alimentation**.

[b] 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.

[c] La valeur entre parenthèses s'applique aux câbles d'alimentation non fixés à demeure munis de connecteurs de tension assignée de 10 A, conformément à la CEI 60320-1 (types C13, C15, C15A et C17), à condition que la longueur du câble de dépasse pas 2 m.

[d] La valeur entre parenthèses s'applique aux câbles d'alimentation non fixés à demeure munis de connecteurs de tension assignée de 16 A, conformément à la CEI 60320-1 (types C19, C21 et C23), à condition que la longueur du câble de dépasse pas 2 m.

[e] 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 Gage et le terme "cmil" 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.

La conformité est vérifiée par examen.

G.7.3 Dispositifs d'arrêt de traction et de relâchement des contraintes pour les câbles d'alimentation fixés à demeure

G.7.3.1 Généralités

Les **protections** contre les contraintes transmises aux bornes des conducteurs de câbles de l'équipement ou des câbles interconnectés au circuit ES2, ES3, PS3 sont spécifiées ci-dessous.

G.7.3.2 Dispositif de relâchement des contraintes du câble

G.7.3.2.1 Exigences

Un nœud ne doit pas être utilisé comme mécanisme de relâchement des contraintes.

Une vis directement insérée dans le cordon ou le câble ne doit pas être utilisée comme mécanisme de relâchement des contraintes à moins que le dispositif d'arrêt de traction, y compris la vis, soit en matériau isolant et que la vis ait une dimension comparable au diamètre de câble à fixer.

Lorsqu'une force linéaire et un couple sont appliqués à un **câble** ou un cordon **d'alimentation fixé à demeure**, une **protection principale** doit empêcher les contraintes de se transmettre aux bornes du câble ou du cordon.

La force linéaire appliquée sur le cordon ou le câble est spécifiée dans le Tableau G.6. La force est appliquée dans la direction la plus défavorable pendant 1 s et est répétée 25 fois.

Tableau G.6 – Force d'essai de relâchement des contraintes

Masse de l'équipement kg	**Force** N
Jusqu'à 1 inclus	30
Supérieure à 1 jusqu'à 4 inclus	60
Supérieure à 4	100

Un couple de 0,25 Nm est appliqué pendant 1 min au cordon ou au câble immédiatement après l'application de la force linéaire. Le couple est appliqué au plus près possible du mécanisme de relâchement des contraintes et est répété dans la direction opposée.

La conformité est déterminée en appliquant la force et le couple spécifiés, par mesure et examen visuel. Il ne doit y avoir aucun dommage au câble ou aux conducteurs et le déplacement des conducteurs ne doit pas dépasser 2 mm. L'allongement de l'enveloppe extérieure du câble sans déplacement des conducteurs n'est pas considéré comme un déplacement.

G.7.3.2.2 Défaillance du mécanisme de relâchement des contraintes

En cas de défaillance de la **protection principale** (mécanisme de relâchement des contraintes) et de transmission des contraintes aux bornes du câble ou du **cordon d'alimentation fixé à demeure**, une **protection supplémentaire** doit garantir que l'extrémité reliée à la terre est la dernière à recevoir les contraintes.

La conformité est déterminée par examen et, si nécessaire, par destruction de la ***protection principale****, ainsi que par examen de la bretelle du conducteur tout en appliquant la force du Tableau G.6.*

G.7.3.2.3 Position de la gaine ou de l'enveloppe du câble/cordon

La gaine ou l'enveloppe du cordon ou du câble doit s'étendre de la **protection principale** (mécanisme de relâchement des contraintes) à l'équipement, sur une longueur au moins équivalente à la moitié du diamètre du cordon ou du câble.

La conformité est vérifiée par examen.

G.7.3.2.4 Matériaux des dispositifs d'arrêt de traction et de relâchement des contraintes des câbles

Le dispositif d'arrêt de traction et de relâchement des contraintes des câbles doit être en matériau isolant ou avoir un revêtement de matériau isolant satisfaisant aux exigences pour l'**isolation principale**. Lorsque le dispositif d'arrêt de traction et de relâchement des contraintes des câbles est une traversée qui comprend la connexion électrique à l'écran d'un câble de puissance blindé, cette exigence ne doit pas s'appliquer.

Si la **protection principale** (mécanisme de relâchement des contraintes) est constituée de matériau polymère, la **protection principale** doit conserver ses propriétés structurelles à la suite de relâchement des contraintes de moulage, conformément à l'Article T.8.

La conformité est déterminée par examen et conformément aux essais de force et de couple de G.7.3.2.1 après que la ***protection principale*** *est redescendue à la température ambiante.*

G.7.4 Point d'entrée du câble/cordon

Les **protections** contre les chocs électriques et les incendies d'origine électrique provoqués par des cordons ou câbles connectés à des circuits ES2, ES3 ou PS3 sont spécifiées ci-après.

Le point d'entrée d'un cordon ou d'un câble dans l'équipement doit être équipé de **protections** contre les chocs électriques tels que spécifiés dans l'Article 5. Si l'enveloppe du câble ou cordon satisfait à l'essai de rigidité diélectrique de 5.4.9.1 pour l'**isolation supplémentaire**, elle peut être considérée comme une **protection supplémentaire**.

Le point d'entrée du cordon ou du câble doit être équipé d'une **protection supplémentaire**, afin:

– d'empêcher l'abrasion de la surface extérieure du cordon ou du câble; et
– d'empêcher le cordon ou le câble d'être poussé dans l'équipement au risque d'endommager le cordon ou le câble ou ses conducteurs ou de déplacer les parties internes de l'équipement.

La conformité est déterminée par un essai de rigidité diélectrique entre les conducteurs du cordon ou du câble et les parties conductrices ***accessibles*** *à la suite des essais de G.7.3.2.1. La tension d'essai doit être telle que requise pour l'****isolation renforcée*** *mise en œuvre conformément à 5.4.9.1.*

G.7.5 Protection des câbles fixés à demeure contre les courbures

G.7.5.1 Exigences

Les **câbles d'alimentation fixés à demeure** des **équipements tenus à la main** ou des équipements destinés à être déplacés en cours de fonctionnement doivent être équipés d'une

protection contre un endommagement de l'enveloppe, de l'isolation ou du conducteur causé par une courbure au point d'entrée de l'équipement.

En variante, l'entrée ou la traversée doit être munie d'un orifice en forme de cloche, soigneusement arrondi, dont le rayon de courbure est au moins égal à 1,5 fois le diamètre extérieur du câble de la plus grande section à raccorder.

La **protection** contre les courbures doit:

– être conçue de manière à protéger le cordon ou le câble contre des courbures excessives au niveau de l'entrée dans l'équipement;
– être composée d'un matériau isolant;
– être fixée de manière fiable; et
– se projeter hors de l'équipement au-delà de l'ouverture du point d'entrée sur une distance d'au moins cinq fois le diamètre total ou, pour les cordons ou les câbles plats, d'au moins cinq fois la plus grande section extérieure du cordon ou du câble.

G.7.5.2 Méthode d'essai et critères de conformité

L'équipement est positionné de telle sorte que l'axe de la ***protection*** *contre les courbures, à l'endroit où le cordon ou le câble sort, fasse saillie d'un angle de 45° lorsque le cordon ou le câble est exempt de contraintes. Une masse égale à 10* $\times D^2$ *g est alors attachée à l'extrémité libre du câble ou du cordon,* D *étant, en millimètres, le diamètre extérieur ou, pour les cordons ou câbles plats, la plus petite dimension extérieure du cordon ou du câble.*

Si le protège-câble est constitué d'une matière sensible à la température, l'essai est effectué à 23 °C $\pm$ *2 °C.*

Les cordons ou câbles plats sont pliés dans le plan de moindre résistance.

Immédiatement après l'accrochage de la masse, le rayon de courbure du cordon ou du câble ne doit être en aucun endroit inférieur à 1,5 D*.*

La conformité est vérifiée par examen, mesure et, si nécessaire, par essai avec le cordon ou le câble fourni avec l'équipement.

G.7.6 Espace pour l'installation des câbles d'alimentation

G.7.6.1 Exigences générales

L'espace pour l'installation des câbles d'alimentation prévu à l'intérieur, ou en tant que partie, de l'équipement pour la connexion à demeure ou pour la connexion d'un **câble d'alimentation fixé à demeure** ordinaire doit être conçu:

– pour permettre l'introduction et le raccordement facile des conducteurs; et
– de façon que l'extrémité non isolée d'un conducteur n'est pas susceptible de se libérer de sa borne ou, si elle le fait, qu'elle ne puisse venir en contact avec:
  • une partie conductrice **accessible** qui n'est pas reliée au **conducteur de protection**; ou
  • une partie conductrice **accessible** d'un **équipement portatif**; et
– pour permettre de vérifier, avant la mise en place du couvercle éventuel, que les conducteurs sont correctement raccordés et disposés; et
– de façon que les couvercles éventuels puissent être mis en place sans risquer d'endommager les conducteurs d'alimentation ou leur isolation; et

– de façon que les couvercles éventuels donnant accès aux bornes puissent être enlevés avec un **outil**.

La conformité est vérifiée par examen et par un essai d'installation avec des cordons ou des câbles de la plus grande section de la plage appropriée spécifiée dans le Tableau G.4.

G.7.6.2 Conducteur à âme câblée

G.7.6.2.1 Exigences

L'extrémité d'un conducteur à âme câblée ne doit pas être consolidée avec de la soudure tendre aux endroits où le conducteur est soumis à une pression de contact, à moins que la méthode de fixation ne soit conçue de façon à prévenir le risque d'un mauvais contact dû au fluage à froid de la soudure.

Les bornes à ressort qui compensent le fluage à froid sont réputées satisfaire à cette exigence.

Le fait d'empêcher les vis de blocage de tourner n'est pas considéré comme suffisant.

Les bornes doivent être placées, protégées ou isolées de façon que, si un brin d'un conducteur souple venait à se détacher après le raccordement du conducteur, il n'y ait pas de risque de contact accidentel entre le brin et:

– les parties conductrices **accessibles**; ou

– les parties conductrices non mises à la terre, séparées des parties conductrices **accessibles** par une **isolation supplémentaire** uniquement.

G.7.6.2.2 Méthode d'essai et critères de conformité

La conformité est vérifiée par examen et, à moins qu'un cordon ou un câble spécial ne soit conçu de telle façon que les brins ne puissent se détacher, par l'essai suivant:

L'extrémité d'un conducteur souple ayant la section nominale appropriée est dénudée de son enveloppe isolante sur une longueur d'environ 8 mm. Un brin du conducteur est décâblé et les autres brins sont introduits complètement et serrés dans la borne. Le brin décâblé est plié, sans que l'enveloppe isolante soit déchirée, dans toutes les directions possibles, mais sans angles vifs le long de la protection.

*Si le conducteur est de source ES3, le brin décâblé ne doit toucher aucune partie conductrice **accessible** ou connectée à une partie conductrice **accessible** ou, dans le cas d'un appareil avec double isolation, aucune partie conductrice qui est séparée des parties conductrices **accessibles** par une **isolation supplémentaire** uniquement.*

Si le conducteur est relié à une borne de terre, le brin décâblé ne doit toucher aucune source ES3.

G.8 Varistances

G.8.1 Généralités

Une varistance doit satisfaire aux spécifications suivantes:

– les **protections** contre les chocs électriques de G.8.2; et

– les **protections** contre l'incendie de G.8.3 si la méthode de "réduction de la probabilité d'inflammation" de 6.4.1 est retenue.

Les **protections** contre l'incendie de G.8.3 ne s'appliquent pas à une varistance utilisée dans un circuit de suppression dont la tension d'amorçage (voir CEI 61051-1) est supérieure à la **tension transitoire du** r**éseau d'alimentation** c.a.

NOTE 1 Une varistance est parfois désignée par le terme "MOV" ou "VDR".

NOTE 2 Les connexions décrites ci-dessus font de la varistance une **source potentielle d'incendie (PIS)**.

G.8.2 Protections contre les chocs électriques

Une varistance doit être conforme à la CEI 61051-2, indépendamment de la présence ou non d'une **enveloppe ignifuge (contre le feu)**, tenant compte de tous les éléments suivants:

– Catégories climatiques préférentielles (voir 2.1.1 de la CEI 61051-2:1991):
  - température de catégorie inférieure: − 10 °C
  - température de catégorie supérieure: + 85 °C
  - durée de l'essai continu de chaleur humide: 21 jours.

– Tension continue maximale:
  - au moins 1,25 fois la **tension assignée** de l'équipement ou
  - au moins 1,25 fois la tension supérieure de la **plage de tensions assignées**.

  NOTE Les tensions continues maximales ne sont pas limitées aux valeurs spécifiées en 2.1.2 de la CEI 61051-2:1991, d'autres tensions peuvent être utilisées.

– Impulsion en combinaison (Tableau I groupe 1 de la CEI 61051-2:1991, Amendement 1:2009).

  Pour l'essai, une impulsion en combinaison est sélectionnée à partir de 2.3.6 de la CEI 61051-2: 1991, Amendement 1: 2009. L'essai comprend 10 impulsions positives ou 10 impulsions négatives, chacune ayant une forme d'impulsion de 1,2/50 μs pour la tension et de 8/20 μs pour le courant.

  Pour la sélection, la tension c.a. du **réseau d'alimentation** et la catégorie de surtension, voir le Tableau 13.

  Le **réseau d'alimentation** en dessous de 300 V est considéré être 300 V.

  Pour la catégorie de surtension IV du Tableau 13, une impulsion en combinaison de 6 kV/3 kA est utilisée sauf pour 600 V, pour laquelle une impulsion en combinaison de 8 kV/4 kA est utilisée. En variante, l'essai de choc en combinaison de la CEI 61051-2:1991, Amendement 1:2009 (2.3.6, Tableau I groupe 1 et Annexe A), prenant en compte la tension nominale du **réseau d'alimentation** et la catégorie de surtension, est acceptable.

  En complément des exigences de performance indiquées dans le Tableau I groupe 1 de la CEI 61051-2:1991, Amendement 1: 2009, la tension de la varistance au courant spécifié par le fabricant à la suite de l'essai ne doit pas être modifiée de plus de 10 % lorsqu'elle est comparée à la valeur avant l'essai.

Le corps de la varistance de limitation de surtension doit satisfaire à l'essai au brûleur-aiguille conformément à la CEI 60695-11-5, avec les sévérités d'essai suivantes:

– Durée de l'application de la flamme d'essai: 10 s
– Temps de persistance de flamme: 5 s

Si le corps de la varistance de limitation de surtension est conforme au **matériau de classe V-1**, il n'est pas nécessaire de réaliser l'essai au brûleur-aiguille.

G.8.3 Protections contre l'incendie

G.8.3.1 Généralités

Les **protections supplémentaires** à apporter contre les incendies causés par une défaillance de la varistance si la méthode de "réduction de la probabilité d'inflammation" de 6.4.1 est retenue sont spécifiées ci-dessous.

Une varistance doit être considérée comme une **PIS**. Lorsque la méthode de "réduction de la probabilité d'inflammation" est retenue, l'essai de surcharge de varistance de G.8.3.2; et l'essai de **surtension temporaire** de G.8.3.3 doivent être réalisés suivant la tension alternative maximale continue de la varistance conformément au Tableau G.7.

Tableau G.7 – Essai de surcharge de varistance et de surtension temporaire

Tension alternative maximale continue d'une varistance	Connexion entre		
	Phase-neutre ou entre phases	Phase-Terre	Neutre-Terre
1,25 × V_r à 2 × V_r	G.8.3.2	G.8.3.2 et G.8.3.3	G.8.3.2 et G.8.3.3
De plus de 2 × V_r à 1 200 + 1,1 × V_r	Pas d'essai	G.8.3.3	G.8.3.3
De plus de 1 200 + 1,1 × V_r	Pas d'essai	Pas d'essai	Pas d'essai
V_r est la **tension assignée** ou la tension supérieure de la **plage de tensions assignées** de l'équipement.			

G.8.3.2 Essai de surcharge de varistance

L'essai suivant est simulé comme spécifié dans le Tableau G.7 pour une varistance ou un circuit limiteur de surtension comprenant des varistances connectées sur le ***réseau d'alimentation*** *(entre phases ou entre phase et neutre), entre phase et terre de protection (phase-PE), ou entre neutre et terre de protection (Neutre-PE).*

Le circuit de simulation d'essai suivant doit être utilisé:

– *tension est la source c.a. de 2* $\times V_r$.

– *Courant est le courant résultant d'une résistance d'essai* R_x *connectée en série à une source c.a.*

– V_r *est la* ***tension assignée*** *ou la tension supérieure de la* ***plage de tensions assignées*** *de l'équipement.*

Pour phase-neutre, si un fusible ne dépassant pas 10 A est placé dans l'équipement avant et en série avec la varistance, soit une résistance d'essai initiale (R_1*) peut être utilisée donnant lieu au même courant que le fusible, ou il est possible d'appliquer un court-circuit. En l'absence de fusible connecté en série, l'essai doit être réalisé avec une résistance d'essai initiale* $R_1 = 16 \times V_r$.

Pour phase-terre de protection et neutre-terre de protection, l'essai doit être réalisé avec une résistance d'essai initiale $R_1 = 16 \times V_r$.

Si le circuit ne s'ouvre pas immédiatement pendant l'application initiale du courant d'essai, l'essai doit être poursuivi jusqu'à stabilisation de la température (voir B.1.6).

Ensuite, l'essai doit être répété avec de nouvelles valeurs de R_x *(*R_2, R_3, R_4*, etc.) jusqu'à ce que le circuit s'ouvre.*

– $R_2 = 8 \times V_r\ \Omega$

– $R_3 = 4 \times V_r \, \Omega$

– $R_4 = 2 \times V_r \, \Omega$

– $R_x = 0,5 \times (R_{x-1}) \, \Omega$

Pendant l'essai, le circuit peut s'ouvrir en raison du fonctionnement d'un dispositif de protection tel qu'un fusible, un fusible thermique ou un éclateur à gaz.

Les composants en parallèle avec la varistance susceptibles d'être affectés par cet essai doivent être déconnectés.

Pendant et après l'essai, il ne doit y avoir aucun risque d'incendie et les ***protections de l'équipement****, autre que la varistance en essai, doivent rester opérationnelles.*

G.8.3.3 Essai de surtension temporaire

L'essai de ***surtension temporaire*** *est simulé par les méthodes d'essai suivantes selon le cas:*

Une varistance ou un circuit limiteur de surtension comprenant des varistances connectées entre les conducteurs du ***réseau d'alimentation*** *et la terre, "Phase-Terre de protection" et "Neutre-Terre de protection", la* ***surtension temporaire*** *décrite ci-dessous est appliquée. La méthode d'essai et les critères de conformité sont décrits en 8.3.8.1 et 8.3.8.2 de la CEI 61643-11.*

– *Phase-Terre de protection:*
  - *supporte 1,71* $\times U_0$ *pendant 5 s.*
  - *supporte 1 200* $+ 1,1 \times U_0$ *V c.a. pendant 5 s ou se met en défaut en toute sécurité.*

– *Neutre-Terre de protection:*
  - *supporte 1 200 V c.a. pendant 200 ms.*

NOTE 1 U_0 est la tension nominale en courant alternatif du système comme défini dans la CEI 61643-11, qui est la tension nominale phase neutre (valeur efficace de la tension alternative) du système auquel l'EUT est destiné à être connecté.

Si un circuit limiteur de surtension est utilisé, l'impulsion de combinaison spécifiée en G.8.2 est appliquée avant cet essai.

Pendant l'essai, le circuit peut s'ouvrir en raison du fonctionnement d'un dispositif de protection tel qu'un fusible thermique ou éclateur à gaz.

NOTE 2 Pour les différents schémas de distribution de l'alimentation, les **surtensions temporaires** sont définies dans l'Annexe B de la CEI 61643-1.

Les composants en parallèle avec la varistance susceptibles d'être affectés par cet essai doivent être déconnectés.

G.9 Limiteurs de courant sur circuit intégré

G.9.1 Exigences

Les limiteurs de courant sur circuit intégré utilisés pour limiter le courant dans les sources d'énergie pour en faire des circuits PS1 ou PS2 ne sont pas court-circuités de l'entrée à la sortie si toutes les conditions suivantes sont réunies:

– les limiteurs de courant sur circuit intégré limitent le courant selon la valeur définie par le fabricant (ne devant pas dépasser 5 A) dans les **conditions normales de fonctionnement** en prenant en compte toute dérive spécifiée;

– les limiteurs de courant sur circuit intégré sont entièrement électroniques et n'ont aucun moyen de fonctionnement ou de réenclenchement manuel;

– ils sont alimentés par une source dont la sortie ne dépasse pas 250 VA,

– le courant de sortie est limité à 5 A ou moins;

– les limiteurs de courant sur circuit intégré limitent le courant ou la tension à la valeur requise selon la dérive définie par le fabricant, le cas échéant, après chacun des essais de conditionnement.

Au choix du fabricant, les essais de conditionnement doivent être réalisés conformément à G.9.2, G.9.3 ou G.9.4. Les limiteurs de courant sur circuit intégré qui satisfont au programme d'essai de G.9.2, G.9.3 ou G.9.4 sont considérés satisfaire aux exigences ci-dessus.

Un échantillon différent peut être utilisé pour chaque essai.

Il convient que la source d'alimentation pour les essais soit capable de fournir au moins 250 VA sauf si le limiteur de courant sur circuit intégré est soumis à essai dans le produit fini.

G.9.2 Programme d'essai 1

Le programme d'essai 1 comprend les étapes suivantes:

– *10 000 cycles en passant alternativement de l'activation à l'arrêt, avec une résistance de 100 $\Omega \pm 5\ \Omega$ et un condensateur de 425 μF$\pm$ 10 μF en parallèle avec la borne de sortie;*

– *10 000 cycles en passant alternativement de l'activation à l'arrêt, avec une inductance à noyau magnétique de 0,35 mH $\pm$ 0,1 mH à 1 kHz, ainsi qu'une résistance de courant continu ne dépassant pas 1 Ω;*

– *10 000 cycles en passant alternativement de l'activation à l'arrêt alors que la borne d'entrée est connectée à un condensateur assigné à 425 μF $\pm$ 1 μF et que la borne de sortie est court-circuitée;*

– *10 000 cycles en passant alternativement de l'activation à l'arrêt de la broche d'entrée alors qu'un condensateur assigné à 425 μF $\pm$ 1 μF à l'alimentation d'entrée permet l'activation et le court-circuitage de la borne de sortie;*

– *10 000 cycles en passant alternativement de l'activation à l'arrêt de la broche d'entrée, avec une inductance à noyau magnétique de 0,35 mH $\pm$ 0,1 mH à 1 kHz, ainsi qu'une résistance de courant continu ne dépassant pas 1 Ω connectée à l'alimentation d'entrée permettant l'activation et le court-circuitage de la borne de sortie;*

– *50 cycles en maintenant la broche d'activation active et en court-circuitant la borne de sortie, chaque cycle consistant à court-circuiter la borne de sortie, puis à ouvrir la borne de sortie;*

– *50 cycles en maintenant la broche d'activation active et en court-circuitant la borne de sortie, en alternant activation et arrêt du courant;*

– *50 cycles en maintenant la broche d'activation active, en activant l'alimentation et en court-circuitant la borne de sortie; arrêter l'alimentation, activer l'alimentation, retirer le court-circuit, retirer l'alimentation.*

G.9.3 Programme d'essai 2

Le programme d'essai 2 comprend les étapes suivantes:

– *50 cycles en maintenant la broche d'activation active et en court-circuitant la borne de sortie; chaque cycle consistant à court-circuiter la borne de sortie, puis à ouvrir la borne de sortie;*

– *50 cycles en maintenant la broche d'activation active et en court-circuitant la borne de sortie, en alternant activation et arrêt du courant;*

- *50 cycles en maintenant la broche d'activation active en chargeant la borne de sortie à la puissance maximale, en alternant activation et arrêt de l'alimentation;*
- *50 cycles en maintenant la broche d'activation active en appliquant la puissance, chaque cycle consistant à court-circuiter la borne de sortie, arrêter l'alimentation, réappliquer l'alimentation, retirer le court-circuit, suivi par le retrait de l'alimentation;*
- *3 cycles en exposant le dispositif (non alimenté) à 70 °C ± 2 °C pendant 24 h; suivi d'au moins 1 h à température ambiante; suivi d'au moins 3 h à -30 °C ± 2 °C; suivi de 3 h à la température ambiante;*
- *10 cycles en exposant le dispositif (alimenté) à 50 °C ± 2 °C pendant 10 min; suivi de 10 min à 0 °C ± 2 °C comprenant une période de transition d'un état à l'autre de 5 min.*
- *7 jours avec la borne de sortie en court-circuit et le dispositif enveloppé dans une double couche d'**étamine**. Un fusible à fusion rapide 5 A maintenu en série avec la borne de sortie ne doit pas ouvrir et un ampèremètre ne doit présenter aucun courant de plus de 5 A.*

G.9.4 Programme d'essai 3

Le programme d'essai 3 comprend les étapes suivantes:

- *Le paragraphe H.17.1.4.2 de la CEI 60730-1:2010;*
- *10 000 cycles en passant alternativement de l'activation à l'arrêt, avec une résistance de 100 Ω et un condensateur de 425 μF en parallèle avec la borne de sortie;*
- *10 000 cycles en passant alternativement de l'activation à l'arrêt, avec une inductance à noyau magnétique de 0,35 mH ± 0,1 mH à 1 kHz ainsi qu'une résistance de courant continu ne dépassant pas 1 Ω connectée au circuit de sortie;*
- *10 000 cycles en passant alternativement de l'activation à l'arrêt alors que la borne d'entrée est connectée à un condensateur assigné à 425 μF et que la borne de sortie est court-circuitée;*
- *10 000 cycles en passant alternativement de l'activation à l'arrêt de la broche d'entrée alors qu'un condensateur assigné à 425 μF à l'alimentation d'entrée permet l'activation et le court-circuitage de la borne de sortie;*
- *10 000 cycles en passant alternativement de l'activation à l'arrêt de la broche d'entrée, avec une inductance à noyau magnétique de 0,35 mH ± 0,1 à 1 kHz ainsi qu'une résistance de courant continu ne dépassant pas 1 Ω connectée à l'alimentation d'entrée permettant l'activation et le court-circuitage de la borne de sortie;*
- *50 cycles en maintenant la broche d'activation active et en court-circuitant la borne de sortie, en alternant activation et arrêt de l'alimentation;*
- *50 cycles en maintenant la broche d'activation active en chargeant la borne de sortie à la puissance maximale, en alternant activation et arrêt de l'alimentation;*
- *50 cycles en maintenant la broche d'activation active en appliquant la puissance, court-circuiter la borne de sortie, arrêter l'alimentation, appliquer l'alimentation, retirer le court-circuit, retirer l'alimentation;*
- *3 cycles en exposant le dispositif (non alimenté) à 70 °C pendant 24 h; suivi d'au moins 1 h à température ambiante; suivi d'au moins 3 h à –30 °C; suivi de 3 h à la température ambiante;*
- *10 cycles en exposant le dispositif (alimenté) à 49 °C pendant 10 min; suivi de 10 min à 0 °C comprenant une période de transition d'un état à l'autre de 5 min.*

G.9.5 Critères de conformité

Après chacun des essais ci-dessus, le dispositif doit limiter le courant conformément aux spécifications applicables ou le dispositif doit devenir en circuit ouvert. Le dispositif en circuit ouvert est remplacé par un nouvel échantillon et les essais sont poursuivis selon le cas.

G.10 Résistances

G.10.1 Généralités

Si requis en 5.5.6, dix échantillons sont soumis à essai pour l'essai de résistance de G.10.2. Un échantillon correspond à une seule résistance si elle est utilisée seule, ou un groupe de résistances en série.

G.10.2 Essai de résistance

Avant l'essai, la résistance des dix échantillons est mesurée.

Les échantillons doivent être soumis à l'essai de chaleur humide conformément à la CEI 60068-2-78, comprenant les détails suivants:

– température: 40 °C ± 2 °C;

– humidité: humidité relative de (93 % ± 3) %;

– durée d'essai: 21 jours;

Chaque échantillon est ensuite soumis à 10 impulsions de polarité alternée, à l'aide du générateur d'essai de chocs du circuit 2 dans le Tableau D.1. L'intervalle entre les impulsions successives est de 60 s, et U_c est égal à la ***tension de tenue requise*** *applicable.*

Après l'essai, la résistance de chacun des échantillons ne doit pas avoir varié de plus de 10%. Aucun défaut n'est autorisé.

La valeur de résistance la plus basse parmi les dix échantillons est utilisée pour mesurer le courant afin de déterminer la conformité avec les termes cités dans le Tableau 4.

NOTE Si une résistance ou un groupe de résistances est connecté entre un circuit alimenté par le **réseau d'alimentation** et le câble coaxial, G.10.3 s'applique.

G.10.3 Résistances servant de protections entre le réseau d'alimentation et un circuit externe sous la forme d'un câble coaxial

G.10.3.1 Généralités

Les exigences d'essai pour les résistances en parallèle sur l'isolation entre le **réseau d'alimentation** et un **circuit externe** sous la forme d'un câble coaxial et qui assurent que leurs valeurs ne changent pas de manière significative sur le long terme sont données ci-dessous.

Dix échantillons de résistances (un échantillon correspondant à une seule résistance utilisée seule ou à un groupe de résistances en série) sont soumis à l'essai de conditionnement de G.10.2, suivi de l'essai de G.10.3.2 ou de G.10.3.3, selon le cas.

G.10.3.2 Essai de tension de choc

Chaque échantillon est soumis à 50 décharges provenant du générateur d'essai de chocs du circuit 3 du Tableau D.1, limité à 12 décharges par minute, où U_c est égal à 10 kV si l'échantillon de résistance est connecté au câble coaxial, lui-même connecté à l'antenne (voir le Tableau 14).

G.10.3.3 Essai de choc

Chaque échantillon est soumis à 10 impulsions provenant du générateur d'essai de chocs du circuit 1 du Tableau D.1, où U_c est égal à 4 kV ou 5 kV de polarité alternée avec un intervalle de 60 s au minimum entre les impulsions, selon le cas (voir le Tableau 14).

G.10.3.4 Critères de conformité

À la suite des essais de G.10.3.2 ou G.10.3.3, la résistance de chaque échantillon ne doit pas avoir varié de plus de 20 %. Aucun défaut n'est autorisé.

G.11 Condensateurs et cellules RC

G.11.1 Généralités

Les exigences ci-dessous spécifient les critères de conditionnement pour les essais sur les condensateurs et les cellules RC ou les composants discrets formant une cellule RC et servant de **protections**. Il indique également les critères de sélection pour les condensateurs et les cellules RC conformes à la CEI 60384-14.

G.11.2 Conditionnement des condensateurs et des cellules RC

Si requis en 5.5.2.1, le conditionnement suivant est appliqué pour l'évaluation d'un condensateur ou d'une cellule RC selon les exigences de la CEI 60384-14.

La durée de l'essai en chaleur humide constante, spécifié en 4.12 de la CEI 60384-14:2005, doit être de 21 jours, à une température de (40 ± 2) °C et une humidité relative de (93 ± 3) %.

Les condensateurs soumis à une durée supérieure à 21 jours pendant l'essai décrit ci-dessus sont considérés comme acceptables.

G.11.3 Règles à appliquer pour sélectionner des condensateurs

La sous-classe appropriée du condensateur doit être sélectionnée parmi celles de la liste du Tableau G.8, conformément aux règles d'application indiquées dans ce tableau.

Tableau G.8 – Valeurs assignées des condensateurs selon la CEI 60384-14

Sous-classe du condensateur selon la CEI 60384-14	Tension assignée du condensateur V efficace	Tension d'essai de choc d'essai de type du condensateur kV crête	Tension d'essai efficace d'essai de type du condensateur kV efficace
Y1	Jusqu'à 500 inclus	8	4
Y2	Supérieur à 150 et jusqu'à 300 inclus	5	1,5
Y4	Jusqu'à 150 inclus	2,5	0,9
X1	Jusqu'à 760 inclus	4 [a]	-
X2	Jusqu'à 760 inclus	2,5 [a]	-

Règles pour l'application de ce tableau.

1 La valeur assignée de la tension du condensateur doit être au moins égale à la **tension de service efficace** au sein de l'isolation mise en parallèle, déterminée selon 5.4.1.8.2.

2 Pour un seul condensateur (de type X) utilisé comme **isolation fonctionnelle**, un défaut du condensateur ne doit pas provoquer un défaut de la **protection** et la tension d'essai de choc de l'**essai de type** doit être au moins égale à la **tension de tenue requise**.

3 Un condensateur de classe supérieure à celui spécifié peut être utilisé, comme suit:

- de sous-classe Y1 si la sous-classe Y2 est spécifiée;
- de sous-classe Y1 ou Y2 si la sous-classe Y4 est spécifiée;
- de sous-classe Y1 ou Y2 si la sous-classe X1 est spécifiée;
- de sous-classe X1, Y1 ou Y2 si la sous-classe X2 est spécifiée.

4 Deux condensateurs ou plus peuvent être utilisés en série à la place d'un seul condensateur spécifié, de la manière suivante:

- de sous-classe Y1 ou Y2 si la sous-classe Y1 est spécifiée;
- de sous-classe Y2 ou Y4 si la sous-classe Y2 est spécifiée;
- de sous-classe X1 ou X2 si la sous-classe X1 est spécifiée.

5 Si deux condensateurs ou plus sont utilisés en série, ils doivent être conformes à 5.5.2.1 lorsque c'est applicable, et se conformer également aux autres règles susmentionnées.

[a] Pour les valeurs de capacité supérieures à 1 µF, cette tension d'essai est diminuée par un facteur de $\sqrt{C}$, où C est la valeur de capacité en µF.

G.11.4 Exemples de l'application des condensateurs

Le Tableau G.9 présente des exemples pour le nombre de condensateurs Y requis pour la mise en parallèle de l'**isolation principale**, l'**isolation supplémentaire** ou l'**isolation renforcée** basée sur la **tension de tenue requise**. Le Tableau G.10 présente la tension maximale pouvant apparaître aux bornes d'un condensateur Y sur la base de la **valeur crête de la tension de service**.

Le Tableau G.11 donne des exemples pour le nombre de condensateurs Y requis pour la mise en parallèle de l'**isolation principale** et de l'**isolation renforcée** basée sur les **surtensions temporaires**. Le Tableau G.12 présente des exemples de l'application des condensateurs X sélectionnés conformément au Tableau G.8.

Tableau G.9 – Exemples de l'application des condensateurs Y basés sur les tensions d'essai du Tableau 26

Tension d'alimentation du réseau d'alimentation en courant alternatif **jusque et y compris** V efficace	**Catégorie de surtension**	**Tension transitoire du réseau d'alimentation** kV	**Isolation mise en parallèle**	**Type de condensateur**	**Nombre de condensateurs requis**
150	II	1,5	B ou S	Y2	1
	II	1,5	D ou R	Y2	2
	II	1,5	D ou R	Y1	1
	III	2,5	B ou S	Y2	2
	III	2,5	D ou R	Y1	1
	IV	4,0	B ou S	Y1	1
	IV	4,0	D ou R	Y1	2
300	II	2,5	B ou S	Y2	2
	II	2,5	D ou R	Y1	1
	II	2,5	D ou R	Y2	2
	III	4,0	B ou S	Y1	1
	III	4,0	B ou S	Y2	2
	III	4,0	D ou R	Y1	2
	III	4,0	D ou R	Y2	3
	IV	6,0	B ou S	Y1	2
	IV	6,0	D ou R	Y1	2
500	II	4,0	B ou S	Y1	1
	II	4,0	D ou R	Y1	2
	III	6,0	B ou S	Y1	2
	III	6,0	D ou R	Y1	2
	IV	8,0	B ou S	Y1	2
	IV	8,0	D ou R	Y1	3
B **isolation principale** S **isolation supplémentaire**			D **double isolation** R **isolation renforcée**		

Tableau G.10 – Exemples de l'application des condensateurs Y basés sur les tensions d'essai du Tableau 27

Type de condensateur	Isolation mise en parallèle	Valeur crête de la tension de service aux bornes du condensateur ne devant pas dépasser kV
Tout type [a]	B	Les condensateurs situés dans les circuits isolés du **réseau d'alimentation** [b], doivent satisfaire à l'essai de rigidité diélectrique de 5.4.9.1
Y4	B ou S	0,978
Y4	D ou R	0,795
Y2	B ou S	1,631
Y2	D ou R	1,325
Y1	B ou S	4,350
Y1	D ou R	3,535

[a] Pour les condensateurs qui mettent en parallèle l'**isolation principale** et sont situés dans les circuits isolés du **réseau d'alimentation**, voir 5.5.2.1.

[b] Pour l'application du condensateur Y situé dans les circuits connectés au **réseau d'alimentation**, voir le Tableau G.9 et le Tableau G.11.

B **isolation principale**

S **isolation supplémentaire**

D **double isolation**

R **isolation renforcée**

Tableau G.11 – Exemples de l'application des condensateurs Y basés sur les tensions d'essai du Tableau 28

Tension nominale du réseau d'alimentation V efficace **jusque et y compris**	Isolation mise en parallèle	Type de condensateur	Nombre de condensateurs
250	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 **isolation principale**

R **isolation renforcée**

Tableau G.12 – Exemples de l'application des condensateurs X, entre phases ou phase-neutre

Tension d'alimentation du réseau d'alimentation en courant alternatif **jusque et y compris** V efficace	**Catégorie de surtension**	**Tension transitoire du réseau d'alimentation** kV	**Type de condens ateur**	**Nombre de condensateurs requis basé sur la tension de tenue requise**
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.12 Optocoupleurs

Les optocoupleurs doivent être conformes aux exigences de la CEI 60747-5-5:2007. Dans l'application de la CEI 60747-5-5:2007.

– l'**essai de type** tel que spécifié en 7.4.3 de la CEI 60747-5-5:2007 doit être réalisé avec une tension $V_{\text{ini,a}}$ au moins égale à la tension d'essai appropriée de 5.4.9.1 de la présente norme, et

– l'**essai individuel de série** tel que spécifié en 7.4.1 de la CEI 60747-5-5:2007 doit être réalisé avec une tension $V_{\text{ini,b}}$ au moins égale à la tension d'essai appropriée de 5.4.9.2 de la présente norme.

G.13 Cartes imprimées

G.13.1 Généralités

Les exigences relatives à l'**isolation principale, l'isolation supplémentaire, l'isolation renforcée** et la **double isolation** sur les cartes imprimées sont spécifiées ci-dessous.

Les exigences s'appliquent également aux enroulements d'un transformateur planaire.

G.13.2 Cartes imprimées sans revêtement

L'isolation entre les conducteurs les surfaces extérieures d'une carte imprimée sans revêtement doit être conforme aux exigences de la **distance dans l'air** minimale en 5.4.2 et aux exigences de la **ligne de fuite** minimale de 5.4.3.

La conformité est vérifiée par examen et par des mesures.

G.13.3 Cartes imprimées avec revêtement

Les exigences relatives aux distances de séparation avant que les cartes ne soient revêtues sont spécifiées ci-dessous.

Une autre méthode de qualification des cartes imprimées avec revêtement est donnée dans la CEI 60664-3.

Pour les cartes imprimées dont les surfaces extérieures sont à revêtir avec un matériau de revêtement convenable, les distances de séparation minimales du Tableau G.13 s'appliquent aux parties conductrices avant qu'elles ne soient revêtues.

La **double isolation** et l'**isolation renforcée** doivent satisfaire aux **essais individuels de série** concernant la rigidité diélectrique en 5.4.9.2.

L'une ou les deux parties conductrices et les distances entières sur la surface entre les parties conductrices doivent être revêtues.

Les **distances dans l'air** minimales de 5.4.2, ainsi que les **lignes de fuite** minimales de 5.4.3 doivent s'appliquer:

– si les conditions ci-dessus ne sont pas satisfaites;
– entre deux parties conductrices sans revêtement; et
– sur l'extérieur du revêtement.

La conformité est vérifiée par examen et par des mesures, en tenant compte des Figures O.11 et O.12, ainsi que par l'exécution des essais de G.13.6.

Tableau G.13 – Distances de séparation minimales pour les cartes imprimées avec revêtement

Valeur crête de la tension de service jusque et y compris V en valeur crête	**Isolation principale ou supplémentaire** mm	**Isolation renforcée** 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
Une interpolation linéaire peut être utilisée entre les deux points les plus proches, l'espacement calculé étant arrondi au 0,1 mm supérieur suivant.		
[a] Il n'est pas nécessaire d'effectuer l'essai de G.13.6.		

G.13.4 Isolation entre des conducteurs situés sur la même surface interne

Les exigences applicables à l'isolation sur la même couche interne d'une carte multicouche sont spécifiées ci-dessous.

Sur une surface interne d'une carte imprimée multicouche (voir la Figure O.17), le chemin entre deux conducteurs doit être conforme aux exigences applicables à un joint scellé en 5.4.4.5.

G.13.5 Isolation entre des conducteurs se trouvant sur des surfaces différentes

Les exigences applicables à l'isolation sur les différentes couches d'une carte multicouches sont spécifiées ci-dessous.

Pour une **isolation principale**, il n'existe aucune exigence d'épaisseur.

L'**isolation supplémentaire** ou l'**isolation renforcée** entre des parties conductrices se trouvant sur des surfaces différentes dans des cartes imprimées monocouche double face, dans des cartes imprimées multicouches et dans des cartes imprimées à noyau métallique, doit soit présenter une épaisseur minimale de 0,4 mm fournie par une seule couche, soit être conforme à l'une des spécifications et satisfaire aux essais correspondants du Tableau G.14.

Tableau G.14 – Isolation dans les cartes imprimées

Spécification d'isolation	Essais de type [a]	Essais individuels de série pour la rigidité diélectrique [c]
Deux couches de matériau isolant en fine feuille, y compris le prépeg [b]	Non	Oui
Trois couches ou plus de matériau isolant en fine feuille, y compris le prépeg [b]	Non	Non
Un système d'isolation présentant un revêtement en céramique sur un substrat métallique, traité à $\geq$ 500 °C	Non	Oui
Un système d'isolation, avec deux revêtements ou plus autres que de la céramique sur un substrat métallique, traité à $<$ 500 °C	Oui	Oui
NOTE 1 Prépeg est le terme utilisé pour une couche de tissu de verre imprégné d'une résine préconditionnée. NOTE 2 Pour une définition de céramique, voir CEI 60050-212:2010, 212-15-25).		
[a] Conditionnement thermique de G.13.6.2 suivi de l'essai de rigidité diélectrique de 5.4.9.1. [b] Les couches sont comptées avant le traitement. [c] L'essai de rigidité diélectrique est réalisé sur la carte imprimée finie.		

G.13.6 Essais sur des cartes imprimées avec revêtement

G.13.6.1 Préparation des échantillons et examen préliminaire

Trois cartes imprimées échantillon (ou, pour les composants avec revêtement de G.14, deux composants et une carte) identifiées comme les échantillons 1, 2 et 3 sont nécessaires. Des cartes réelles ou des échantillons produits à cet effet avec un revêtement représentatif et des séparations minimales peuvent être utilisé(e)s. Chaque carte échantillon doit être représentative des séparations minimales utilisées, et doit avoir un revêtement. Chaque échantillon est soumis à la séquence complète des processus de fabrication, y compris à la soudure et au nettoyage, à laquelle il est normalement soumis pendant l'assemblage de l'équipement.

Lors de l'examen visuel, les cartes ne doivent présenter ni micro trous ni bulles dans le revêtement ni rupture des pistes conductrices aux coins.

G.13.6.2 Méthode d'essai et critères de conformité

L'échantillon 1 est soumis à la séquence de cycles thermiques de 5.4.1.5.3.

L'échantillon 2 est vieilli dans une étuve ventilée à la température et selon la durée choisie dans le graphique indiqué à la Figure G.2, en utilisant la ligne d'indice de température correspondant à la température de fonctionnement maximale de la carte avec revêtement. La température de l'étuve est maintenue à la température spécifiée ± 2 °C. La température utilisée pour déterminer la ligne d'indice de température est la température la plus élevée sur la carte lorsque la sécurité est impliquée.

Lors de l'utilisation de la Figure G.2, l'interpolation peut être utilisée entre les deux lignes d'indice de température les plus proches.

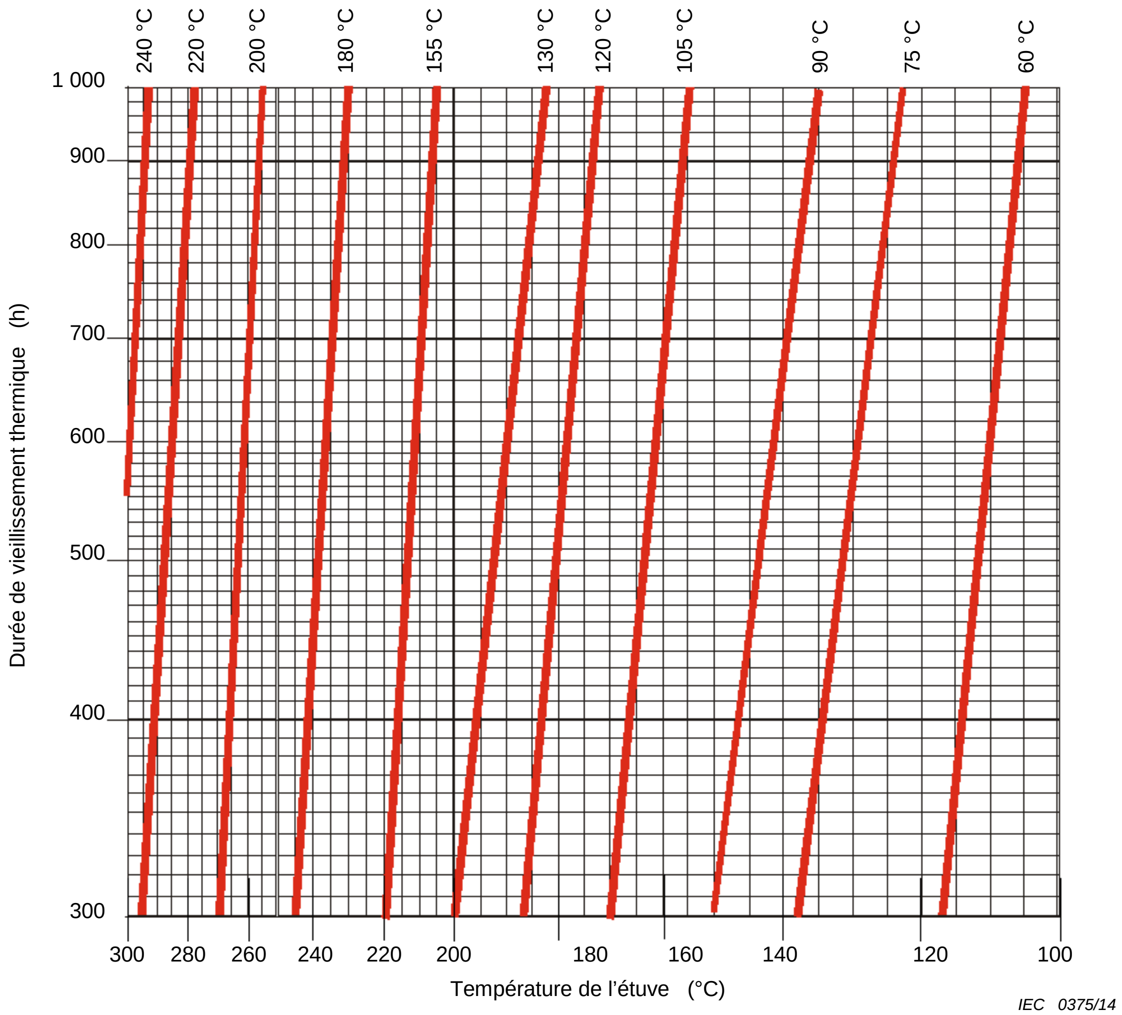


Figure G.2 – Durée de vieillissement thermique

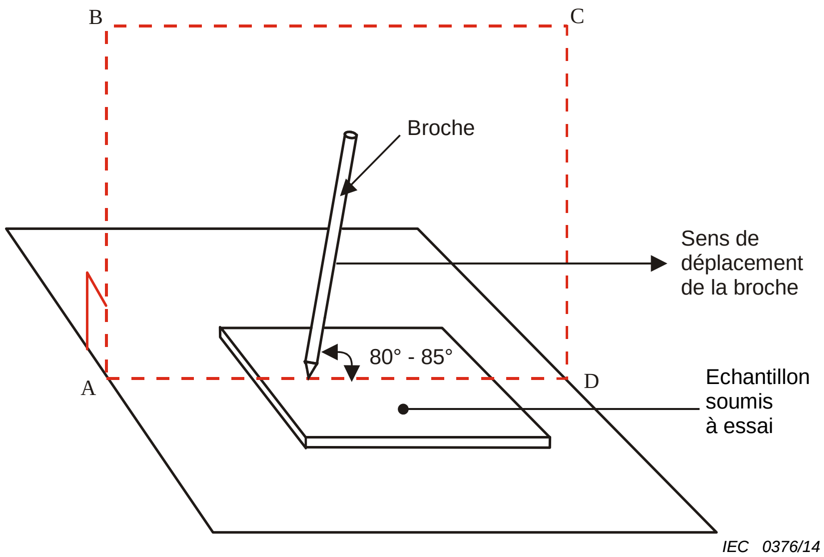
Les échantillons 1 et 2 sont ensuite soumis à l'épreuve hygroscopique de 5.4.8 et doivent supporter l'essai de rigidité diélectrique de 5.4.9.1 entre conducteurs.

La carte échantillon 3 est soumise à l'essai de résistance à l'abrasion suivant.

Des rayures sont effectuées sur cinq paires de parties conductrices et les séparations intermédiaires aux points où les séparations sont soumises à la différence de potentiel maximale pendant les essais.

Les rayures sont effectuées au moyen d'une broche en acier trempé, dont l'extrémité a la forme d'un cône ayant un angle au sommet de 40°, la pointe étant arrondie et polie, avec un rayon de 0,25 mm ± 0,02 mm.

Les rayures sont effectuées en déplaçant la broche le long de la surface dans un plan perpendiculaire aux arêtes du conducteur à une vitesse de 20 mm/s ± 5 mm/s comme indiqué dans la Figure G.3. La broche est appuyée de telle sorte que la force exercée le long de son axe est de 10 N ± 0,5 N. Les rayures doivent être espacées d'au moins 5 mm et se trouver au moins à 5 mm du bord de l'échantillon.



NOTE La broche se trouve dans le plan ABCD perpendiculaire à l'échantillon soumis à essai.

Figure G.3 – Essai de résistance à l'abrasion pour couches de revêtement

Après l'essai, la couche de revêtement ne doit pas s'être relâchée ni avoir été percée. Le revêtement doit supporter un essai de rigidité diélectrique comme spécifié en 5.4.9.1 entre conducteurs. Dans le cas de cartes imprimées à noyaux métalliques, le substrat est l'un des conducteurs.

NOTE Si une contrainte mécanique ou une courbure est appliquée à la carte, des essais supplémentaires permettant d'identifier les fissures peuvent être nécessaires (voir la CEI 60664-3).

G.14 Revêtements sur les bornes des composants

G.14.1 Exigences

Les exigences pour les revêtements sur les bornes des composants et éléments analogues, où le revêtement est utilisé pour réduire les **distances dans l'air** et les **lignes de fuite** sont spécifiées ci-dessous.

Les revêtements peuvent être utilisés sur des extrémités extérieures de composants afin d'augmenter les **distances dans l'air** et les **lignes de fuite** efficaces (voir la Figure O.11). Les distances de séparation minimales du Tableau G.13 s'appliquent au composant avant revêtement, et le revêtement doit satisfaire à toutes les exigences de G.13.3. La disposition mécanique et la rigidité des extrémités doivent être appropriées afin de s'assurer que, au cours d'une manipulation normale, de l'assemblage dans l'équipement et de l'utilisation ultérieure, les extrémités ne sont pas soumises à une déformation entraînant la fissuration du revêtement ou la réduction des distances de séparation entre les parties conductrices en dessous des valeurs du Tableau G.13 (voir G.13.3).

G.14.2 Méthode d'essai et critères de conformité

La conformité est vérifiée par examen en prenant en compte la Figure O.11 et en appliquant la séquence d'essais traités en G.13.3. Ces essais sont réalisés sur un assemblage achevé comprenant le(s) composant(s).

L'essai de résistance à l'abrasion de G.13.6.2 est réalisé sur une carte imprimée échantillon préparée à cet effet comme décrit pour l'échantillon 3 en G.13.6.1, sauf que la séparation entre les parties conductrices doit être représentative des séparations minimales et des différences de potentiel maximales utilisées dans l'ensemble.

G.15 Composants remplis de liquide sous pression (LFC)

G.15.1 Généralités

Les exigences de construction et d'essai pour les LFC sous pression utilisés au sein de l'équipement afin d'éviter toute blessure provoquée par des fuites de liquide dans le LFC au sens de la présente norme sont spécifiées ci-dessous.

Le présent paragraphe ne s'applique pas

– à un LFC étanche mais ouvert à l'atmosphère dans l'équipement; ou
– aux composants contenant des petites quantités de liquides non susceptibles d'engendrer une blessure (par exemple, écrans à cristaux liquides, condensateurs électrolytiques, caloducs refroidisseurs de liquide, etc.); ou
– aux **batteries à piles** liquides, (voir l'Annexe M).
– à un LFC et ses parties associées qui sont conformes à P.3.3.

G.15.2 Exigences

Un LFC situé à l'intérieur de l'équipement doit être conforme à toutes les exigences suivantes:

– les liquides inflammables ou conducteurs doivent être stockés dans un récipient et le LFC doit être conforme aux essais de G.15.3.3, G.15.3.4, G.15.3.5 et G.15.3.6;
– le liquide doit être fourni avec une protection conformément à l'Article 7 (substances dangereuses);
– les parties non métalliques du système de récipient doivent supporter les essais de G.15.3.1 et de G.15.3.2;
– le LFC doit être monté à l'intérieur de l'équipement d'une telle façon que les tubes ne doivent pas entrer en contact avec des arêtes vives ou toute autre surface pouvant les endommager et si le LFC éclate ou relâche de la pression, le fluide ne peut pas entrer en contact avec les parties ES3.

L'ordre des essais n'est pas spécifié. Les essais peuvent être réalisés sur des échantillons séparés, sauf dans le cas de l'essai de G.15.3.2 devant être suivi de l'essai de G.15.3.1.

G.15.3 Méthodes d'essai et critères de conformité

G.15.3.1 Essai de pression hydrostatique

La conformité est vérifiée par évaluation des données disponibles ou par l'essai suivant. Un LFC à l'air libre ou non pressurisé (par exemple, une cartouche d'encre) n'est pas soumis à cet essai.

Un échantillon de LFC est soumis à un essai de pression hydrostatique pendant 2 min à température ambiante et à la pression la plus élevée, comme suit:

– *cinq fois la pression de service maximale spécifiée par le fabricant mesurée à la température maximale atteinte dans les **conditions normales de fonctionnement**; et*
– *trois fois la pression de service maximale mesurée à la température maximale atteinte pendant l'application des **conditions anormales de fonctionnement** de l'Article B.3 et des **conditions de premier défaut** de l'Article B.4.*

G.15.3.2 Essai de résistance au fluage

Deux échantillons du LFC, dont une ou plusieurs parties sont fabriquées à partir de matériaux non métalliques, doivent être conditionnés pendant 14 jours à une température de 87 °C et placés dans une étuve entièrement ventilée. À la suite de ce conditionnement, le système doit être conforme à l'essai de G.15.3.1 et les parties non métalliques ne doivent montrer aucun signe de détérioration tel que des fissures et une fragilisation.

G.15.3.3 Essai de compatibilité entre les tubes et les fixations

Dix échantillons constitués du matériau utilisé pour les tubes et les fixations associées au LFC, dont une ou plusieurs parties sont fabriquées à partir de matériaux non métalliques, doivent être soumis à un essai de résistance à la traction conformément à la série ISO 527. Cinq échantillons doivent être soumis à essai dans l'état de livraison puis les cinq échantillons restant après un essai de conditionnement pendant 40 jours à 38 °C dans une étuve entièrement ventilée ou dans un bain-marie, rempli avec le liquide prévu et maintenu à 38 °C. La pression interne des ensembles est maintenue à la pression atmosphérique. La résistance à la traction après le conditionnement ne doit pas être inférieure à 60 % de la résistance à la traction avant l'essai.

G.15.3.4 Essai de vibrations

Un échantillon du LFC ou de l'équipement contenant le LFC doit être fixé dans une position normale d'utilisation au générateur de vibrations, comme spécifié dans la CEI 60068-2-6 au moyen de vis, de pinces ou de courroies passées autour du composant. La direction des vibrations est verticale, et la sévérité est la suivante:

– *durée:* *30 min;*
– *amplitude:* *0,35 mm;*
– *gamme de fréquences:* *10 Hz, 55 Hz, 10 Hz;*
– *vitesse de balayage:* *approximativement une octave par minute.*

G.15.3.5 Essai de cycles thermiques

*Un échantillon du LFC est soumis à trois cycles de conditionnement pendant 7 h à une température de 10 °C au-dessus de la température maximale obtenue dans les **conditions normales de fonctionnement**, les **conditions anormales de fonctionnement** de l'Article B.3, et les **conditions de premier défaut** de l'Article B.4, suivi d'un maintien à la température ambiante pendant 1 h.*

NOTE Le LFC n'est pas alimenté pendant l'essai ci-dessus.

G.15.3.6 Essai de force

*Un échantillon du LFC est soumis aux essais de l'Article T.2 (essai de 10 N appliqué aux fixations **accessibles** à une **personne qualifiée**) et l'Article T.3 (essai de 30 N appliqué à des fixations **accessibles** à une **personne avertie** ou à une **personne ordinaire**).*

G.15.4 Critères de conformité

La conformité est vérifiée par examen et évaluation des données disponibles ou par les essais de G.15.3. Pendant et après ces essais, il ne doit y avoir aucune rupture, fuite ou relâchement de toute connexion ou partie.

G.16 IC incluant une fonction de décharge de condensateur (ICX)

G.16.1 Exigences

Un ICX et les composants associés indispensables pour la fonction de décharge d'un condensateur à une partie **accessible** (tel que le condensateur du **réseau d'alimentation**) ne sont pas soumis à un essai de défaut si l'une des conditions suivantes est remplie:

– l'ICX avec les circuits associés tels qu'ils sont fournis dans l'équipement satisfait aux essais de G.16.2. Tout composant atténuant les impulsions (tel que les varistances et les GDT) vers l'ICX et les circuits associés est déconnecté. Si les composants de décharge externes à l'ICX sont nécessaires, ils ne doivent pas connaître de défaillance pendant les essais; ou

– l'ICX soumis séparément à essai est conforme aux exigences de G.16.2. Si les composants de décharge externes à l'ICX sont nécessaires:
  - ils doivent être inclus dans l'essai de G.16.2, et
  - ils ne doivent pas connaître de défaillance pendant les essais, et
  - les composants de décharge utilisés dans l'équipement doivent être dans la gamme soumise à essai.

G.16.2 Essais

Lorsque l'ICX est soumis à l'essai par lui-même, le montage d'essai doit être tel que recommandé par le fabricant de l'ICX.

– *épreuve hygroscopique du 5.4.8 pendant 120 h.*

– *100 impulsions positives et 100 impulsions négatives entre phase et neutre en utilisant un condensateur ayant la capacité la plus élevée et une résistance avec la résistance la plus faible spécifiées par le fabricant de l'ICX; répétition avec un condensateur avec la capacité la plus faible et la résistance ayant la résistance la plus élevée. Le délai qui s'écoule entre deux impulsions quelconques ne doit pas être inférieur à 1 s. L'impulsion doit être telle que cela est spécifié dans le circuit 2 du Tableau D.1 avec* U_c *égal à la tension transitoire.*

– *Application d'une tension alternative égale à 110 % de la* ***tension assignée*** *pendant 2,5 minutes.*

– *10 000 cycles en alternant mise sous tension et arrêt en utilisant un condensateur avec la capacité la plus faible et une résistance avec la résistance la plus élevée comme spécifié par le fabricant de l'ICX. La durée des cycles sous tension et arrêt ne doit pas être inférieure à 1 s.*

Si un des composants des circuits associés autres que ceux indispensables pour la fonction de décharge connaît une défaillance, il est admis de le remplacer par un nouveau composant.

G.16.3 Critères de conformité

La conformité est vérifiée par l'évaluation des données disponibles ou en réalisant les essais ci-dessus. L'essai de décharge de condensateur est réalisé à l'issue des essais ci-dessus, en s'assurant que l'ICX ou l'EUT équipé de l'ICX continue d'assurer la fonction de ***protection****.*

NOTE Il convient que l'évaluation des données disponibles inclue des informations sur la défaillance de n'importe quel composant des circuits associés qui maintient le mode de décharge dans le mode marche/arrêt.

Annexe H
(normative)

Critères applicables aux signaux de sonnerie de téléphone

H.1 Généralités

Les deux méthodes alternatives décrites dans cette annexe reflètent les expériences satisfaisantes dans différentes régions du monde. La Méthode A est typique des réseaux téléphoniques analogiques en Europe et la Méthode B, de ceux en Amérique du Nord. Les deux méthodes mènent à des normes de sécurité électrique qui sont largement équivalentes.

H.2 Méthode A

Cette méthode nécessite que les courants I_{TS1} et I_{TS2} traversant une résistance de 5 000 Ω, placée entre deux conducteurs quelconques ou entre un conducteur et la terre de protection, ne dépassent pas les limites spécifiées, comme suit.

a) *Pour les **conditions normales de fonctionnement**, I_{TS1}, le courant déterminé à partir du courant calculé ou mesuré pour toute période de sonnerie active unique t_1 (telle que définie dans la Figure H.1), ne dépasse pas:*

   – *pour des signaux cadencés ($t_1 < \infty$), le courant indiqué par la courbe de la Figure H.2 à t_1;*

   – *pour une sonnerie continue ($t_1 = \infty$), 16 mA.*

   I_{TS1}, en mA, est tel que donné par

$$I_{TS1} = \frac{I_p}{\sqrt{2}} \qquad \textit{pour} \ (t_1 \leq 600\ \text{ms})$$

$$I_{TS1} = \frac{t_1 - 600}{600} \times \frac{I_{pp}}{2\sqrt{2}} + \frac{1200 - t_1}{600} \times \frac{I_p}{\sqrt{2}} \qquad \textit{pour} \ (600\ \text{ms} < t_1 < 1200\ \text{ms})$$

$$I_{TS1} = \frac{I_{pp}}{2\sqrt{2}} \qquad \textit{pour} \ (t_1 \geq 1200\ \text{ms})$$

   où

   I_p *est le courant crête, en mA, de la forme d'onde applicable indiquée dans la Figure H.3;*

   I_{pp} *est le courant crête à crête, en mA, de la forme d'onde applicable indiquée dans la Figure H.3;*

   t_1 *est exprimé en ms.*

b) *Pour les **conditions normales de fonctionnement**, I_{TS2}, le courant moyen pour des pointes répétées d'un signal de sonnerie cadencé calculé pour un cycle de sonnerie cadencée t_2 (tel que défini dans la Figure H.1), ne dépasse pas 16 mA en valeur efficace.*

   I_{TS2} en mA est donné par

$$I_{TS2} = \left[\frac{t_1}{t_2} \times I_{TS1}^2 + \frac{t_2 - t_1}{t_2} \times \frac{I_{dc}^2}{3{,}75^2} \right]^{1/2}$$

   où

   I_{TS1} *en mA, est tel qu'indiqué dans H.2 a);*

I_{dc} *est le courant continu en mA traversant la résistance de 5 000 Ω pendant la période non active du cycle cadencé;*

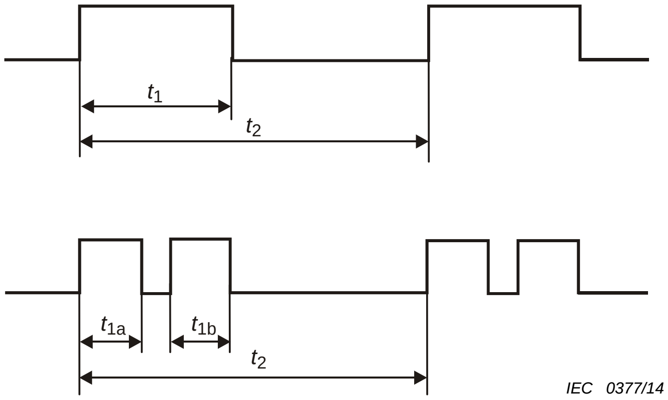
t_1 *et* t_2 *sont exprimés en ms.*

NOTE Les fréquences des tensions des sonneries de téléphone sont normalement comprises entre 14 Hz et 50 Hz.

c) *Dans les* ***conditions de premier défaut****, y compris lorsque la sonnerie cadencée devient continue:*

– I_{TS1} *ne doit pas dépasser soit le courant indiqué par la courbe de la Figure H.2, soit 20 mA, selon la valeur la plus haute; et*

– I_{TS2} *ne doit pas dépasser une limite de 20 mA.*



Légende

t_1 *est*

la durée d'une période de sonnerie unique, où la sonnerie est active pendant toute la période de sonnerie unique;

la somme des périodes de sonnerie actives au sein de la période de sonnerie unique, pendant laquelle ladite période contient deux périodes de sonnerie actives discrètes ou plus, comme dans l'exemple suivant, pour lequel $t_1 = t_{1a} + t_{1b}$;

t_2 *est la* durée d'un cycle de cadence complet.

Figure H.1 – Définition d'une période de sonnerie et d'un cycle de cadence

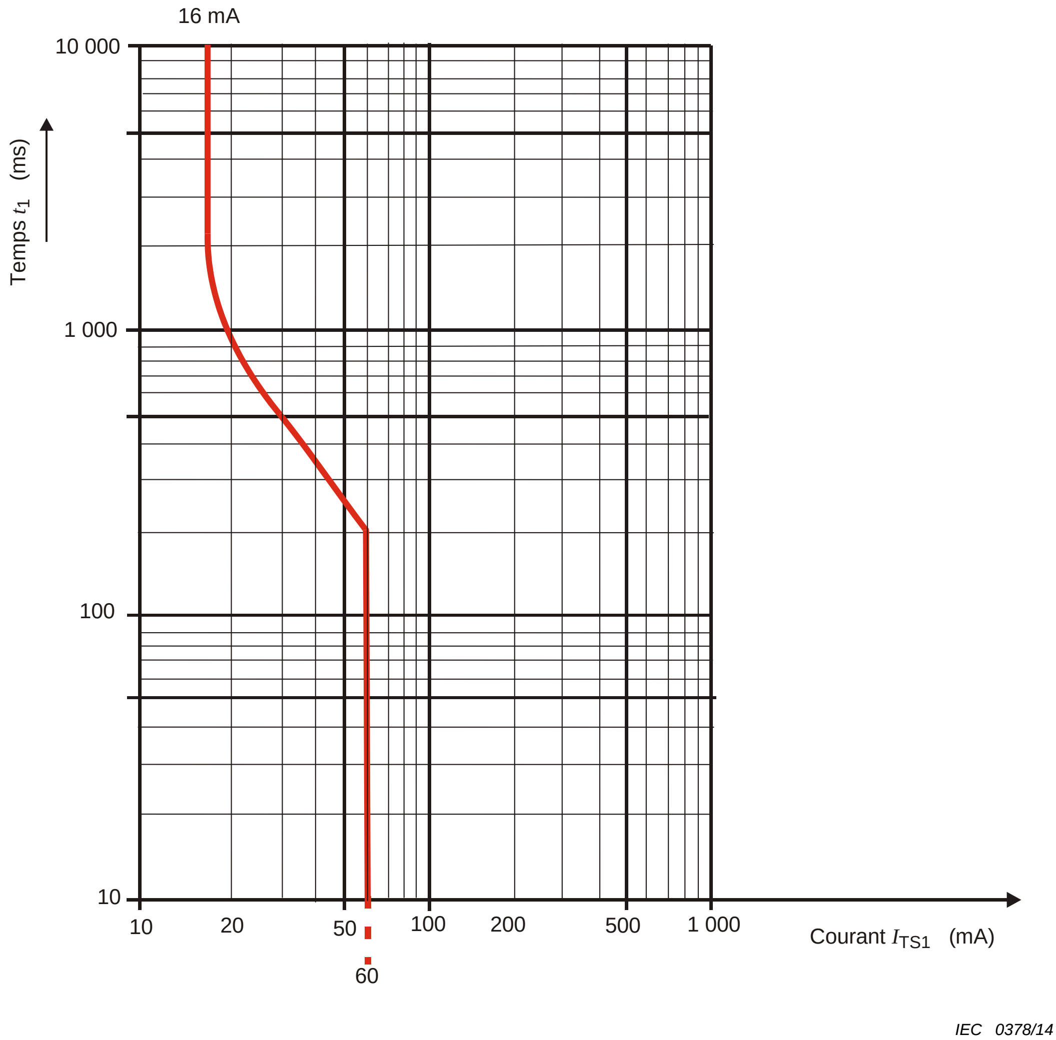


Figure H.2 – Courbe de limite I_{TS1} du signal de sonnerie cadencée

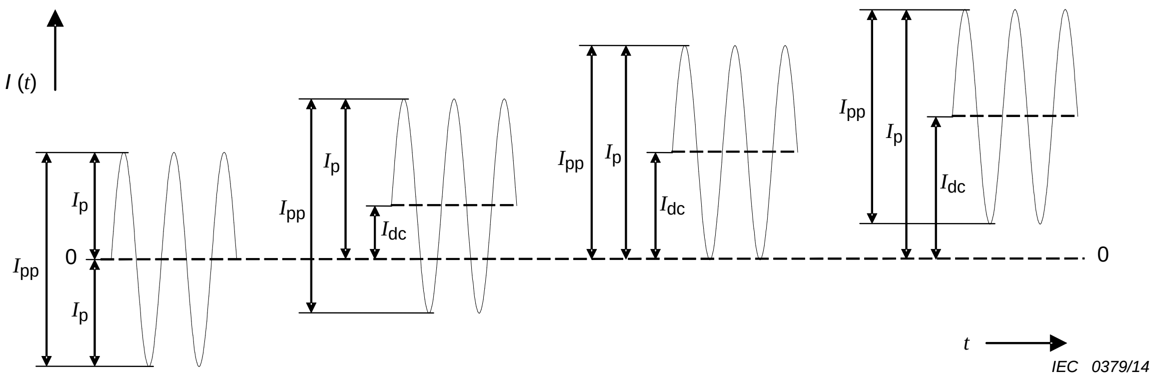


Figure H.3 – Courants crête et crête à crête

H.3 Méthode B

H.3.1 Signal de sonnerie

H.3.1.1 Fréquence

Le signal de sonnerie doit utiliser uniquement des fréquences dont la composante fondamentale est inférieure ou égale à 70 Hz.

H.3.1.2 Tension

La tension de sonnerie doit être inférieure à 300 V crête à crête et inférieure à 200 V crête par rapport à la terre, mesurée à travers une résistance d'au moins 1 MΩ.

H.3.1.3 Cadence

La tension de sonnerie doit être interrompue pour créer des intervalles sans sonnerie d'une durée d'au moins 1 s séparés par 5 s maximum. Lors des intervalles sans sonnerie, la tension par rapport à la terre ne doit pas dépasser 60 V c.c.

H.3.1.4 Courant de premier défaut

Lorsque le signal cadencé devient continu à cause d'un premier défaut, le courant à travers une résistance de 5 000 Ω connectée entre deux conducteurs de sortie quelconques ou entre un conducteur de sortie et la terre ne doit pas dépasser 56,5 mA crête à crête, comme indiqué dans la Figure H.3.

H.3.2 Dispositif de déclenchement et tension de surveillance

H.3.2.1 Conditions d'utilisation du dispositif de déclenchement ou d'une tension de surveillance

Un circuit de signal de sonnerie doit comprendre un dispositif de déclenchement, comme indiqué en H.3.2.2, ou apporter une tension de surveillance, comme indiqué en H.3.2.3, ou les deux, selon le courant passant à travers une résistance spécifiée qui est connectée entre un générateur de signal de sonnerie et la terre, comme suit:

– si le courant qui traverse une résistance de 500 Ω ou plus ne dépasse pas 100 mA crête à crête, ni un dispositif de déclenchement ni une tension de surveillance ne sont nécessaires;

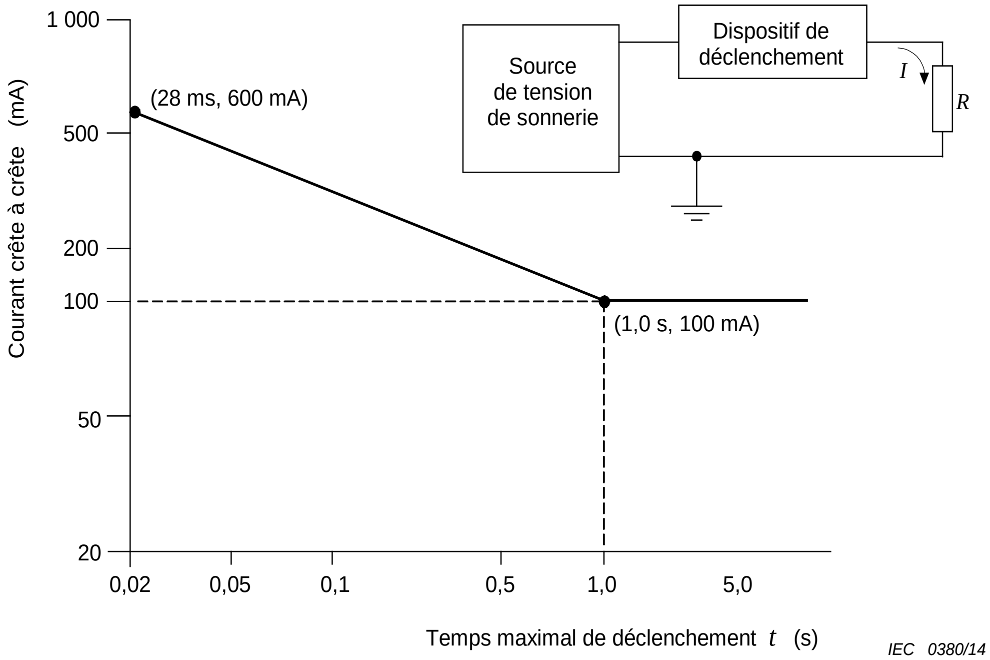
– si le courant qui traverse une résistance de 1 500 Ω ou plus dépasse 100 mA crête à crête, un dispositif de déclenchement doit être inclus. Si le dispositif de déclenchement répond aux critères de déclenchement indiqués dans la Figure H.4 avec $R \geq 500\ \Omega$, une tension de surveillance n'est pas nécessaire. Cependant, si le dispositif de déclenchement correspond uniquement aux critères correspondants avec $R \geq 1\ 500\ \Omega$, une tension de surveillance doit également être fournie;

– si le courant qui traverse une résistance de 500 Ω ou plus dépasse 100 mA crête à crête, mais que le courant qui traverse une résistance de 1 500 Ω ou plus ne dépasse pas cette valeur, soit:

  - un dispositif de déclenchement doit être fourni, répondant aux critères correspondants indiqués dans la Figure H.4 avec $R \geq 500\ \Omega$, ou
  - une tension de surveillance doit être fournie.

NOTE 1 Les dispositifs de déclenchement sont, en général, sensibles au courant et n'ont pas de réponse linéaire en raison de leurs caractéristiques de résistance/courant et de délai/facteur de réponse dans leur conception.

NOTE 2 Afin de réduire la durée d'essai, on utilise normalement une boîte à résistance variable.



NOTE 1 t est mesuré depuis le moment de la connexion de la résistance R vers le circuit.

NOTE 2 La partie descendante de la courbe est définie sous la forme $I = 100 / \sqrt{t}$.

Figure H.4 – Critères de déclenchement de la tension de sonnerie

H.3.2.2 Dispositif de déclenchement

Dispositif de déclenchement sensible au courant en série dans le conducteur de sonnerie qui déclenche la sonnerie comme indiqué à la Figure H.4.

H.3.2.3 Tension de surveillance

Tension par rapport à la terre dans le conducteur de données ou de sonnerie avec une amplitude d'au moins 19 V de crête, mais ne dépassant pas 60 V en tension continue, chaque fois que la tension de sonnerie n'est pas présente (période de repos).

Annexe I
(informative)

Catégories de surtension (voir la CEI 60364-4-44)

Le concept des catégories de surtension est utilisé pour les équipements directement alimentés à partir du **réseau d'alimentation** en courant alternatif.

La tension transitoire la plus importante susceptible d'être rencontrée au niveau de l'interface d'entrée de l'énergie de l'équipement connecté au **réseau d'alimentation** est connue comme la **tension transitoire du réseau d'alimentation**. Dans la présente norme, les **distances dans l'air** minimales pour une isolation dans des circuits connectés au **réseau d'alimentation** se basent sur la **tension transitoire du réseau d'alimentation**.

Conformément à la CEI 60664-1, la valeur de la **tension transitoire du réseau d'alimentation** est déterminée à partir de la tension du **réseau d'alimentation** et de la catégorie de surtension, I à IV (voir le Tableau 13 de la présente norme).

La catégorie de surtension doit donc être identifiée pour chaque équipement devant être connecté au **réseau d'alimentation** (voir Tableau I.1).

Les catégories de surtension tiennent plus des probabilités que de la signification de l'atténuation physique de la tension transitoire en aval dans l'installation.

NOTE 1 Ce concept de catégories de surtension est utilisé dans la CEI 60364-4-44:2007, section 443.

NOTE 2 Le terme "catégorie de surtension" utilisé dans la présente norme est synonyme de catégorie de tenue aux chocs utilisée dans la CEI 60364-4-44:2007, section 443.

Le terme "catégorie de surtension" n'est pas utilisé en connexion avec les systèmes de distribution d'alimentation en courant continu dans la présente norme.

Tableau I.1 – Catégories de surtension

Catégorie de surtension	Equipement et point de connexion au réseau d'alimentation en courant alternatif associé	Exemples d'équipement
IV	Equipement à connecter au point où le **réseau d'alimentation** pénètre dans le bâtiment	• Compteurs d'électricité • ATI (appareil de traitement de l'information) de communications pour le comptage de l'électricité à distance
III	Equipement faisant partie intégrante du câblage du bâtiment	• Prises de courant, panneaux de fusibles et panneaux de commande • Equipement de contrôle de l'énergie
II	Equipement enfichable ou **relié en permanence** alimenté à partir du câblage du bâtiment	• Appareils domestiques, outils portables, appareils électroniques domestiques • La plupart des ATI utilisés dans le bâtiment
I	Equipement à connecter à un **réseau d'alimentation** spécial pour lequel des mesures ont été prises pour réduire les transitoires	• ATI alimenté par l'intermédiaire d'un filtre externe ou d'un générateur motorisé

Annexe J
(normative)

Fils de bobinage isolés destinés à une utilisation sans isolation intercouche

J.1 Généralités

La présente annexe spécifie les exigences concernant les fils de bobinage dont l'isolation peut être utilisée pour fournir l'**isolation principale**, l'**isolation supplémentaire**, la **double isolation** ou l'**isolation renforcée** dans les composants bobinés sans isolation intercouche.

La présente annexe s'applique aux:

– fils de bobinage pleins ronds ayant des diamètres compris entre 0,01 mm et 5,0 mm et aux fils de bobinage toronnés de sections équivalentes, et
– fils de bobinage pleins carrés et rectangulaires (flexion perpendiculaire) de sections comprises entre 0,000 079 mm^2 et 19,6 mm^2.

NOTE Voir G.6.1 pour le nombre minimal de couches en chevauchement.

J.2 Essais de type

J.2.1 Généralités

*Le fil de bobinage doit satisfaire aux **essais de type** suivants, effectués à une température comprise entre 15 °C et 35 °C et une humidité relative comprise entre 45 % et 75 %, sauf spécification contraire.*

J.2.2 Rigidité diélectrique

J.2.2.1 Fils de bobinage pleins ronds et toronnés

J.2.2.1.1 Fils d'un diamètre de conducteur nominal jusqu'à 0,1 mm compris

Le spécimen d'essai est préparé conformément au 4.3 de la CEI 60851-5:2008. Il est ensuite soumis à l'essai de rigidité diélectrique de 5.4.9.1 entre le conducteur du fil et le cylindre,avec une tension minimale d'essai de:

– *3 kV en valeur efficace ou 4,2 kV en valeur de crête pour l'**isolation renforcée**, ou*
– *1,5 kV en valeur efficace ou 2,1 kV en valeur de crête pour l'**isolation principale** ou l'**isolation supplémentaire**.*

J.2.2.1.2 Fils d'un diamètre de conducteur nominal supérieur à 0,1 mm jusqu'à 2,5 mm compris

Le spécimen d'essai est préparé conformément au 4.4.1 de la CEI 60851-5:2008 (paire torsadée). Il est ensuite soumis à l'essai de rigidité diélectrique de 5.4.9.1 avec une tension d'essai au moins égale au double de la tension appropriée de 5.4.9.1, avec un minimum de:

– *6 kV en valeur efficace ou 8,4 kV en valeur de crête pour l'**isolation renforcée**, ou*
– *3 kV en valeur efficace ou 4,2 kV en valeur de crête pour l'**isolation principale** ou l'**isolation supplémentaire**.*

J.2.2.1.3 Fils d'un diamètre de conducteur nominal supérieur à 2,5 mm

Le spécimen d'essai est préparé conformément au 4.5.1 de la CEI 60851-5:2008. Il est ensuite soumis à l'essai de rigidité diélectrique de 5.4.9.1 entre le conducteur du fil et la grenaille, avec une tension minimale d'essai de:

– *3 en valeur efficace ou 4,2 kV en valeur de crête pour l'**isolation renforcée**, ou*

– *1,5 kV en valeur efficace ou 2,1 kV en valeur de crête pour l'**isolation principale** ou l'**isolation supplémentaire***

J.2.2.2 Fils carrés ou rectangulaires

Le spécimen d'essai est préparé conformément au 4.7.1 de la CEI 60851-5:2008 (conducteur unique entouré de grenailles métalliques). Le spécimen d'essai est ensuite soumis à l'essai de rigidité diélectrique du 5.4.9.1 avec une tension d'essai minimale de:

– *3 kV* en valeur efficace ou *4,2 kV* en valeur de crête *pour l'**isolation renforcée**, ou*

– *1,5 kV en valeur efficace ou 2,1 kV en valeur de crête pour l'**isolation principale** ou l'**isolation supplémentaire**.*

J.2.3 Flexibilité et adhérence

L'essai 8 de 5.1 de la CEI 60851-3:2009 doit être utilisé, à l'aide des diamètres du mandrin du Tableau J.1.

Le spécimen d'essai est ensuite examiné conformément au 5.1.1.4 de la CEI 60851-3:2009, suivi par l'essai de rigidité diélectrique du 5.4.9.1 de la présente norme avec une tension d'essai minimale de:

– *3 kV en valeur efficace ou 4,2 kV en valeur de crête pour l'**isolation renforcée**, ou*

– *1,5 kV en valeur efficace ou 2,1 kV en valeur de crête pour l'**isolation principale** ou **supplémentaire**.*

La tension d'essai est appliquée entre le fil et le mandrin.

Tableau J.1 – Diamètre du mandrin

Diamètre nominal du conducteur ou épaisseur mm	Diamètre du mandrin mm
inférieur à 0,35	4,0 ± 0,2
inférieur à 0,50	6,0 ± 0,2
inférieur à 0,75	8,0 ± 0,2
inférieur à 2,50	10,0 ± 0,2
inférieur à 5,00	Quatre fois le diamètre du conducteur ou l'épaisseur [a]
[a] Conformément à la CEI 60317-43.	

La tension à appliquer au fil pendant l'enroulement sur le mandrin est calculée à partir du diamètre de fil équivalant à 118 MPa ± 10 % (118 N/mm^2 ± 10 %).

La flexion parallèle sur la plus petite dimension latérale (largeur) n'est pas nécessaire pour le fil rectangulaire.

Pour l'essai d'enroulement sur le mandrin du fil carré et rectangulaire, les deux spires adjacentes n'ont pas besoin d'être en contact.

J.2.4 Choc thermique

Le spécimen d'essai doit être préparé conformément au 3.1.1 (Essai 9) de la CEI 60851-6:1996, suivi par l'essai de rigidité diélectrique du 5.4.9.1 de la présente norme, avec une tension d'essai minimale de:

– *3 kV en valeur efficace ou 4,2 kV en valeur de crête pour l'**isolation renforcée**, ou*

– *1,5 kV en valeur efficace ou 2,1 kV en valeur de crête pour l'**isolation principale** ou l'**isolation supplémentaire**.*

La tension d'essai est appliquée entre le fil et le mandrin. La température du four est la température applicable pour la classe thermique d'isolation du Tableau J.2. Le diamètre du mandrin et la tension appliquée au fil pendant l'enroulement sur le mandrin sont ceux indiqués dans le Tableau J.1. L'essai de rigidité diélectrique est effectué à température ambiante après que l'échantillon ait été retiré du four.

Tableau J.2 – Température du four

Classe thermique	**Classe 105 (A)**	**Classe 120 (E)**	**Classe 130 (B)**	**Classe 155 (F)**	**Classe 180 (H)**	**Classe 200 (N)**	**Classe 220 (R)**	**Classe 250 -**
Température du four °C	200	215	225	250	275	295	315	345
Les températures du four doivent être maintenues à ± 5° de la température spécifiée. Les classes sont liées à la classification des matériaux isolants électriques et des systèmes d'isolation électriques conformément à la CEI 60085. Les désignations alphabétiques assignées sont données entre parenthèses.								

La flexion parallèle sur la plus petite dimension latérale (largeur) n'est pas nécessaire pour le fil rectangulaire.

NOTE Le Paragraphe 3.1.2 dans l'Essai 9 de la CEI 60851-6:1996 n'est pas utilisé pour les fils de bobinage pleins carrés et rectangulaires.

J.2.5 Rétention de la rigidité diélectrique après courbure

Cinq spécimens sont préparés comme en J.2.3 et soumis à essai comme suit. Chaque spécimen est retiré du mandrin et placé dans un récipient de façon qu'il soit entouré par 5 mm de grenaille métallique au moins. Les extrémités du conducteur dans le spécimen doivent être suffisamment longues pour éviter les contournements. La grenaille métallique ne doit pas avoir plus de 2 mm de diamètre et doit être composée de billes en acier inoxydable, en nickel ou en acier nickelé. Le récipient est rempli doucement de grenaille jusqu'à ce que le spécimen en essai soit recouvert d'au moins 5 mm de grenaille. La grenaille doit être nettoyée périodiquement à l'aide d'un solvant approprié.

NOTE La procédure d'essai ci-dessus est reprise de 4.6.1 c) de la CEI 60851-5, désormais retirée. Elle n'a pas été reproduite dans la quatrième édition (2008) de cette norme.

Les spécimens doivent être soumis à l'essai de rigidité diélectrique de 5.4.9.1 avec une tension d'essai minimale de:

– *3 kV en valeur efficace ou 4,2 kV en valeur de crête pour l'**isolation renforcée**, ou*

– *1,5 kV en valeur efficace ou 2,1 kV en valeur de crête pour l'**isolation principale** ou **supplémentaire**.*

Le diamètre du mandrin et la tension appliquée au fil pendant l'enroulement sur le mandrin sont ceux indiqués dans le Tableau J.1.

J.3 Essai en cours de production

J.3.1 Généralités

Le fil doit être soumis par le fabricant de câbles à des essais de rigidité diélectrique, en cours de production, comme spécifié en J.3.2 et J.3.3.

J.3.2 Essai individuel de série

*La tension d'essai pour l'****essai individuel de série*** *doit être conforme à celle de l'essai de rigidité diélectrique du 5.4.9.1 avec un minimum de:*

- *3 kV en valeur efficace ou 4,2 kV en valeur de crête pour l'****isolation renforcée****, ou*
- *1,5 kV en valeur efficace ou 2,1 kV en valeur de crête pour l'****isolation principale*** *ou l'****isolation supplémentaire****.*

J.3.3 Essai d'échantillonnage

*L'****essai d'échantillonnage*** *doit être réalisé conformément à l'essai approprié spécifié en J.2.2.*

Annexe K
(normative)

Verrouillages de sécurité

K.1 Généralités

K.1.1 Exigences générales

Les **verrouillages de sécurité** doivent être conçus de façon à ce que, pour une **personne ordinaire**, les sources d'énergie de classes 2 et 3 soient supprimées avant que le panneau, la porte, etc. ne soient dans une position risquant de les rendre **accessibles** en tant que source d'énergie de classe 1.

Les **verrouillages de sécurité** doivent être conçus de façon à ce que, pour une **personne avertie**, les sources d'énergie de classe 3 soient supprimées avant que le panneau, la porte, etc. ne soient dans une position risquant de les rendre **accessibles** en tant que source d'énergie de classe 2 ou inférieure.

Le verrouillage doit au choix:

– nécessiter la mise hors tension préalable desdites parties, ou
– initier une déconnexion automatique de l'alimentation desdites parties et les réduire à une:
  - source d'énergie de classe 1 dans un délai de 2 s pour une **personne ordinaire**; et
  - source d'énergie de classe 2 dans un délai de 2 s pour une **personne avertie**.

Si la réduction de la classe de la source d'énergie prend plus de 2 s, la **protection par instructions** doit être fournie conformément à l'Article F.5, à l'exception du fait que:

– l'élément 1a doit être placé sur la porte, couvercle ou autre partie qui initie l'action de verrouillage et est ouvert ou retiré pour l'accès; et
– l'élément 3 est facultatif.

Les éléments de la **protection par instructions** doivent être comme suit:

– élément 1a: , CEI 60417-6057 (2011-05) pour les parties mobiles; ou , CEI 60417-5041 (2002-10) pour les parties chaudes.
– élément 2: non spécifié
– élément 3: non spécifié
– élément 4: le moment où la source d'énergie est réduite à la classe requise.

K.1.2 Méthode d'essai et critères de conformité

Le niveau d'énergie des parties considérées comme des sources d'énergie de classe 2 ou 3 est surveillé.

La conformité est vérifiée par examen, par mesure et en utilisant le doigt d'essai rigide conformément à l'Annexe V.

K.2 Composants du mécanisme de protection du verrouillage de sécurité

Les composants constituant le mécanisme de **verrouillage de sécurité** doivent être considérés comme des **protections** et doivent se conformer aux exigences applicables des **protections** et doivent être soumis aux exigences applicables de l'Annexe G.

La conformité est vérifiée conformément à l'Annexe G et par examen.

K.3 Modification par inadvertance du mode de fonctionnement

Un **verrouillage de sécurité** ne doit pas être activable par le biais des sondes spécifiées à la Figure V.1 ou à la Figure V.2, selon le cas, de façon à modifier la classe d'énergie au sein de la zone, de l'espace ou du point d'accès sous contrôle en une source d'énergie de classe 3 pour une **personne avertie** ou en une source d'énergie de classe 2 ou 3 pour une **personne ordinaire**.

La conformité est vérifiée conformément à l'Annexe V et par examen.

K.4 Réenclenchement forcé de la protection du verrouillage

Un **verrouillage de sécurité** peut être réenclenché par une **personne qualifiée**. Le système de réenclenchement forcé du **verrouillage de sécurité**:

– doit nécessiter un effort volontaire pour fonctionner; et

– doit réenclencher automatiquement le fonctionnement normal lorsque l'entretien est achevé, ou doit empêcher un fonctionnement normal à moins que la **personne qualifiée** n'ait réalisé une restauration; et

– s'il est situé dans une zone **accessible** à une **personne ordinaire**, ou, le cas échéant, à une **personne avertie**, il ne doit pas être activable par le biais des sondes spécifiées dans l'Annexe V et un **outil** doit être nécessaire pour le faire fonctionner.

La conformité est vérifiée conformément à l'Annexe V et par examen.

K.5 Fonctionnement sans défaillance

K.5.1 Exigence

Dans le cas de toute **condition de premier défaut** dans le système de **verrouillage de sécurité**, l'espace contrôlé par le **verrouillage de sécurité** doit

– revenir à une source d'énergie de classe 1 pour une **personne ordinaire** ou une source d'énergie de classe 2 pour une **personne avertie**, ou

– être verrouillé dans les **conditions normales de fonctionnement** et être conforme aux exigences applicables à une source d'énergie de classe 3.

K.5.2 Méthode d'essai et critères de conformité

La conformité est vérifiée en introduisant des défauts de composants électriques, électromécaniques et mécaniques, un par un. Les ***conditions de premier défaut*** *sont décrites dans l'Article B.4. Pour chaque défaut, l'espace contrôlé par le* ***verrouillage de sécurité*** *doit se conformer aux exigences applicables aux* ***conditions de premier défaut*** *pour la source d'énergie respective. Les distances de séparation fixes des circuits de* ***verrouillage de sécurité*** *(par exemple, ceux associés aux cartes imprimées) ne sont pas soumises à des* ***conditions de premier défaut*** *simulées si les distances de séparation sont conformes à K.7.1.*

K.6 Verrouillages de sécurité à fonctionnement mécanique

K.6.1 Exigence d'endurance

Les parties mécaniques mobiles dans les systèmes de **verrouillage de sécurité** mécaniques et électromécaniques doivent avoir une endurance appropriée.

K.6.2 Méthode d'essai et critères de conformité

*La conformité est vérifiée en examinant le système de **verrouillage de sécurité**, les données disponibles et, si nécessaire, en soumettant le système de **verrouillage de sécurité** à un fonctionnement de 10 000 cycles. Dans le cas où un défaut surviendrait pendant ou après les 10 000 cycles de fonctionnement dans le système de **verrouillage de sécurité**, l'espace contrôlé par le **verrouillage de sécurité** doit:*

– *revenir à une source d'énergie de classe 1 pour une **personne ordinaire** ou une source d'énergie de classe 2 pour une **personne avertie**, ou*

– *être verrouillé dans les **conditions normales de fonctionnement** et être conforme aux exigences applicables à une source d'énergie de classe 3.*

NOTE L'essai ci-dessus est réalisé de façon à vérifier l'endurance des parties mobiles autres que celles figurant dans les systèmes, interrupteurs et relais des **verrouillages de sécurité**. Les systèmes, interrupteurs et relais des **verrouillages de sécurité** sont, le cas échéant, soumis à l'Annexe G.

K.7 Isolation des circuits de verrouillage

K.7.1 Distances de séparation pour les distances d'ouverture des contacts et les éléments des circuits de verrouillage

Si l'interrupteur ou le relais déconnecte un conducteur de circuit dans un circuit connecté au **réseau d'alimentation**, les distances de séparation pour les distances d'ouverture des contacts et les circuits associés ne doivent pas être inférieures à celles applicables à un **dispositif de déconnexion** (voir Annexe L).

Si l'interrupteur ou le relais se trouve dans un circuit isolé du **réseau d'alimentation**, les distances de séparation pour des distances d'ouverture des contacts ne doivent pas être inférieures à la valeur de **distance dans l'air** minimale adéquate pour une **isolation principale** pour une isolation des sources d'énergie de classe 2. Les éléments des circuits de verrouillage, dont un défaut peut entraîner le dysfonctionnement du système de verrouillage, doivent avoir une **isolation principale**.

Si l'interrupteur ou le relais se trouve dans un circuit isolé du **réseau d'alimentation**, les distances de séparation pour des distances d'ouverture des contacts ne doivent pas être inférieures à la valeur de **distance dans l'air** minimale adéquate pour une **isolation renforcée** pour une isolation des sources d'énergie de classe 3. Les éléments des circuits de verrouillage, dont un défaut peut entraîner le dysfonctionnement du système de verrouillage, doivent avoir une **isolation renforcée**.

Deux systèmes de verrouillage indépendants utilisant une **isolation principale** peuvent être utilisés en variante pour fournir une **isolation renforcée**.

En variante, la distance de séparation entre les contacts en position de coupure doit supporter l'essai de rigidité diélectrique de 5.4.9.1 à la tension d'essai requise pour une **isolation principale** ou **renforcée**, selon le cas. La distance d'ouverture des contacts doit être conforme aux exigences ci-dessus avant et après la réalisation de l'essai d'endurance aux 10 000 cycles de K.6.2. La condition de l'essai d'endurance doit représenter la **condition normale de fonctionnement** maximale au sein de l'équipement par rapport à la tension et au courant interrompu par les contacts.

La **distance dans l'air** de la distance d'ouverture des contacts doit être conforme avec la distance applicable du Tableau 15, à condition que l'interrupteur ou le relais soit conforme à K.7.2, K.7.3 et K.7.4.

K.7.2 Essai de surcharge

Le contact d'un interrupteur ou d'un relais dans le système de ***verrouillage de sécurité*** *est soumis à un essai de surcharge. Cet essai consiste à appliquer 50 cycles de fonctionnement à une cadence de 6 à 10 cycles par minute, ouvrant et fermant 150 % du courant imposé dans l'application, sauf dans le cas où un contact d'interrupteur ou de relais commute une charge de moteur, l'essai est réalisé avec le rotor du moteur dans une position bloquée.*

Après l'essai, le système de ***verrouillage de sécurité****, y compris l'interrupteur ou le relais, doit toujours être fonctionnel.*

K.7.3 Essai d'endurance

Le contact d'un interrupteur ou d'un relais dans le système de ***verrouillage de sécurité*** *est soumis à un essai d'endurance, ouvrant et fermant 100 % du courant imposé dans l'application à une cadence de 6 à 10 cycles de fonctionnement par minute. Une cadence plus élevée peut être utilisée si le fabricant l'exige.*

Pour les interrupteurs à lame souple utilisés dans un système de ***verrouillage de sécurité*** *dans ES1 ou ES2, l'essai est de 100 000 cycles de fonctionnement. Pour les autres interrupteurs et relais dans un système de* ***verrouillage de sécurité****, l'essai est de 10 000 cycles de fonctionnement.*

Après l'essai, le système de ***verrouillage de sécurité****, y compris l'interrupteur ou le relais, doit toujours être fonctionnel.*

K.7.4 Essai de rigidité diélectrique

Sauf dans le cas d'interrupteurs à lame souple dans ES1 ou ES2, un essai de rigidité diélectrique comme spécifié en 5.4.9.1 est appliqué entre les contacts après les essais de K.7.3. Si le contact se trouve dans un circuit connecté au ***réseau d'alimentation****, la tension d'essai est telle que celle spécifiée pour l'****isolation renforcée****. Si le contact se trouve dans un circuit isolé du* ***réseau d'alimentation****, la tension d'essai est telle que spécifiée pour une* ***isolation principale*** *dans un circuit connecté au* ***réseau d'alimentation****.*

Annexe L
(normative)

Dispositifs de déconnexion

L.1 Exigences générales

Un **dispositif de déconnexion** doit être fourni afin de déconnecter l'équipement de l'alimentation. Si un **dispositif de déconnexion** interrompt le conducteur de neutre, il doit simultanément interrompre tous les conducteurs de phase.

Le **dispositif de déconnexion** peut être:

– la fiche sur le câble d'alimentation; ou
– une prise d'appareil; ou
– un interrupteur d'isolation; ou
– un disjoncteur, ou
– tout moyen équivalent de déconnexion.

Pour un équipement prévu pour être alimenté à partir d'un **réseau d'alimentation** en courant alternatif d'une catégorie de surtension I, II ou III ou à partir d'un **réseau d'alimentation** en courant continu appartenant à ES3, un **dispositif de déconnexion** doit avoir une séparation de contact d'au moins 3 mm. Pour un **réseau d'alimentation** en courant alternatif de la catégorie de surtension IV, la CEI 60947-1 doit s'appliquer. S'il est intégré dans l'équipement, le **dispositif de déconnexion** doit être connecté aussi près que possible à l'alimentation entrante.

Pour l'équipement prévu pour être alimenté à partir d'un **réseau d'alimentation** en courant continu n'appartenant pas à ES3,

– un **dispositif de déconnexion** doit avoir une séparation de contact au moins égale à la **distance dans l'air** minimale pour l'**isolation principale**;
– un fusible amovible peut être utilisé en tant que **dispositif de déconnexion**, à condition qu'il soit uniquement **accessible** à une **personne avertie** ou à une **personne qualifiée**.

L.2 Equipement relié en permanence

Pour l'**équipement relié en permanence**, le **dispositif de déconnexion** doit être intégré dans l'équipement, à moins que l'équipement ne comporte des instructions d'installation spécifiant qu'un **dispositif de déconnexion** approprié doit être fourni comme partie intégrante de l'installation du bâtiment.

NOTE Les **dispositifs de déconnexion** extérieurs ne sont pas nécessairement fournis avec l'équipement.

L.3 Parties restant alimentées

Les parties sur le côté alimentation d'un **dispositif de déconnexion** dans l'équipement qui restent alimentées lorsque le **dispositif de déconnexion** est coupé doivent être protégées afin de réduire le risque de contact accidentel par des **personnes qualifiées**.

En variante, les instructions doivent être fournies dans le manuel d'entretien.

L.4 Equipement monophasé

Pour l'équipement monophasé, le **dispositif de déconnexion** doit déconnecter les deux pôles simultanément, sauf qu'un **dispositif de déconnexion** unipolaire peut être utilisé pour déconnecter le conducteur de phase lorsqu'il est possible de se reposer sur l'identification du neutre dans le **réseau d'alimentation**. Si l'équipement comporte uniquement un **dispositif de déconnexion** unipolaire, les instructions doivent être données en vue de l'ajout d'un **dispositif de déconnexion** bipolaire dans l'installation du bâtiment lorsque l'équipement est utilisé au moment où l'identification du neutre dans le **réseau d'alimentation** est impossible.

EXEMPLE Les cas où un **dispositif de déconnexion** bipolaire est nécessaire sont:

– sur un équipement alimenté à partir d'un système d'alimentation IT;
– sur un équipement enfichable alimenté par le biais d'une prise d'appareil réversible ou d'une fiche réversible (à moins que la prise de l'appareil ou la fiche proprement dite ne soit utilisée comme **dispositif de déconnexion**;
– sur un équipement alimenté à partir d'un socle de prises de courant avec une polarité indéterminée.

L.5 Equipement triphasé

Pour l'équipement triphasé, le **dispositif de déconnexion** doit déconnecter simultanément tous les conducteurs de phase de l'alimentation. Pour l'équipement nécessitant une connexion neutre à un système d'alimentation IT, le **dispositif de déconnexion** doit être un dispositif quadripolaire et doit déconnecter tous les conducteurs de phase et le conducteur de neutre. Si ce dispositif quadripolaire n'est pas fourni dans l'équipement, les instructions d'installation doivent spécifier qu'il est nécessaire de le fournir comme partie intégrante de l'installation du bâtiment.

L.6 Interrupteurs servant de dispositifs de déconnexion

Lorsque le **dispositif de déconnexion** est un interrupteur intégré dans l'équipement, les positions "marche" et "arrêt" doivent être marquées conformément à F.3.5.2.

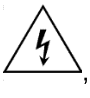
L.7 Fiches servant de dispositifs de déconnexion

Lorsqu'une fiche située sur le câble d'alimentation est utilisée comme **dispositif de déconnexion**, les instructions d'installation doivent spécifier, pour des équipements enfichables, que le socle de la prise de courant doit être facilement **accessible**. Pour l'équipement enfichable prévu pour être installé par une **personne ordinaire**, les instructions d'installation doivent être mises à la disposition de cette personne.

L.8 Sources d'alimentation multiples

Lorsqu'une unité reçoit de l'énergie à partir de plusieurs sources (par exemple, des tensions/fréquences différentes ou une énergie redondante), il doit y avoir une **protection par instructions** bien visible conformément à l'Article F.5 au niveau de chaque **dispositif de déconnexion** donnant les instructions adéquates pour supprimer toute l'énergie de l'unité.

Les éléments de la **protection par instructions** doivent être comme suit:

– élément 1a: , CEI 60417-6042 (2010-11); et

, CEI 60417-6172 (2012-09)

– élément 2: “Attention” ou mot ou texte équivalent, et “Danger de choc” ou texte équivalent

– élément 3: facultatif

– élément 4: “Déconnecter toutes les sources d’énergie” ou texte équivalent.

Si plusieurs **dispositifs de déconnexion** de ce type sont fournis sur une unité, tous ces dispositifs doivent être regroupés. Il n’est pas nécessaire de lier mécaniquement les dispositifs.

L’équipement intégrant un onduleur (UPS, Alimentation sans interruption) interne doit avoir des dispositifs pour désactiver l’UPS de manière fiable et déconnecter sa sortie avant l’entretien de l’équipement. Les instructions relatives à la déconnexion de l’UPS doivent être fournies. La source d’énergie interne de l’UPS doit être marquée de façon adéquate et protégée contre tout contact accidentel par une **personne qualifiée**.

L.9 Critères de conformité

La conformité est vérifiée par examen.

Annexe M
(normative)

Equipements contenant des piles ou batteries et leurs circuits de protection

M.1 Exigences générales

La présente annexe fournit des exigences supplémentaires pour l'équipement contenant des **piles** ou **batteries**. L'utilisation de **piles** ou **batteries** dans l'équipement peut nécessiter des **protections** n'ayant pas été abordées dans d'autres parties de la norme. La présente annexe n'aborde pas les exigences relatives aux **piles** ou **batteries** externes, à leur installation ou à la maintenance des **piles** ou **batteries** autres que le remplacement de ces dernières par une **personne ordinaire** ou une **personne avertie**. De même, la présente annexe n'aborde par l'équipement de charge des **piles** ou **batteries** externes.

Lorsqu'une norme de sécurité sur les **batteries** comporte des exigences équivalentes aux exigences de la présente annexe, une **batterie** conforme à la norme sur les **batteries** correspondante est considérée satisfaire aux exigences correspondantes de la présente annexe, et les essais faisant partie intégrante de la norme de sécurité sur les **batteries** n'ont pas besoin d'être répétés dans le cadre de la présente annexe.

Pour les équipements contenant une **pile** remplaçable par une **personne ordinaire**, une **protection par instructions** doit être prévue conformément à l'Article F.5, sauf que la **protection par instructions** complète peut être fournie dans les instructions.

Les éléments de la **protection par instructions** doivent être comme suit:

– élément 1a: non disponible.
– élément 2: "ATTENTION" ou énoncé ou texte équivalent.
– élément 3: "Risque d'explosion si la **batterie** est remplacée par un type incorrect" ou texte équivalent.
– élément 4: facultatif.

M.2 Sécurité des piles et batteries et leurs éléments

M.2.1 Exigences

Les **piles** ou **batteries** et leurs éléments doivent satisfaire aux normes CEI de **batteries** applicables énumérées ci-dessous.

CEI 60086-4, CEI 60086-5, CEI 60896-11, CEI 60896-21, CEI 60896-22, CEI 61056-1 et CEI 61056-2, CEI 61427, CEI/TS 61430, CEI 61434, CEI 61959, CEI 62133, CEI 6228-1 et CEI 62485-2.

NOTE 1 D'autres normes de sécurité sur les **batteries** sont à l'étude et sont destinées à être incluses à l'avenir.

M.2.2 Méthode d'essai et critères de conformité

La conformité est vérifiée par examen ou une évaluation basée sur les données fournies par le fabricant.

M.3 Circuits de protection des batteries fournis dans l'équipement

M.3.1 Exigences

Les circuits de protection des **batteries** fournis dans l'équipement et qui ne font pas partie intégrante de la **batterie** doivent être conçus de façon à ce que:

– les **protections** soient opérationnelles dans les **conditions normales de fonctionnement**, les **conditions anormales de fonctionnement**, les **conditions de premier défaut**, les conditions d'installation et de transport; et
– les caractéristiques de sortie d'un circuit de charge de la **batterie** soient compatibles avec la **batterie** rechargeable associée; et
– pour les **batteries** non rechargeables, une décharge à une vitesse dépassant les recommandations du fabricant de la **batterie** et une charge involontaire soient impossibles, et
– pour les **batteries** rechargeables, une charge et une décharge à une vitesse dépassant les recommandations du fabricant de la **batterie** et une charge inversée soient impossibles; et
– les **batteries** se trouvant dans des **équipements portatifs**, à **enficher directement** et **transportables** pouvant être remplacées par une **personne ordinaire** doivent être intrinsèquement protégées afin d'éviter la création d'une source d'énergie de classe 2 ou 3.

NOTE Une charge en polarité inverse d'une **batterie** rechargeable survient lorsque la polarité du circuit de charge est inversée aidant la décharge de la **batterie**.

M.3.2 Méthode d'essai

Les circuits de protection des ***batteries*** *sont vérifiés par examen et en évaluant les données fournies par le fabricant de l'équipement et des batteries sur les vitesses de chargement et de déchargement.*

Lorsqu'aucune donnée appropriée n'est disponible, la conformité est vérifiée par essai. Cependant, les ***batteries*** *intrinsèquement sûres pour les conditions données ne sont pas soumises à l'essai dans ces conditions. Les* ***piles*** *ordinaires carbone-zinc ou alcalines non rechargeables sont considérées sûres dans les conditions de court-circuit et ne sont donc pas soumises à essai pour les décharges, pas plus qu'elles ne le sont pour les fuites dans les conditions de stockage.*

La ***batterie*** *utilisée pour les essais suivants est soit une nouvelle* ***pile*** *non rechargeable, soit une* ***batterie*** *complètement rechargée fournie avec l'équipement ou recommandée par le fabricant pour l'utilisation avec ce dernier. L'essai des circuits de protection des* ***batteries*** *dans l'équipement peut être réalisé en utilisant un simulateur de* ***batterie*** *pour remplacer la* ***batterie*** *proprement dite. L'essai en température est réalisé dans une enceinte à régulation de température. Un signal de commande simulant le signal réel provenant du capteur de température dans la* ***batterie*** *peut être utilisé pour réaliser l'essai.*

– *Surcharge d'une* ***batterie*** *rechargeable. La* ***batterie*** *est chargée tout en étant brièvement soumise à la simulation de toute* ***condition de premier défaut*** *susceptible de se produire dans le circuit de charge et donnant lieu à une surcharge de la* ***batterie****. Afin de réduire la durée de l'essai, la défaillance choisie est celle qui engendre la condition de surcharge la plus défavorable. La* ***batterie*** *est alors chargée pendant une seule période de 7 h avec présence de la défaillance simulée.*
– *Décharge excessive. La* ***batterie*** *est soumise à une décharge rapide en créant un défaut de circuit ouvert ou un court-circuit à un dispositif de limitation de courant ou de limitation de tension dans le circuit de charge de la* ***pile*** *à l'essai (un composant à la fois).*

Lorsque plus d'une ***pile*** *est fournie dans une* ***batterie****, toutes les* ***piles*** *doivent être soumises à l'essai comme une unité.*

NOTE Certains de ces essais spécifiés peuvent être dangereux pour les personnes réalisant les essais. Utiliser des mesures appropriées pour protéger de telles personnes contre tout danger chimique ou d'**explosion** potentiel.

*Pour les équipements contenant une **batterie** qu'il est possible de retirer par une **personne ordinaire**, les essais supplémentaires suivants s'appliquent:*

– *Charge en polarité inverse d'une **batterie** rechargeable. Vérifier si l'équipement contenant une **batterie** a une configuration telle que la **batterie** peut être placée dans l'équipement de manière à provoquer une charge inversée. Il est également vérifié si la connexion électrique est établie. Si l'on considère qu'une charge inversée est possible par examen, l'essai suivant est réalisé. Cependant, lorsque les normes CEI applicables sur les **batteries** couvrent cette exigence dans l'Annexe, l'essai est considéré comme réalisé.*

  *La **batterie** est installée dans la position inverse et le circuit de charge est alors soumis à la simulation de toute défaillance de composant. Afin de réduire la durée des essais, la défaillance est choisie de manière à causer le courant de charge en polarité inverse le plus élevé. La **batterie** est alors chargée en polarité inverse pendant une période unique de 7 h avec la défaillance simulée en place.*

– *Charge non intentionnelle d'une **batterie** non rechargeable. La **batterie** se charge tout en étant brièvement soumise à la simulation de toute défaillance de composant susceptible de survenir dans le circuit de charge et qui donnerait lieu à une charge non intentionnelle de la **batterie**. Afin de réduire la durée des essais, la défaillance est choisie de manière à causer le courant de charge le plus élevé. La **batterie** est alors chargée pendant une période unique de 7 h avec la défaillance simulée en place.*

M.3.3 Critères de conformité

Ces essais ne doivent provoquer aucune des réactions suivantes:

– *une fuite chimique provoquée par la fissure, la rupture ou l'éclatement de l'enveloppe de la **batterie**, dans le cas où une telle fuite peut nuire à la **protection**; ou*

– *l'écoulement de liquide à partir de tout dispositif d'échappement de la pression dans la **batterie**, à moins qu'un tel écoulement ne soit contenu par l'équipement sans qu'il n'y ait de risque d'endommager la **protection** ou de blesser une **personne ordinaire** ou **avertie**; ou*

– *l'**explosion** de la **batterie**, si une telle **explosion** est susceptible de blesser une **personne ordinaire** ou **avertie**; ou*

– *l'émission de flammes ou l'expulsion de métal fondu à l'extérieur de l'**enveloppe** de l'équipement.*

Pendant tous les essais:

– *la température de la **batterie** ne doit pas dépasser la température admissible de la **batterie** spécifiée par le fabricant de la **batterie**; et*

– *le courant maximal tiré de la **batterie** doit être dans la plage de la spécification de la **batterie**.*

M.4 Protections supplémentaires pour les équipements contenant des batteries secondaires au lithium

M.4.1 Généralités

Les équipements conçus pour fonctionner en intégrant une ou plusieurs **batteries secondaires au lithium** étanches portatives sont soumis aux exigences du présent article.

M.4.2 Protections de charge

M.4.2.1 Exigences

Dans les **conditions normales de fonctionnement**, les **conditions anormales de fonctionnement** ou les **conditions de premier défaut,** la tension de charge par **batterie secondaire au lithium** et le courant de charge par **batterie secondaire au lithium** ne doivent pas dépasser la **tension de charge maximale spécifiée** et le **courant de charge maximal spécifié**.

Le circuit de charge des **batteries** doit s'arrêter de charger lorsque la température de la **batterie** dépasse la **température de charge la plus élevée spécifiée**. Le circuit de charge de **batteries** doit limiter le courant à la valeur spécifiée par le fabricant de **batterie** lorsque la température de la **batterie** est inférieure à la **température de charge la plus basse spécifiée**.

M.4.2.2 Critères de conformité

La conformité est vérifiée par mesure de la tension de charge, du courant de charge et de la température de chaque pile individuelle de la ***batterie secondaire au lithium*** *dans les* ***conditions normales de fonctionnement****, les* ***conditions anormales de fonctionnement*** *et les* ***conditions de premier défaut****. La température de la* ***pile*** *doit être mesurée aux points spécifiés par le fabricant de* ***batterie****. Les c****onditions de premier défaut*** *qui peuvent affecter la tension de charge ou le courant de charge ou la température doivent être appliquées conformément à l'Article B.4.*

NOTE 1 Pour les ensembles enrobés, les thermocouples pourraient être fixés à la surface de la **pile** avant l'enrobage.

Une tension de charge plus élevée que la ***tension de charge maximale spécifiée*** *ou un courant de charge plus élevé que le* ***courant de charge maximal spécifié****, qui se produit juste après l'introduction d'une* ***condition de fonctionnement anormal*** *ou d'une* ***condition de premier défaut****, peut être ignoré si le fonctionnement d'un dispositif ou d'un circuit de protection, fourni en complément du circuit de régulation normal, empêche la* ***batterie*** *d'être dans une condition dangereuse.*

Le cas échéant, pour les besoins des mesures, la ***batterie*** *peut être remplacée par un circuit simulant la charge de* ***batterie****.*

La tension de charge doit être mesurée lorsque la ***batterie secondaire au lithium*** *est totalement chargée. Le courant de charge doit être mesuré pendant tout le cycle de charge jusqu'à la* ***tension de charge maximale spécifiée****.*

Pendant et après l'essai, aucun incendie ou ***explosion*** *(autre que d'évacuation de gaz) de la* ***batterie secondaire au lithium*** *ne doit se produire. La tension de charge ne doit pas dépasser la* ***tension de charge maximale spécifiée****. Le courant de charge ne doit pas dépasser le* ***courant de charge maximal spécifié****. La charge de la* ***batterie*** *doit être arrêtée lorsque la température de la* ***batterie*** *dépasse la* ***température de charge la plus élevée spécifiée****. Les circuits de charge de la* ***batterie*** *doivent limiter le courant à la valeur spécifiée par le fabricant de* ***batterie*** *lorsque la température de celle-ci est inférieure à la* ***température de charge la plus basse spécifiée***

NOTE 2 L'évacuation de gaz sans flamme, incendie ou expulsion de matériaux solides constitue une **protection** d'une **batterie secondaire au lithium**.

De plus, pour les équipements dont la ***batterie*** *peut être retirée par une* ***personne ordinaire****, la conformité est vérifiée par mesure de la tension de charge et du courant de charge et par évaluation de la fonction de régulation de température de l'équipement dans les* ***conditions normales de fonctionnement****, les* ***conditions anormales de fonctionnement*** *et les* ***conditions de premier défaut****.*

*Tous les paramètres contrôlés par le circuit de protection doivent correspondre à ceux spécifiés dans la norme CEI applicable sur les **batteries**, et doivent couvrir les éléments suivants:*

- *le courant maximal tiré de la **batterie** doit être dans la plage de la spécification de la **batterie**; et*
- *pendant tous les essais, la température de la **batterie** ne doit pas dépasser la température admissible de la **batterie** spécifiée par le fabricant de la **batterie**.*

NOTE 3 Les éléments de régulation sont la tension, le courant et la température.

M.4.3 Enveloppe ignifuge (contre le feu)

La **batterie secondaire au lithium** doit être munie d'une **enveloppe ignifuge (contre le feu)** conformément à 6.4.8. L'**enveloppe ignifuge (contre le feu)** peut être celle de la **batterie secondaire au lithium** proprement dite ou celle de l'équipement contenant la **batterie secondaire au lithium**.

Les équipements à **batteries** sont exemptés de l'exigence ci-dessus, à condition que:

- la **batterie** soit conforme aux limites de circuit PS1; ou
- l'équipement avec la **batterie** satisfasse aux exigences de **protection supplémentaire** de 6.4.5.2.

*La conformité est vérifiée par examen du matériau applicable ou par évaluation de la fiche technique de la **batterie secondaire au lithium**.*

M.4.4 Essai de chute de l'équipement contenant une batterie secondaire au lithium

M.4.4.1 Généralités

Les essais applicables à l'**équipement à enficher directement**, **équipement portatif** et à l'**équipement transportable** contenant une **batterie secondaire au lithium** sont spécifiés ci-dessous. Ces essais sont spécifiés pour vérifier que le choc mécanique ne compromettra pas une **protection** à l'intérieur de la **batterie** ou de l'équipement.

M.4.4.2 Préparation et procédure de l'essai de chute

L'essai de chute est effectué dans l'ordre suivant:

- *Etape 1: chute de l'équipement contenant une **batterie,** comme spécifié en M.4.4.3*
- *Etape 2: vérifier la fonction de charge et de décharge de l'équipement ayant chuté, comme spécifié en M.4.4.4*
- *Etape 3: effectuer un essai de cycle de charge-décharge de la **batterie** ayant chuté, comme spécifié en M.4.4.5.*

*En préparation de l'essai de chute, deux **batteries** sont totalement chargées en même temps dans les mêmes conditions de charge. Les tensions en circuit ouvert des deux **batteries** sont mesurées pour confirmer que les tensions initiales sont identiques. Une **batterie** est utilisée pour l'essai de chute et l'autre comme référence.*

M.4.4.3 Chute

*L'équipement avec une **batterie** totalement chargée installée doit être soumis à l'essai de chute de l'Article T.7.*

*A l'issue de l'essai de chute, la **batterie** est retirée de l'équipement. Les tensions en circuit ouvert de la **batterie** ayant subi l'essai de chute et de la **batterie** de référence (n'ayant pas subi l'essai) sont surveillées périodiquement pendant les 24 heures suivantes. La différence de tension ne doit pas dépasser 5 %.*

M.4.4.4 Vérification de la fonction de charge/décharge

Les fonctions des circuits de charge/décharge (tension de contrôle de charge, courant de contrôle de charge et contrôle de température) sont vérifiées pour déterminer qu'elles continuent à fonctionner et que toutes les ***protections*** *sont efficaces. Une* ***batterie*** *fictive ou un outil de mesure approprié qui représente les caractéristiques de la* ***batterie*** *peut être utilisé pour cet examen pour faire la différence entre les dommages affectant la* ***batterie*** *et les dysfonctionnements de l'équipement.*

Si la fonction de charge/décharge ne marche pas, il est mis fin à l'essai et il n'est pas nécessaire de passer à l'étape 3; la conformité est déterminée par M.4.4.6.

M.4.4.5 Essai de cycle de charge – décharge

Si l'équipement ayant chuté fonctionne toujours, l'équipement auquel appartient la ***batterie*** *ayant chuté est soumis à trois cycles complets de décharge et de charge dans des* ***conditions de fonctionnement normal****.*

M.4.4.6 Critères de conformité

*Pendant les essais, l'incendie ou l'****explosion*** *de la* ***batterie*** *ne doit pas se produire sauf si une* ***protection*** *appropriée permettant de contenir l'incendie ou l'****explosion*** *est prévue. En cas d'évacuation, toute fuite d'électrolyte ne doit pas supprimer une* ***protection****.*

Lorsqu'un circuit de protection de charge ou de décharge dans l'équipement ou dans la ***batterie*** *détecte une anomalie dans la* ***batterie*** *et arrête la charge ou la décharge, le résultat est considéré comme acceptable.*

M.5 Risque de brûlure provoqué par un court-circuit pendant le transport

M.5.1 Exigences

Les bornes de **batterie** doivent être protégées afin d'éviter qu'une **personne ordinaire** ou qu'une **personne avertie** ne se brûle pendant le transport d'une **batterie** avec des bornes conductrices nues accessibles (comme par exemple, dans le sac de transport de l'utilisateur) à cause d'un court-circuit provoqué par des objets métalliques, tels que des pinces, des clés et des colliers.

M.5.2 Méthode d'essai et critères de conformité

Si la ***batterie*** *est conçue pour être transportée avec des bornes conductrices nues, elle doit satisfaire à l'essai de P.2.3.*

Les critères de conformité de M.3.3 s'appliquent.

M.6 Protection contre les courts-circuits et autres effets du courant électrique

M.6.1 Courts-circuits

M.6.1.1 Exigences générales

L'énergie électrique stockée dans les **piles** ou les **batteries** peut être libérée involontairement et de façon incontrôlée en raison du court-circuit externe des bornes ou d'un défaut de la **protection** interne, comme un contaminant métallique mis en parallèle sur l'isolation. Par conséquent, l'énergie, la chaleur et la pression considérables générées par le courant élevé peuvent produire une fusion du métal, des étincelles, une **explosion** et une vaporisation d'électrolyte.

Pour traiter des défauts externes, les connexions principales des bornes de la **batterie** doivent au choix:

– être munies d'un dispositif de protection contre les surintensités suffisant afin d'empêcher tout court-circuit accidentel pouvant impliquer les conditions telles que mentionnées ci-dessus; ou
– les connexions de la **batterie** jusqu'au premier dispositif de protection contre les surintensités doivent être construites de façon à ce qu'un court-circuit ne soit pas susceptible de se produire et les connexions doivent être conçues pour supporter les forces électromagnétiques expérimentées pendant un court-circuit.

NOTE 1 Lorsque les bornes et les conducteurs ne sont pas isolés, par conception ou à des fins de maintenance, seuls des **outils** isolés sont à utiliser dans cette zone.

Sauf dans le cas où un essai de défaut interne a été réalisé sur la **batterie** dans le cadre des essais de conformité à la norme CEI applicable aux **batteries** en M.2.1, l'essai de défaut interne décrit ci-dessous est exigé.

NOTE 2 Toutes les normes de **batteries** de M.2.1 ne contiennent pas un essai de défaut interne similaire.

Chaque **pile** doit être soumise à un défaut de façon à évacuer les gaz en toute sécurité sans introduire de risque d'**explosion** ou d'incendie. Lorsqu'une **pile** est intégrée dans une **batterie** ou dans l'équipement, un espace suffisant doit être dégagé en vue du fonctionnement correct des évacuations de gaz de chaque **pile**.

M.6.1.2 Critères de conformité

Concernant les défauts externes, la conformité peut être vérifiée par examen.

L'échantillon ne doit pas exploser ni émettre de matériau fondu à aucun moment pendant aucun des essais.

M.6.2 Courants de fuite

Afin de résister aux effets des influences environnementales telles que la température, l'humidité, la poussière, les gaz, la vapeur et les contraintes mécaniques, et pour éviter tout risque d'incendie ou de corrosion, les **batteries** doivent être conservées propres et sèches.

Il convient que le système de **batterie** soit isolé de l'installation fixe avant la réalisation du présent essai.

NOTE Avant la réalisation de tout essai, prendre en considération la présence de la tension ES2 ou ES3 entre la **batterie** et le casier ou l'**enveloppe** associé(e).

La conformité est vérifiée en mesurant la résistance d'isolement entre le circuit de la ***batterie*** *et les autres parties conductrices locales. La résistance d'isolement doit être supérieure à 100 Ω par volt (de tension nominale de la* ***batterie****), correspondant à un courant de fuite inférieur à 10 mA.*

M.7 Risque d'explosion des batteries d'accumulateurs au plomb-acide et au nickel-cadmium

M.7.1 Ventilation empêchant la concentration en gaz explosif

Lorsque les **batteries** sont fournies à l'intérieur d'un équipement tel que les gaz émis peuvent se concentrer dans un espace confiné à l'intérieur de l'équipement, la construction de la **batterie**, le débit d'air ou la ventilation doivent être tels que l'atmosphère au sein de l'équipement n'atteigne pas une concentration **explosive**.

L'article M.7 s'applique aux **batteries** de type ouvert et aux **batteries** à régulation par soupapes. Les **batteries** étanches comportant un mécanisme de réduction des gaz sont considérées satisfaire à cette exigence.

M.7.2 Méthode d'essai et critères de conformité

*Ventiler l'emplacement de la **batterie** ou l'**enveloppe** a pour objectif de maintenir la teneur en hydrogène en dessous du seuil **explosif** de la limite inférieure d'explosivité (LEL), soit 4 %$_{\text{vol}}$. La teneur en hydrogène dans l'emplacement de la **batterie** ne doit pas dépasser 1 %$_{\text{vol}}$.*

NOTE 1 Lorsqu'une **pile** atteint un état de charge complet, l'électrolyse de l'eau survient conformément à la loi de Faraday.

Dans des conditions normalisées de température et de pression normales, où T = 273 K, P = 1 013 hPa:

– *1 Ah décompose H_2O en 0,42 l H_2 + 0,21 l O_2,*

– *la décomposition de 1 cm^3 (1 g) de H_2O requiert 3 Ah,*

– *26,8 Ah décompose H_2O en 1 g H_2 + 8 g O_2.*

*Lorsque l'opération de charge s'arrête, l'émission de gaz à partir des **piles** peut être considérée comme finie 1 h après avoir éteint le courant de charge.*

*Le débit d'air minimal pour la ventilation d'un emplacement ou d'un compartiment de **batteries** doit être calculé à l'aide de la formule suivante:*

$$Q = v \times q \times s \times n \times I_{\text{gaz}} \times C_{\text{rt}} \times 10^{-3} \quad \left[\text{m}^3/\text{h}\right]$$

où

Q *est le débit d'air de ventilation en m^3/h;*

v *est la dilution nécessaire de l'hydrogène:*

$$\frac{(100-4)\ \%}{4\ \%} = 24$$

q = $0{,}42 \times 10^{-3}$ $\left[\text{m}^3/\text{Ah}\right]$ *d'hydrogène généré;*

s *= 5, facteur de sécurité général;*

n *est le nombre de **piles**;*

I_{gaz} *est le courant produisant du gaz en capacité assignée mA/Ah pour le courant de charge flottant $I_{flottant}$ ou le courant de charge rapide I_{pression};*

C_{rt} est la capacité C_{10} pour les **piles** d'accumulateurs au plomb-acide (Ah) ou la capacité C_5 pour les **piles** au nickel-cadmium (Ah).

NOTE 2 C_{10} est le débit de 10 h avec le courant I_{10} pour les **piles** au plomb-acide: (Ah) avec U_{final} = 1,80 V/**pile** à une température de 20 °C.

C_5 est le débit de 5 h avec le courant I_5 pour les **piles** au nickel-cadmium: (Ah) avec U_{final} = 1,00 V/**pile** à une température de 20 °C.

avec $v \times q \times s = 0{,}05 \left[\text{m}^3/\text{Ah}\right]$*, la formule de calcul du débit d'air de ventilation est:*

$$Q = 0{,}05 \times n \times l_{gaz} \times C_{rt} \times 10^{-3} \left[m^3/h\right]$$

Le courant I_{gaz} en mA produisant du gaz est déterminé par l'une des formules suivantes:

$$I_{\text{gaz}} = I_{\text{flottant}} \times f_{\text{g}} \times f_{\text{s}} \left[\text{mA/Ah}\right] \ \textit{ou}$$

$$I_{\text{gaz}} = I_{\text{pression}} \times f_{\text{g}} \times f_{\text{s}} \ [\text{mA/Ah}]$$

où

I_{gaz} *est le courant produisant du gaz en capacité assignée mA/Ah pour le courant de charge flottant $I_{flottant}$ ou le courant de charge rapide $I_{pression}$;*

I_{flottant} *est le courant de charge flottant dans des conditions de charge complète à une tension de charge flottante définie à 20 °C;*

I_{pression} *est le courant de charge rapide dans des conditions de charge complète à une tension de charge rapide définie à 20 °C;*

f_{g} *est le facteur d'émission de gaz, soit la proportion de courant à un état de charge complète produisant de l'hydrogène (voir Tableau M.1);*

f_{s} *est le facteur de sécurité, afin de contenir des **piles** défectueuses dans une **batterie** et une **batterie** âgée (voir Tableau M.1).*

Tableau M.1 – Valeurs de f_g et f_s

	Piles avec mise à l'air libre des batteries au plomb-acide Sb < 3 %	**Piles VRLA des batteries au plomb-acide**	**Piles avec mise à l'air libre des batteries au nickel-cadmium**
facteur d'émission de gaz f_g	1	0,2	1
facteur de sécurité d'émission de gaz f_s (y compris 10 % de **piles** défectueuses et vieillissement)	5	5	5

Pour les équipements en extérieur, l'Article 11 de la CEI 60950-22:2005 s'applique.

M.8 Protection contre une inflammation interne à partir des sources d'étincelles externes des batteries à électrolyte aqueux

M.8.1 Généralités

Les exigences spécifiées ci-dessous s'appliquent aux **batteries** rechargeables fournissant un système de ventilation.

NOTE Par exemple, une **batterie** utilisée dans une UPS.

Le niveau du débit de ventilation de l'air doit garantir qu'aucun risque d'**explosion** n'existe en maintenant la teneur en hydrogène dans l'air en dessous de 1 $\%_{\text{vol}}$ à la source potentielle d'incendie **PIS**.

L'utilisation d'un limiteur de flammes efficace dans le système de ventilation de la **batterie** empêche qu'une **explosion** externe ne se propage dans la **batterie**.

L'article M.8 s'applique aux **batteries** de type ouvert et aux **batteries** à régulation par soupapes. Les **batteries** étanches comportant un mécanisme de réduction des gaz sont considérées satisfaire à cette exigence.

M.8.2 Méthode d'essai

M.8.2.1 Généralités

L'essai doit être réalisé conformément à la CEI 60896-21:2004, 6.4.

NOTE 1 Cet essai est conçu pour révéler la protection offerte par l'unité de la soupape contre l'inflammation des gaz à l'intérieur d'une **pile** par une source d'inflammation extérieure. Au cours de cet essai, prendre des mesures de précaution appropriées afin d'assurer la **protection** des personnes et de l'équipement de tout risque d'**explosion** et de brûlure.

Une distance minimale d qui s'étend dans l'air doit être maintenue, à l'intérieur de laquelle une température de surface maximale de 300 °C ne doit pas être dépassée (absence de flammes, étincelles, arcs ou éléments incandescents).

NOTE 2 Lors du calcul de la distance minimale d pour protéger contre l'**explosion** à proximité immédiate de la source d'échappement d'une **pile** ou d'une **batterie**, la dilution des gaz **explosifs** n'est pas toujours garantie. La dispersion des gaz **explosifs** dépend du taux d'échappement des gaz et des caractéristiques de ventilation proches de la source d'échappement.

*La distance minimale d peut être estimée en calculant les dimensions d'un volume hypothétique V_z d'un gaz potentiellement **explosif** autour de la source d'échappement, en dehors de laquelle la teneur en hydrogène est en dessous de la concentration sûre de la LEL.*

$$d = 28{,}8 \times \sqrt[3]{I_{\text{gaz}}} \times \sqrt[3]{C_{\text{rt}}} \qquad [\text{mm}]$$

où

I_{gaz} *est le courant produisant du gaz [mA / Ah];*

C_{rt} *est la capacité assignée [Ah].*

NOTE 3 La distance requise d peut être atteinte en utilisant un mur de séparation entre la **batterie** et le dispositif générateur d'étincelles.

*Lorsque les **batteries** font partie intégrante d'un système d'alimentation (par exemple, dans un système UPS), la distance d, où d est la distance minimale (**distance dans l'air**) entre la ventilation de la **batterie** et l'équipement électronique qui peut présenter des flammes, des étincelles, des arcs ou des éléments incandescents (température de surface maximale de 300 °C), peut être réduite conformément aux calculs ou aux mesures du fabricant de l'équipement. Il convient que le niveau du débit de ventilation de l'air garantisse qu'aucun risque d'**explosion** n'existe en maintenant la teneur en hydrogène dans l'air en dessous de 1 %vol plus une marge à la source potentielle d'incendie **PIS**.*

M.8.2.2 Estimation du volume hypothétique V_z

Le débit de ventilation minimal théorique pour diluer le gaz inflammable (hydrogène) à une concentration en dessous de la LEL peut être calculé au moyen de la formule:

$$\left(\frac{dV}{dt}\right)_{\text{min}} = \frac{(dG/dt)_{\text{max}}}{k \times \text{LEL}} \times \frac{T}{293}$$

où

dV/dt_{min} est le débit volumétrique minimal d'air frais nécessaire pour diluer le gaz (m^3/s);

dG/dt_{max} est le taux d'échappement maximal des gaz (kg/s);

LEL est égale à 4% de volume pour de l'hydrogène (kg/m^3);

k est le facteur appliqué à la LEL; k = 0,25 est choisi pour la dilution du gaz hydrogène;

T est la température ambiante en K (293 Kelvin = 20 °C).

Le volume V_z représente le volume au-dessus duquel la concentration moyenne de gaz inflammable est 0,25 fois la LEL. Cela signifie qu'aux extrémités du volume hypothétique, la concentration du gaz est significativement inférieure à la LEL (par exemple, le volume hypothétique où la concentration est au-dessus de la LEL est inférieur à V_z).

M.8.2.3 Facteurs de correction

Avec un nombre donné de renouvellements d'air par unité de temps, c, lié à la ventilation générale, le volume hypothétique V_z de l'atmosphère potentiellement **explosive** autour de la source d'échappement peut être estimé comme suit:

$$V_z = \left(\frac{dV}{dt}\right)_{\text{min}} / \ c$$

où c est le nombre de renouvellements d'air frais par unité de temps (s^{-1}).

La formule ci-dessus est valable pour un mélange instantané et homogène à la source de l'échappement dans des conditions de débit idéales d'air frais. En pratique, des conditions idéales existent rarement. Ainsi, un facteur de correction f est introduit pour indiquer l'efficacité de la ventilation.

$$V_z = \ f \times \left(\frac{dV}{dt}\right)_{\text{min}} / \ c$$

où f est le facteur d'efficacité de la ventilation, indiquant l'efficacité de la ventilation en termes de son efficacité à diluer l'atmosphère **explosive**, f allant de 1 (idéal) à 5 généralement (débit d'air contrarié). Pour les installations de **batterie**, le facteur d'efficacité de la ventilation est $f = 1,25$.

M.8.2.4 Calcul de la distance *d*

Le terme $\left(\frac{dV}{dt}\right)_{\text{min}}$

comprenant tous les facteurs correspondant au débit d'air de ventilation horaire Q (en m^3/h) pour les batteries secondaires calculé de la façon suivante:

$$Q = \ f \ \times \left(\frac{dV}{dt}\right)$$

$$Q = 0{,}05 \times (N) \times \ I_{\text{gaz}} \times C_{\text{rt}} \times 10^{-3} \quad [m^3/h]$$

Ce débit d'air de ventilation horaire Q peut être utilisé pour définir un volume hypothétique. En supposant une dispersion hémisphérique de gaz, un volume d'un hémisphère $V_z = 2/3 \ \pi \ d^3$ peut être défini, où d est la distance à partir de la source d'échappement.

Cela entraîne la formule de calcul pour la distance d, avec $c = 1$ renouvellement d'air par heure à l'intérieur de l'hémisphère:

$$d^3 = \frac{3}{2\pi} \times 0{,}05 \times 10^6 \times (N) \times I_{\text{gaz}} \times C_{\text{rt}} \quad [mm^3]$$

$$d = 28{,}8 \times \left(\sqrt[3]{N}\right) \times \sqrt[3]{I_{\text{gaz}}} \times \sqrt[3]{C_{\text{rt}}} \quad [mm]$$

En fonction de la source d'échappement de gaz, le nombre de **piles** par **batterie** monobloc (N) ou d'ouvertures de ventilation par **pile** concernée ($1/N$) doit être pris en compte (par exemple, par le facteur $\sqrt[3]{N}$, respectivement $\sqrt[3]{1/N}$).

La distance d en fonction de la capacité assignée pour des courants de charge divers I (mA/Ah) est illustrée à la Figure M.1.

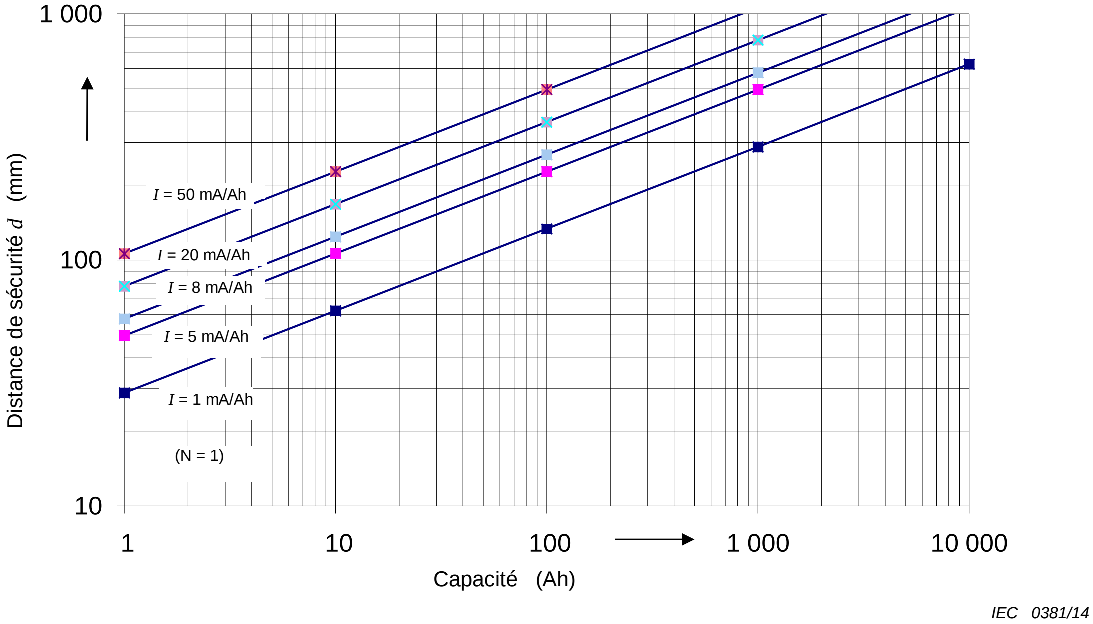


Figure M.1 – Distance *d* en fonction de la capacité assignée pour des courants de charge divers *I* (mA/Ah)

M.9 Prévention contre l'écoulement d'électrolyte

M.9.1 Prévention contre l'écoulement d'électrolyte

L'équipement doit être construit de telle façon que l'écoulement d'électrolyte à partir des **batteries**, pouvant avoir un effet indésirable sur la peau, les yeux et autres parties du corps humain, ainsi que les autres **protections** ou les locaux, soit improbable. Il convient de prendre en compte tous les modes de fonctionnement possibles pendant la maintenance, y compris le remplacement de la **batterie** et le rechargement du matériau consommé.

La conformité est vérifiée par examen.

M.9.2 Réceptacle pour la prévention contre l'écoulement d'électrolyte

Si une défaillance de **pile** peut provoquer l'écoulement d'électrolyte, l'écoulement doit être contenu (par exemple, en utilisant un réceptacle de retenue appropriée pour contenir l'électrolyte) en prenant en compte la quantité d'écoulement maximale possible.

Cette exigence est applicable à l'**équipement stationnaire**, et ne s'applique pas si la construction de la **batterie** est telle qu'une fuite d'électrolyte de la **batterie** est improbable, ou si un écoulement d'électrolyte n'affecte pas de façon indésirable l'isolation requise.

NOTE Un exemple de construction de **batterie** où la fuite d'électrolyte est considérée improbable est la **batterie** étanche à régulation par soupapes.

La conformité est vérifiée par examen.

M.10 Instructions destinées à éviter tout mauvais usage raisonnablement prévisible

Une **batterie** intégrée dans l'équipement et une **batterie** munie de ses composants associés (y compris les **piles** et les générateurs d'électricité) doivent être construites d'une telle façon qu'un choc électrique ou qu'une défaillance de **protection** au feu (par exemple, une fuite chimique inflammable provoquant un incendie ou endommageant l'isolation) soient improbables, en prenant en compte toutes les conditions prévisibles. Cela doit comprendre les conditions extrêmes, le cas échéant, comme spécifié par le fabricant, telles que:

– des températures extrêmes faibles ou élevées auxquelles une **batterie** peut être soumise pendant l'utilisation, le stockage ou le transport; et

– une faible pression de l'air à haute altitude.

Lorsque le fait d'équiper une **batterie** ou un équipement de dispositifs ou de conceptions de sécurité n'est pas raisonnablement pratique au vu de la nature fonctionnelle de la **batterie** ou de l'équipement contenant une **batterie**, les **protections par instructions** conformes à l'Article F.5 doivent être fournies afin de protéger la **batterie** contre des conditions extrêmes ou tout mauvais usage de la part de l'utilisateur. Les exemples qui doivent être pris en compte sont les suivants:

– remplacement d'une **batterie** par un type incorrect pouvant supprimer une **protection** (par exemple, dans le cas de certains types de batteries au lithium);

– mise au rebut d'une **batterie** dans un feu ou dans un four chaud, ou écrasement mécanique ou coupure d'une batterie, susceptible de provoquer une **explosion**;

– maintien d'une **batterie** dans un environnement à très haute température pouvant provoquer une **explosion** ou la fuite de liquide ou de gaz inflammables;

– **batterie** soumise à une pression de l'air extrêmement faible pouvant provoquer une **explosion** ou la fuite de liquide ou de gaz inflammables.

La conformité est vérifiée par examen, par évaluation des données disponibles fournies par le fabricant et, si nécessaire, par des essais dans les ***conditions anormales de fonctionnement*** *selon B.3.6, prenant en compte toutes les conditions d'installation, de transport et d'utilisation possibles.*

Annexe N
(normative)

Potentiels électrochimiques (V)

Magnésium, alliages de magnésium	Zinc, alliages de zinc	Étain 80/zinc 20 sur acier zinc sur fer ou acier l	Aluminium	Cadmium sur acier	Alliage aluminium/magnésium	Acier doux	Duralumin	Plomb	Chrome sur acier, soudure tendre	Cr sur Ni sur acier, étain sur acier, acier inoxydable 12 % Cr	Acier inoxydable à haute teneur en chrome	Cuivre, alliages de cuivre	Soudure à l'argent, acier inoxydable austénitique	Nickel sur acier	Argent	Rhodium sur argent sur cuivre, alliage argent/or	Carbone	Or, platine	
0	0,5	0,55	0,7	0,8	0,85	0,9	1,0	1,05	1,1	1,15	1,25	1,35	1,4	1,45	1,6	1,65	1,7	1,75	Magnésium, alliages de magnésium
	0	0,05	0,2	0,3	0,35	0,4	0,5	0,55	0,6	0,65	0,75	0,85	0,9	0,95	1,1	1,15	1,2	1,25	Zinc, alliages de zinc
		0	0,15	0,25	0,3	0,35	0,45	0,5	0,55	0,6	0,7	0,8	0,85	0,9	1,05	1,1	1,15	1,2	Étain 80/zinc 20 sur acier zinc sur fer ou
			0	0,1	0,15	0,2	0,3	0,35	0,4	0,45	0,55	0,65	0,7	0,75	0,9	0,95	1,0	1,05	Aluminium
				0	0,05	0,1	0,2	0,25	0,3	0,35	0,45	0,55	0,6	0,65	0,8	0,85	0,9	0,95	Cadmium sur acier
					0	0,05	0,15	0,2	0,25	0,3	0,4	0,5	0,55	0,6	0,75	0,8	0,85	0,9	Alliage aluminium / magnésium
						0	0,1	0,15	0,2	0,25	0,35	0,45	0,5	0,55	0,7	0,75	0,8	0,85	Acier doux
							0	0,05	0,1	0,15	0,25	0,35	0,4	0,45	0,6	0,65	0,7	0,75	Duralumin
								0	0,05	0,1	0,2	0,3	0,35	0,4	0,55	0,6	0,66	0,7	Plomb
									0	0,05	0,15	0,25	0,3	0,35	0,5	0,55	0,6	0,65	Chrome sur acier, soudure tendre
										0	0,1	0,2	0,25	0,3	0,45	0,5	0,55	0,6	Cr sur Ni sur acier, étain sur acier, acier inoxydable 12 % Cr
											0	0,1	0,15	0,2	0,35	0,4	0,45	0,5	Acier inoxydable à haute teneur en chrome
												0	0,05	0,1	0,25	0,3	0,35	0,4	Cuivre, alliages de cuivre
													0	0,05	0,2	0,25	0,3	0,35	Soudure à l'argent, acier inoxydable
														0	0,15	0,2	0,25	0,3	Nickel sur acier
															0	0,05	0,1	0,15	Argent
																0	0,05	0,1	Rhodium sur argent sur cuivre, alliage argent/or
																	0	0,05	Carbone
																		0	Or, platine

Cr = Chrome

Ni = Nickel

La corrosion due à une action électrochimique entre métaux dissemblables qui sont en contact est réduite le plus possible si le potentiel électrochimique combiné est inférieur environ à 0,6 V. Le tableau ci-dessus donne la liste des potentiels électrochimiques combinés pour un certain nombre de paires de métaux couramment employés. Il convient d'éviter les combinaisons au-dessus de la ligne de démarcation.

Annexe O
(normative)

Mesure des lignes de fuite et des distances dans l’air

Dans les Figures O.1 à O.20 suivantes, la valeur de X est donnée dans le Tableau O.1. Lorsque la distance montrée est inférieure à X, la profondeur de l'ouverture ou de l'encoche n’est pas prise en compte pour la mesure d'une **ligne de fuite**.

Si la **distance dans l’air** minimale requise est supérieure à 3 mm, la valeur de X est donnée dans le Tableau O.1.

Si la **distance dans l’air** minimale requise est inférieure à 3 mm, la valeur de X est la valeur la plus petite parmi les deux valeurs suivantes:

– la valeur applicable du Tableau O.1; ou
– un tiers de la **distance dans l’air** minimale requise.

Tableau O.1 – Valeur de *X*

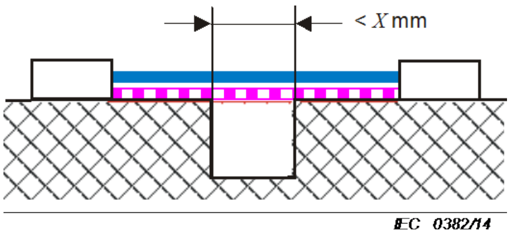
Degré de pollution (voir 5.4.1.5)	X mm
1	0,25
2	1,00
3	1,50

NOTE On applique la convention suivante dans l’ensemble de la présente annexe:

clearance
creepage distance path

Légende

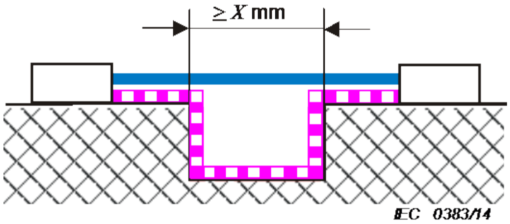
Anglais	Français
Clearance	Distance dans l’air
Creepage distance path	Chemin de la ligne de fuite



Condition: Le chemin considéré comprend une encoche à flancs parallèles ou convergents, de profondeur quelconque et de largeur inférieure à X mm.

Règle: La **ligne de fuite** et la **distance dans l’air** sont mesurées en ligne droite au-dessus de l’encoche.

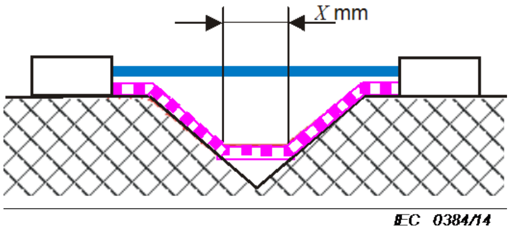
Figure O.1 – Encoche étroite



Condition: Le chemin considéré comprend une encoche à flancs parallèles de profondeur quelconque et de largeur égale ou supérieure à X mm.

Règle: La **distance dans l'air** est la distance "en ligne droite". Le chemin de la **ligne de fuite** longe le profil de l'encoche.

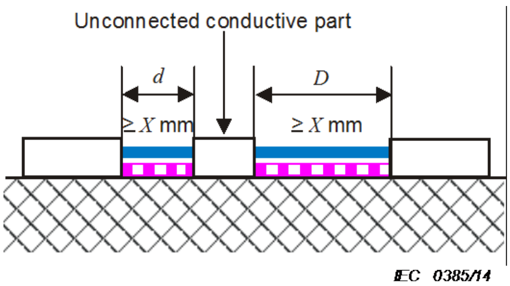
Figure O.2 – Encoche large



Condition: Le chemin considéré comprend une encoche en forme de V dont l'angle interne est inférieur à 80° et dont la largeur est supérieure à X mm.

Règle: La **distance dans l'air** est la distance "en ligne droite". Le chemin de la **ligne de fuite** longe le profil de l'encoche, mais "court-circuite" le bas de l'encoche par un tronçon long de X mm.

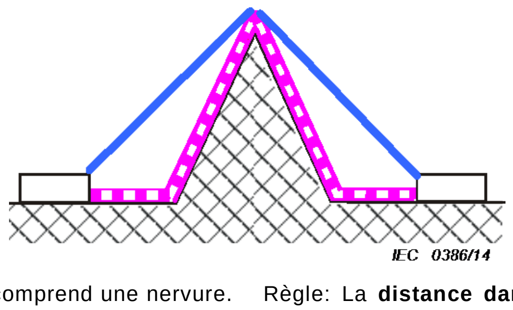
Figure O.3 – Encoche en forme de V



Condition: Distance d'isolation avec une partie conductrice non connectée intercalée.

Règle: La **distance dans l'air** est la distance $d + D$. La **ligne de fuite** est aussi $d + D$. Lorsque la valeur de d ou D est inférieure à X mm, elle doit être considérée comme égale à 0.

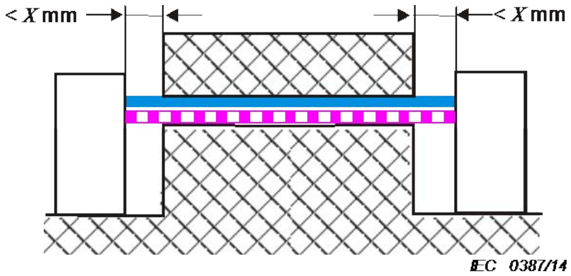
Figure O.4 – Partie conductrice non connectée intercalée



Condition: Le chemin considéré comprend une nervure.

Règle: La **distance dans l'air** est le chemin dans l'air direct le plus court par-dessus le sommet de la nervure. Le chemin de la **ligne de fuite** longe le profil de la nervure.

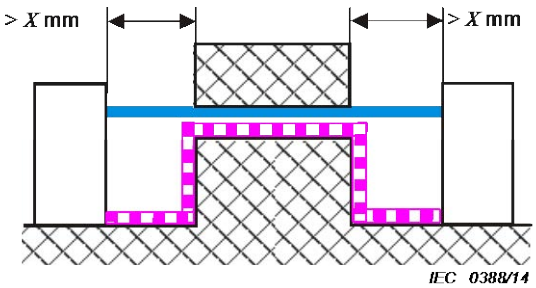
Figure O.5 – Nervure



Condition: Le chemin considéré comprend un joint non scellé avec des encoches de largeur inférieure à X mm de chaque côté.

Règle: Le chemin de la **distance dans l'air** et de la **ligne de fuite** est la distance "en ligne droite" indiquée.

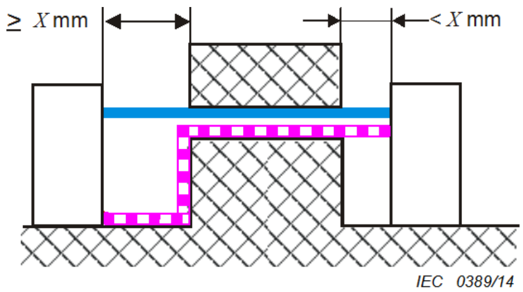
Figure O.6 – Joint non scellé avec encoche étroite



Condition: Le chemin considéré comprend un joint non scellé avec des encoches de largeur égale ou supérieure à X mm de chaque côté.

Règle: La **distance dans l'air** est la distance "en ligne droite". Le chemin de la **ligne de fuite** longe le profil de l'encoche.

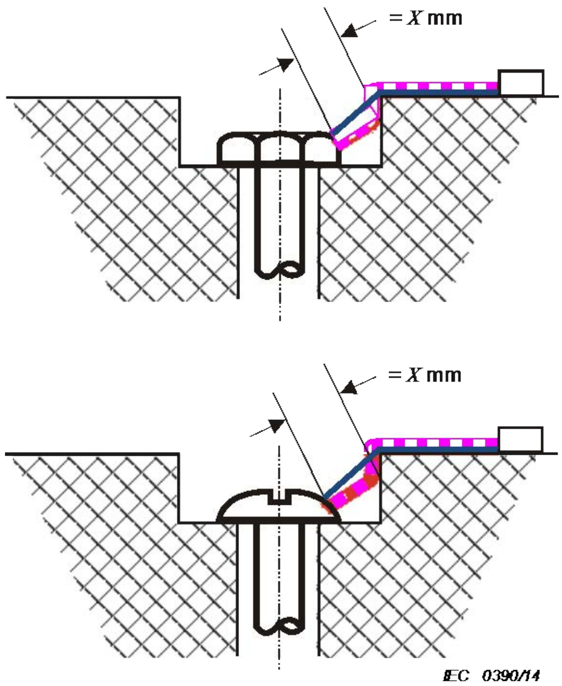
Figure O.7 – Joint non scellé avec encoche large



Condition: Le chemin considéré comprend un joint non scellé avec, d'un côté, des encoches de largeur inférieure à X mm et, de l'autre côté, une encoche de largeur égale ou supérieure à X mm.

Règle: La **distance dans l'air** et le chemin de la **ligne de fuite** sont comme indiqués.

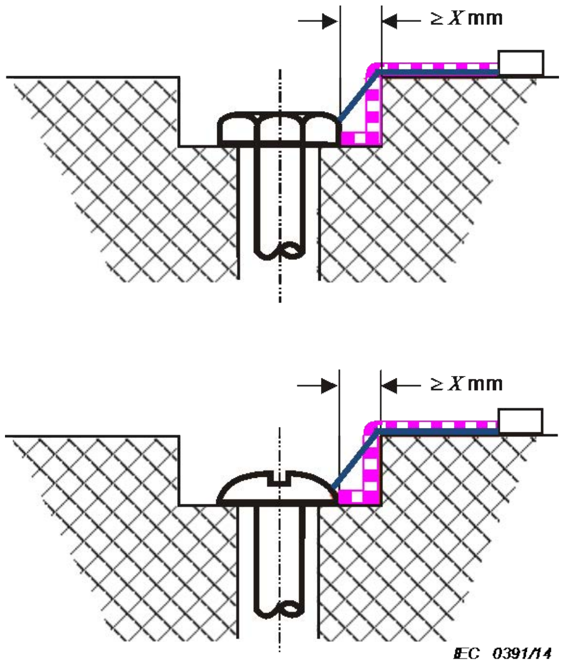
Figure O.8 – Joint non scellé avec encoches large et étroite



Distance entre tête de vis et paroi du logement trop faible pour être prise en compte.

Lorsque la distance entre la tête de vis et la paroi du logement est inférieure à X mm, la mesure de la **ligne de fuite** est réalisée entre la vis et la paroi à l'endroit où la distance est égale à X mm.

Figure O.9 – Faible retrait



Distance entre tête de vis et paroi du logement suffisante pour être prise en compte.

Figure O.10 – Large retrait

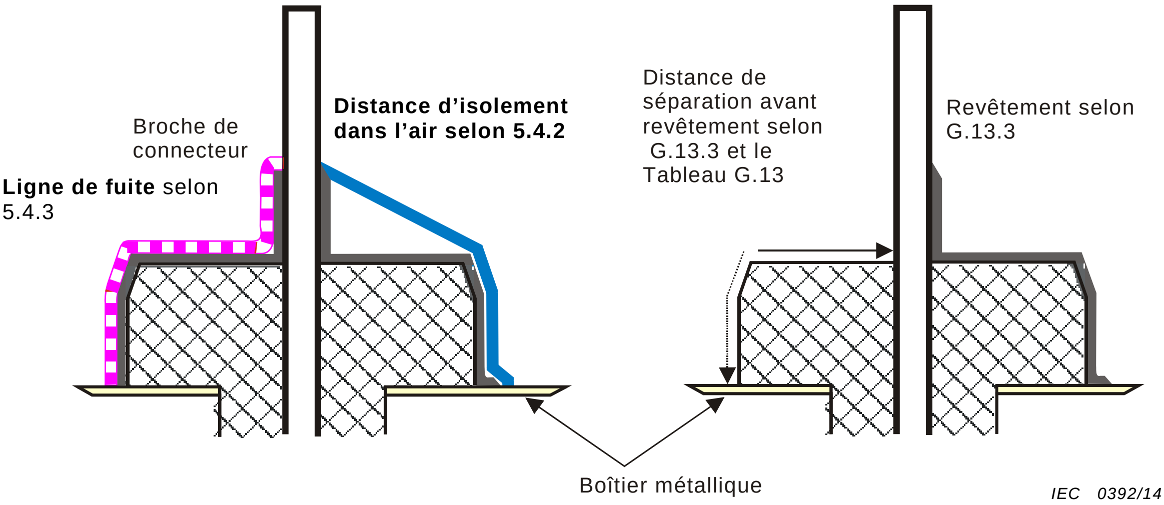


Figure O.11 – Revêtement autour des bornes

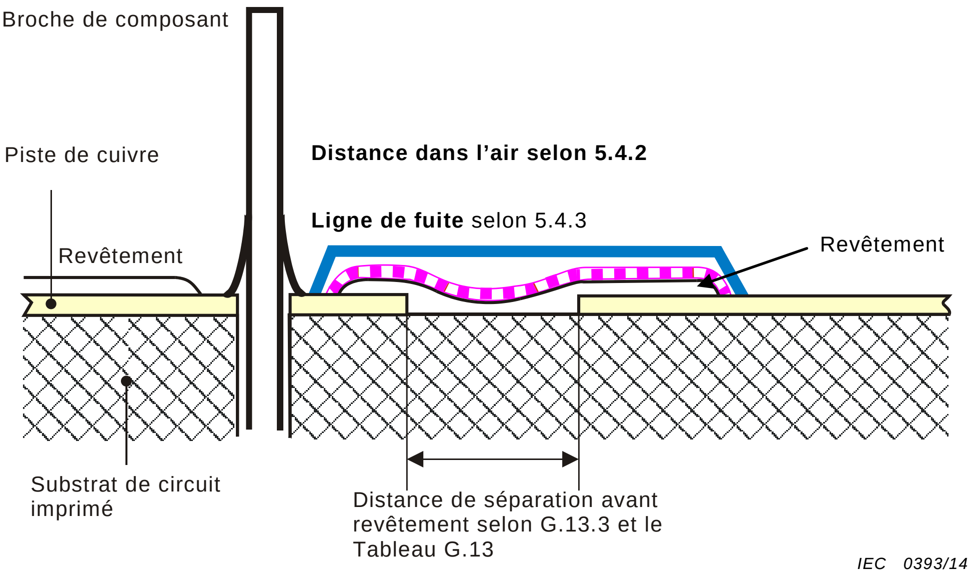


Figure O.12 – Revêtement sur circuit imprimé

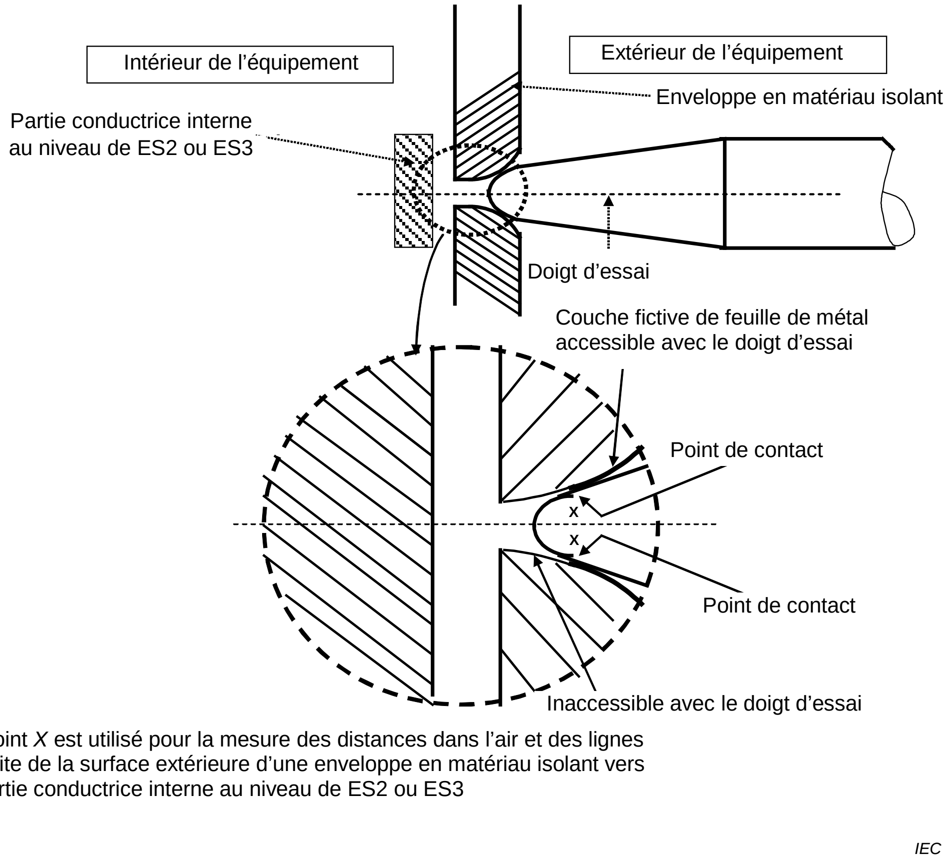
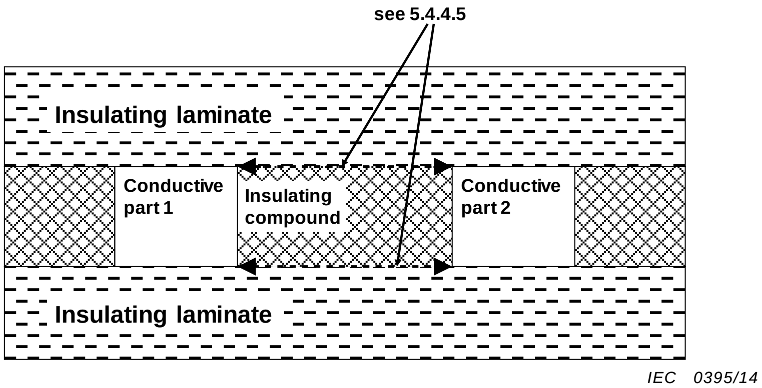


Figure O.13 – Exemple de mesures dans une enveloppe en matériau isolant



Légende

Anglais	Français
See 5.4.4.6	Voir 5.4.4.6
Insulating laminate	Laminé isolant
Conductive part 1	Partie conductrice 1
Insulating compound	Isolant
Conductive part 2	Partie conductrice 2

Figure O.14 – Joints scellés sur cartes de circuit imprimé multicouches

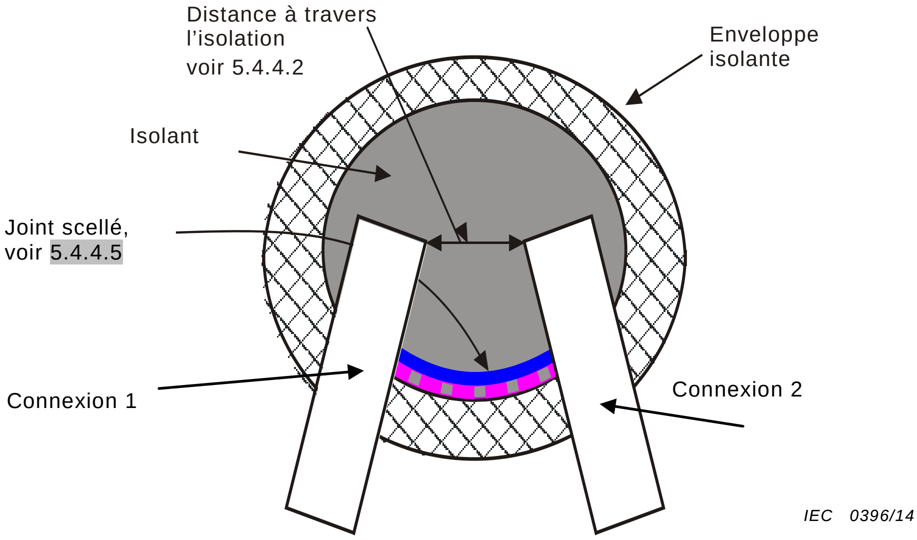
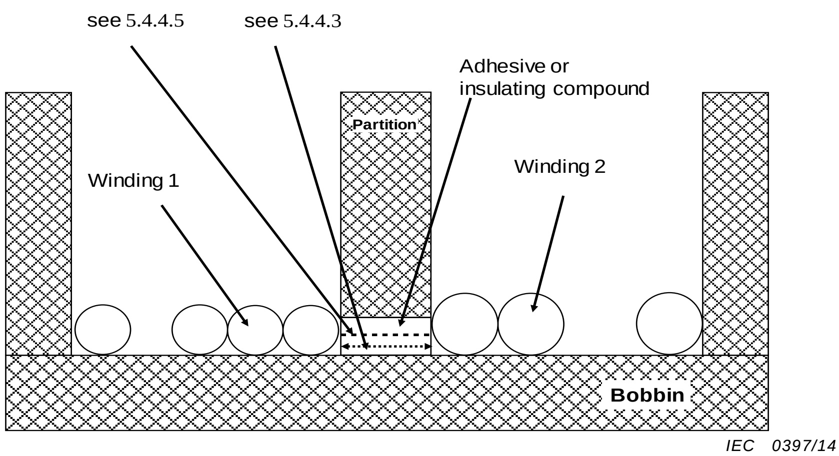


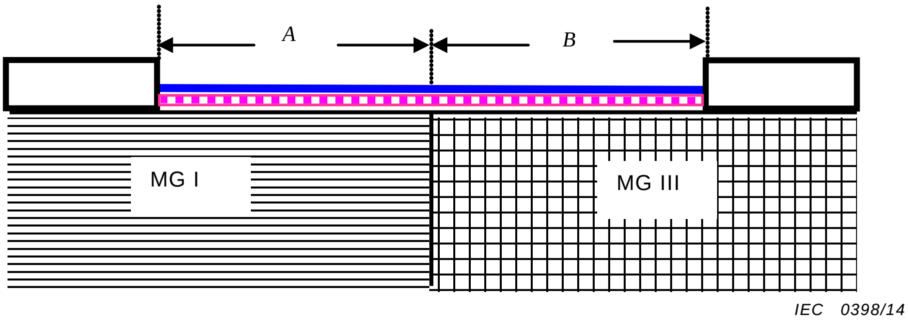
Figure O.15 – Composant rempli d'isolant



Légende

Anglais	Français
See 5.4.4.5	Voir 5.4.4.5
See 5.4.4.3	Voir 5.4.4.3
Winding 1	Enroulement 1
Winding 2	Enroulement 2
Adhesive or insulating compound	Adhésif ou isolant
Partition	Cloison
Bobbin	Bobine

Figure O.16 – Bobine cloisonnée

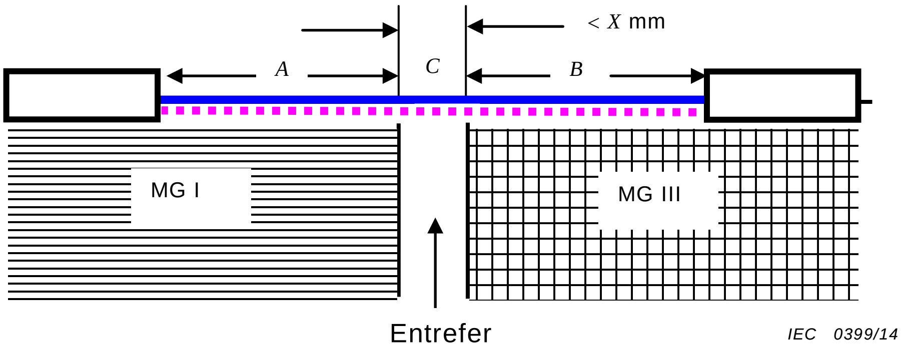


Condition: Le chemin considéré est le long de deux matériaux ayant des valeurs d'IRC différentes.

Règle: La **ligne de fuite** est calculée de la façon suivante:

$$\frac{A}{\textbf{Ligne de fuite} \text{ requise pour MG I}} + \frac{B}{\textbf{Ligne de fuite} \text{ requise pour MG III}} \geq 1$$

Figure O.17 – Matériaux avec des valeurs d'IRC différentes

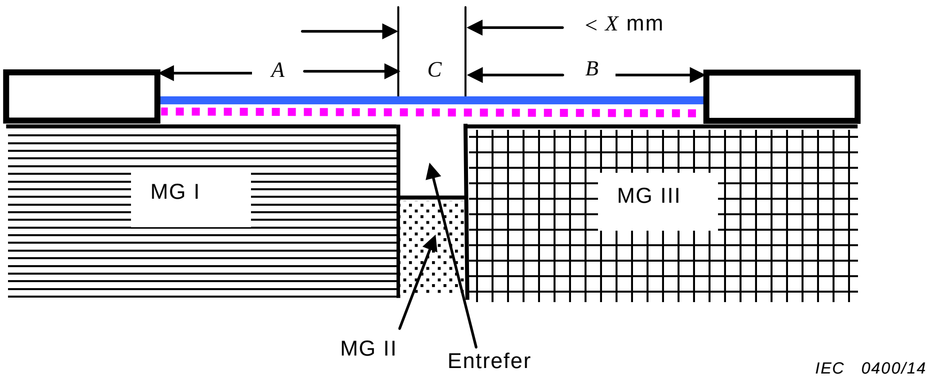


Condition: Le chemin considéré comprend un entrefer à flancs parallèles ou convergents, de largeur inférieure à X mm et deux matériaux différents de chaque côté.

Règle: La **ligne de fuite** est calculée de la façon suivante:

$$\frac{A}{\textbf{Ligne de fuite} \text{ requise pour MG I}} + \frac{B + C}{\textbf{Ligne de fuite} \text{ requise pour MG III}} \geq 1$$

Figure O.18 – Matériaux ayant des valeurs d'IRC différentes avec un entrefer inférieur à X mm

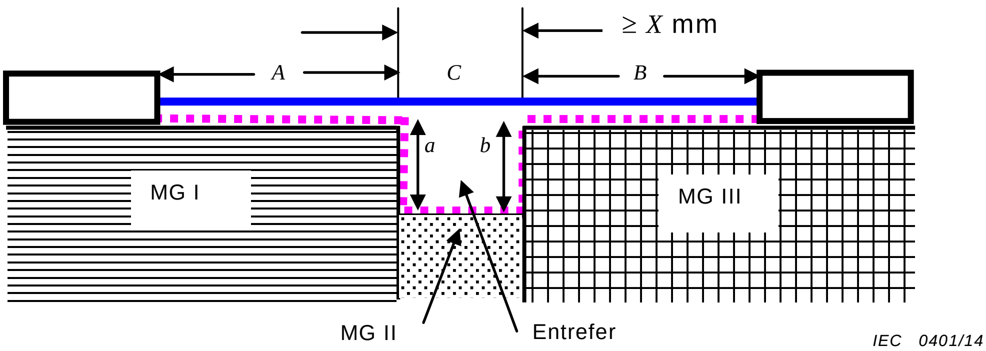


Condition: Le chemin considéré comprend une encoche à flancs parallèles ou convergents, de largeur inférieure à X mm et deux matériaux différents de chaque côté et un matériau différent sous l'encoche.

Règle: La **ligne de fuite** est calculée de la façon suivante:

$$\frac{A}{\textbf{Ligne de fuite}\text{ requise pour MG I}} + \frac{B + C}{\textbf{Ligne de fuite}\text{ requise pour MG III}} \geq 1$$

Figure O.19 – Matériaux ayant des valeurs d'IRC différentes avec une encoche inférieure à *X* mm



Condition: Le chemin considéré comprend une encoche à flancs parallèles ou convergents, de largeur supérieure ou égale à X mm et deux matériaux différents de chaque côté et un matériau différent sous l'encoche.

Règle: La **ligne de fuite** est calculée de la façon suivante:

$$\frac{A + a}{\textbf{Ligne de fuite}\text{ requise pour MG I}} + \frac{C}{\textbf{Ligne de fuite}\text{ requise pour MG II}} + \frac{B + b}{\textbf{Ligne de fuite}\text{ requise pour MG III}} \geq 1$$

Figure O.20 – Matériaux ayant des valeurs d'IRC différentes avec une encoche non inférieure à *X* mm

Annexe P
(normative)

Protections contre les objets conducteurs

P.1 Généralités

La présente annexe spécifie les **protections** utilisées pour réduire les probabilités d'incendie, de choc électrique et de réaction chimique indésirable dues à l'entrée d'objets par les ouvertures sur le dessus ou sur le côté de l'équipement, ou dues à l'écoulement de liquides internes, ou à la défaillance des revêtements métallisés et pièces conductrices de fixation adhésives à l'intérieur de l'équipement.

La **protection principale** contre l'entrée d'un objet étranger est que les personnes ne sont pas censées insérer un objet étranger dans l'équipement. Les **protections** spécifiées dans cette annexe sont des **protections supplémentaires**.

Cette annexe ne s'applique pas aux ouvertures faisant partie intégrante des connecteurs.

Pour les équipements destinés, selon les instructions du fabricant, à être utilisés dans plusieurs orientations, les **protections** doivent être efficaces pour chacune de ces orientations.

Pour l'**équipement transportable**, les **protections** doivent être efficaces pour toutes les orientations.

NOTE Les exemples de la Figure P.1, de la Figure P.2 et de la Figure P.3 ne sont pas destinés à être utilisés comme des plans d'ingénierie mais sont seulement donnés afin d'illustrer les propos de ces exigences.

P.2 Protections contre l'entrée ou les conséquences de l'entrée de corps étrangers

P.2.1 Généralités

Les équipements doivent satisfaire aux exigences de P.2.2 ou de P.2.3.

P.2.2 Protections contre l'entrée de corps étrangers

Les ouvertures sur le haut et sur les côtés des **enveloppes accessibles** doivent être situées ou conçues de façon à réduire la probabilité que des objets étrangers pénètrent par les ouvertures.

Les ouvertures des équipements doivent être conformes aux exigences spécifiées ci-dessous lorsque les portes, panneaux et couvercles, etc., sont fermés ou en place. Ces exigences ne s'appliquent pas aux ouvertures situées derrière les portes, panneaux, couvercles, etc., même s'ils peuvent être ouverts ou retirés par une **personne ordinaire**.

Les constructions suivantes sont considérées comme satisfaisantes:

– ouvertures qui ne dépassent pas 5 mm dans toutes les dimensions;
– ouvertures qui ne dépassent pas 1 mm de large, quelle que soit leur longueur;
– ouvertures satisfaisant aux exigences des classifications IP3X ou IP4X;
– ouvertures sur le dessus à l'intérieur desquelles aucun objet étranger ne peut entrer verticalement (voir exemples en Figure P.1);

– ouvertures latérales équipées de volets en grille-écran dont la forme permet de dévier, vers l'extérieur, un objet externe tombant verticalement (voir exemples en Figure P.2);

– ouvertures latérales sans volets en grille-écran où l'épaisseur de l'**enveloppe** au niveau de l'ouverture est supérieure ou égale à la dimension de l'ouverture dans le sens vertical.

La conformité est vérifiée par examen ou mesure.

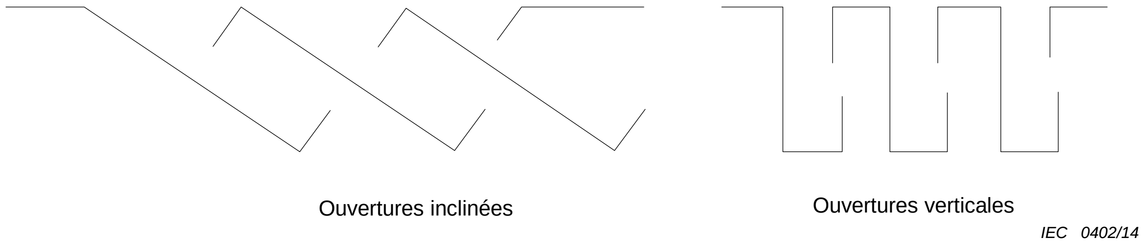


Figure P.1 – Exemples de sections transversales de constructions d'ouvertures sur le dessus empêchant l'entrée d'objets tombant verticalement

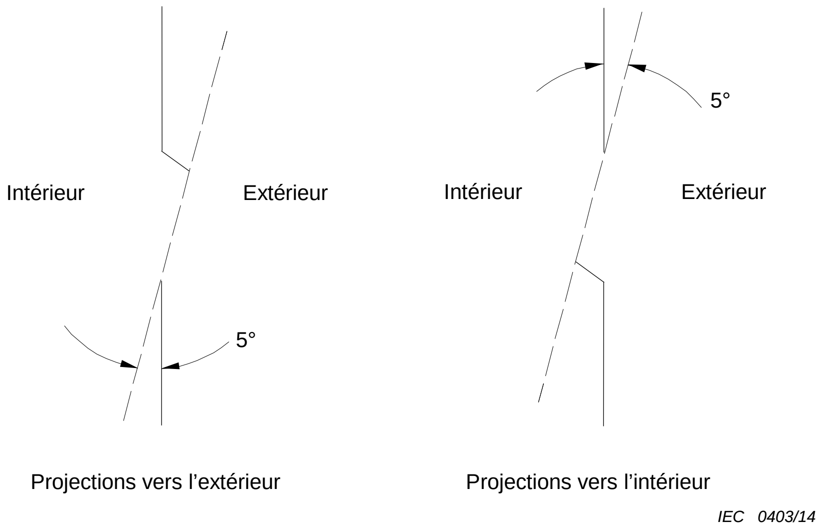


Figure P.2 – Exemples de sections transversales de constructions d'ouvertures latérales avec volets en grille-écran empêchant l'entrée d'objets tombant verticalement

P.2.3 Protections contre les conséquences de l'entrée d'un objet étranger

P.2.3.1 Exigences relatives à la protection

L'entrée d'un corps étranger ne doit pas supprimer une **protection supplémentaire de l'équipement** ou une **protection renforcée de l'équipement**. Par ailleurs, l'objet ne doit pas créer une **PIS**.

Les **protections** contre les conséquences de l'entrée d'objets étrangers comprennent les éléments suivants:

– une barrière interne qui empêche un objet étranger de supprimer une **protection de l'équipement** ou de créer une **PIS**;

– dans le volume projeté illustré à la Figure P.3

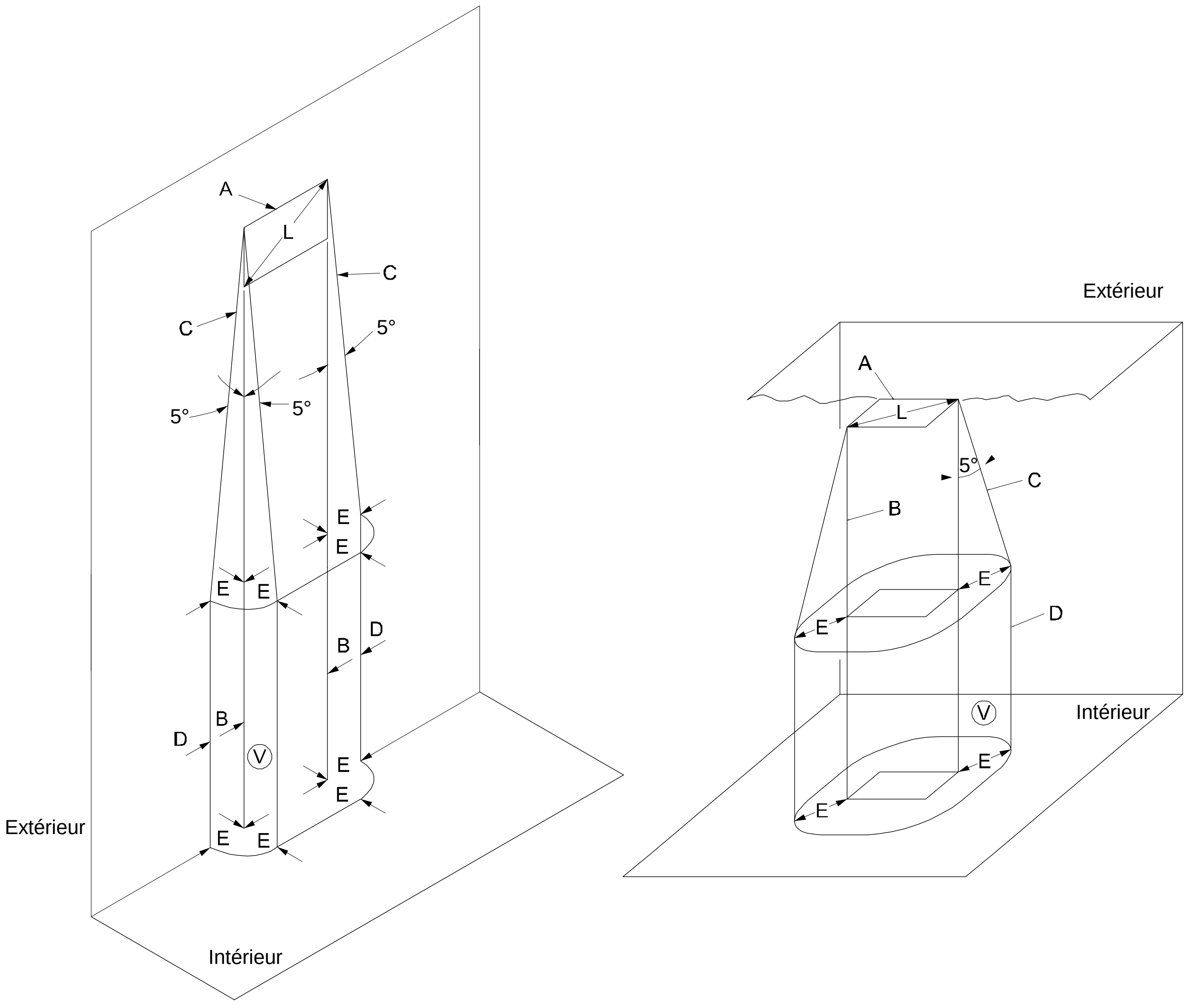
- il n'y a pas de parties conductrices nues d'une **protection**; ou
- il n'y a pas de **PIS**; ou
- il n'y a pas de parties conductrices nues de circuits ES3 ou PS3; ou

- il y a seulement des parties conductrices recouvertes de revêtements conformes ou analogues.

NOTE 1 Les parties conductrices recouvertes de revêtements conformes ou analogues ne sont pas considérées comme des parties conductrices nues. Un revêtement conforme est un matériau diélectrique déposé sur une carte de circuit imprimé et sur des composants en vue de les protéger contre l'humidité, la poussière, la corrosion et d'autres contraintes environnementales.

– dans le volume projeté illustré à la Figure P.3, des parties conductrices nues à ES3 ou PS3 soumises aux essais de P.2.3.2.

Les autres constructions doivent être soumises à l'essai de P.2.3.2.



IEC 0404/14

Légende

A ouverture dans l'**enveloppe**

B projection verticale des bords extérieurs de l'ouverture

C lignes inclinées qui se projettent selon un angle de 5° à partir des bords de l'ouverture jusqu'à des points situés à une distance E par rapport à B

D ligne projetée vers le bas selon une droite, dans le même plan que la paroi latérale de l'**enveloppe**

E projection du bord extérieur de l'ouverture (B) et de la ligne inclinée (C) (ne devant pas être supérieure à L)

L dimension maximale de l'ouverture dans l'**enveloppe**

V volume projeté (réservé) pour les **protections supplémentaire** ou **renforcée**

Figure P.3 – Volume interne destiné à empêcher l'entrée d'objets étrangers

Pour l'**équipement transportable**, si la conception ne permet pas d'empêcher l'entrée d'un objet étranger, l'objet est considéré se déplacer dans toutes les directions dans l'équipement. Le volume réservé ES3 et PS3 de la Figure P.3 ne s'applique pas à l'**équipement transportable**.

Pour un **équipement transportable** avec des parties en plastique métallisées et analogue, si la conception ne permet pas d'empêcher l'entrée d'un objet étranger, la distance entre les parties métallisées et toutes les parties conductrices nues de ES3 ou PS3 doit être d'au moins 13 mm. En variante, les parties métallisées et les parties conductrices nues doivent être soumises à essai en court-circuit.

NOTE 2 Les exemples de barrières métallisées ou d'**enveloppes** métallisées incluent les barrières ou les enveloppes construites en matériaux composites conducteurs ou en matériaux à revêtement électrolytique, à dépôt par évaporation sous vide, avec feuille de protection ou recouverts de peinture métallisée.

La conformité est vérifiée par examen, mesure et, si nécessaire, par l'essai de P.2.3.2.

P.2.3.2 Conséquence de l'essai d'entrée

Toutes les parties conductrices nues de ES3 ou PS3 doivent être soumises à un essai de mise en court-circuit dans le volume V, Figure P.3, le long du chemin direct en ligne droite vers toutes les autres parties conductrices nues et toutes les parties en plastique métallisé dans un rayon d'environ 13 mm. L'essai de mise en court-circuit est réalisé au moyen d'un objet métallique droit, de 1 mm de diamètre et d'une longueur jusqu'à 13 mm, appliqué sans force notable.

*Pour l'**équipement transportable**, l'essai de mise en court-circuit doit être réalisé à tous les emplacements susceptibles de contenir un objet étranger.*

*Pendant et après les essais, toutes les **protections supplémentaires** et **protections renforcées** doivent être efficaces et aucune partie ne doit devenir une **source potentielle d'incendie**.*

P.3 Protections contre l'écoulement de liquides internes

P.3.1 Généralités

Les exigences spécifiées ci-dessous s'appliquent aux équipements contenant des liquides internes susceptibles de pouvoir supprimer une **protection de l'équipement**.

Ces exigences ne s'appliquent pas aux:

– liquides non conducteurs, non inflammables, non toxiques et non corrosifs et qui ne sont pas contenus dans des récipients sous pression;
– condensateurs électrolytiques;
– liquides dont la viscosité est supérieure ou égale à 1 Pa s;
– batteries (voir Annexe M).

NOTE Une viscosité de 1 Pa s est à peu près équivalente à une huile moteur de viscosité 60.

P.3.2 Détermination des conséquences d'un écoulement

Si l'équipement n'est pas un **équipement transportable**, il doit être alimenté et le liquide doit pouvoir s'écouler des raccords de tuyauterie et des joints similaires du circuit du liquide.

Si l'équipement est un **équipement transportable**, alors, suite à l'introduction de la fuite, l'équipement doit être mis dans toutes les positions possibles puis alimenté.

P.3.3 Protections contre l'écoulement

Si l'écoulement conduit à une **condition de premier défaut** non traitée dans l'Article B.4, alors:

– le récipient servant de **protection principale** ne doit permettre aucun écoulement dans des **conditions normales de fonctionnement**, et **la protection supplémentaire** (par exemple, une barrière ou un bac de récupération, ou un récipient de confinement supplémentaire, etc.) doit limiter de manière efficace la propagation de l'écoulement; ou

– le liquide doit être contenu dans un récipient comprenant une **protection renforcée**; ou

– la **protection** du récipient de confinement doit comprendre une **double protection** ou une **protection renforcée**.

Si le liquide est conducteur, inflammable, toxique ou corrosif, alors:

– le liquide doit être contenu dans une **double protection** ou une **protection renforcée; ou**

– suite à l'écoulement:

  • un liquide toxique ne doit pas être **accessible** aux **personnes ordinaires** ni aux **personnes averties**, et

  • un liquide conducteur ne doit pas mettre en parallèle une **isolation principale**, une **isolation supplémentaire** ou une **isolation renforcée**, et

  • un liquide inflammable (ou sa vapeur) ne doit pas entrer en contact avec une **PIS** ou des parties à une température qui peut enflammer le liquide, et

  • un liquide corrosif ne doit pas entrer en contact avec une connexion du **conducteur de protection.**

Un récipient satisfaisant aux exigences d'essai applicables de l'Article G.15 est considéré comporter une **protection renforcée**.

NOTE Les liquides suivants sont généralement considérés non-inflammables:

– Huiles ou liquides équivalents utilisé(e)s pour la lubrification ou dans un système hydraulique ayant un point d'éclair de 149 °C ou plus; ou

– Liquides rechargeables tels que les encres d'imprimerie ayant un point d'éclair de 60°C ou plus.

P.3.4 Critères de conformité

La conformité est vérifiée par examen ou données disponibles, et le cas échéant, par les essais correspondants.

*Pendant et après les essais, toutes les **protections supplémentaires** et **protections renforcées** doivent être efficaces et aucune partie ne doit devenir une PIS (**source potentielle d'incendie)**.*

P.4 Revêtements métallisés et pièces de fixation adhésives

P.4.1 Généralités

Le revêtement métallisé et l'adhésif doivent avoir des propriétés d'adhérence appropriées tout au long de la durée de vie de l'équipement.

La conformité est vérifiée par examen de la construction et des données disponibles. En l'absence de telles données, la conformité est vérifiée par les essais de P.4.2.

*Pour les revêtements métallisés, les **distances dans l'air** et les **lignes de fuite** pour le **degré de pollution** 3 doivent être maintenues à la place des essais de P.4.2.*

P.4.2 Essais

Un échantillon de l'équipement ou un sous-ensemble de l'équipement contenant des parties ayant un revêtement métallisé et des parties collées par un adhésif est évalué en plaçant la partie de l'échantillon fixée avec un adhésif à l'envers.

Conditionner l'échantillon dans une étuve à une température T_C pendant la durée spécifiée (huit semaines, trois semaines ou une semaine) comme suit:

$$T_C = T_R + (T_A + 10 - T_S)$$

Lorsque la valeur de $T_A + 10 - T_S$ est négative, la valeur est remplacée par zéro.

où

- T_C *est la température de conditionnement;*
- T_R *est la valeur de la température de conditionnement assignée de (82 ± 2) °C pendant huit semaines; de (90 ± 2) °C pendant trois semaines ou de (100 ± 2) °C (pendant une semaine) selon le cas;*
- T_A *est la température du revêtement ou de la partie dans les* ***conditions normales de fonctionnement*** *(voir B.2.6.1);*
- T_S *= 82.*

NOTE 1 Par exemple, pour un conditionnement de huit semaines, si la température réelle est de 70 °C, alors $T_A + 10 - T_S = 70 + 10 - 82 = -2$, cette valeur -2 est ignorée. La température minimale de conditionnement reste à 82 °C. De même, pour un conditionnement de trois semaines, si la température réelle est de 70 °C, alors $T_A + 10 - T_S = 70 + 10 - 82 = -2$, cette valeur –2 est ignorée. La température minimale de conditionnement reste à 90 °C. De même, pour un conditionnement d'une semaine, si la température réelle est de 70 °C, alors $T_A + 10 - T_S = 70 + 10 - 82 = -2$, cette valeur -2 est ignorée. La température minimale de conditionnement reste à 100 °C.

NOTE 2 Par exemple, pour un conditionnement de huit semaines, si la température réelle est de 75 °C, alors $T_A + 10 - T_S = 75 + 10 - 82 = +3$, La température minimale de conditionnement devient 82 + 3 = 85 °C. De même, pour un conditionnement de trois semaines, si la température réelle est de 75 °C, alors $T_A + 10 - T_S = 75 + 10 - 82 = +3$, ensuite la température minimale de conditionnement devient 90 + 3 = 93 *°C*. De même, pour un conditionnement d'une semaine, si la température réelle est de 75 °C, alors $T_A + 10 - T_S = 75 + 10 - 82 = +3$, ensuite la température minimale de conditionnement devient 100 + 3 = 103 °C.

NOTE 3 Le tableau ci-dessous résume les résultats de la NOTE 1 et de la NOTE 2:

T_A	T_R	T_S	T_A+10-T_S	$T_C = T_R + T_A + 10 - T_S$
70	82 (8 semaines)	82	70+10-82= –2	82 + 0 = 82
70	90 (3 semaines)	82	70+10-82= –2	90 + 0 = 90
70	100 (1 semaine)	82	70+10-82= –2	100 + 0 = 100
75	82 (8 semaines)	82	75+10-82= +3	82 + 3 = 85
75	90 (3 semaines)	82	75+10-82= +3	90 + 3 = 93
75	100 (1 semaine)	82	75+10-82= +3	100 + 3 = 103

A l'issue de la période de conditionnement en température, soumettre l'échantillon aux opérations suivantes:

- *retirer l'échantillon de l'étuve et le laisser à toute température adaptée comprise entre 20 °C et 30 °C pendant un minimum de 1 h;*
- *placer l'échantillon dans un congélateur à –40 °C ± 2 °C pendant un minimum de 4 h;*
- *retirer l'échantillon et le laisser revenir à une température adaptée comprise entre 20 °C et 30 °C pendant un minimum de 8 h;*
- *placer l'échantillon dans une enceinte avec une humidité relative comprise entre 91 % et 95 % pendant 72 h à toute température adaptée comprise entre 20 °C et 30 °C;*

– *retirer l'échantillon et le laisser à toute température adaptée comprise entre 20 °C et 30 °C pendant un minimum de 1 h;*
– *placer l'échantillon dans une étuve à la température utilisée pour le conditionnement en température (T_C) pendant un minimum de 4 h;*
– *retirer l'échantillon et le laisser reprendre toute température adaptée comprise entre 20 °C; et 30 °C pendant un minimum de 8 h.*

L'échantillon est alors immédiatement soumis aux essais de l'Annexe T conformément au 4.4.4.

Avec le concours du fabricant, les durées ci-dessus peuvent être prolongées.

Après les essais ci-dessus:

– *un revêtement métallisé ou une partie fixée par un adhésif ne doit pas se détacher ou se décoller en partie;*
– *un revêtement métallisé doit être soumis à l'essai de résistance à l'abrasion de G.13.6.2. A l'issue de l'essai de résistance à l'abrasion, le revêtement ne doit pas s'être détaché et aucune particule ne doit se décoller du revêtement;*
– *les parties d'**enveloppe** servant de **protections** doivent satisfaire à toutes les exigences applicables aux **enveloppes**.*

Annexe Q
(normative)

Circuits destinés à l'interconnexion avec le câblage du bâtiment

Q.1 Source à puissance limitée

Q.1.1 Exigences

Une source à puissance limitée doit être conforme à l'un des éléments suivants:

a) la sortie est limitée par construction conformément au Tableau Q.1; ou

b) une impédance linéaire ou non linéaire limite la sortie conformément au Tableau Q.1. Si un dispositif à coefficient de température positif (CTP) est utilisé, ce dernier doit:

   1) satisfaire aux essais spécifiés dans les Articles 15, 17, J.15 et J.17 de la CEI 60730-1:2010; ou

   2) satisfaire aux exigences de la CEI 60730-1 pour un dispositif fournissant une action du type 2.AL;

   3) un réseau régulateur limite la sortie conformément au Tableau Q.1, à la fois avec et sans premier défaut simulé (voir l'Article B.4), dans le réseau régulateur (circuit ouvert ou court-circuit); ou

c) un dispositif de protection contre les surintensités est utilisé et la sortie est limitée conformément au Tableau Q.2: ou

d) un limiteur de courant sur circuit intégré conforme à l'Article G.9 qui limite le courant de sortie conformément au Tableau Q.1.

Lorsqu'un dispositif de protection contre les surintensités est utilisé, il doit être soit un fusible soit un dispositif électromécanique non réenclenchable automatiquement et non ajustable.

Q.1.2 Méthode d'essai et critères de conformité

La conformité est vérifiée par examen et par des mesures et, le cas échéant, par examen des données du fabricant en ce qui concerne les ***batteries****. Les* ***batteries*** *doivent être entièrement chargées lors de la mesure de U_{oc} et I_{sc} selon les Tableaux Q.1 et Q.2. La puissance maximale doit être prise en compte, provenant d'une* ***batterie*** *et d'un circuit d'****alimentation****.*

La charge non capacitive à laquelle il est fait référence dans les notes b) et c) des Tableaux Q.1 et Q.2 est ajustée pour produire respectivement un transfert de courant maximum et un transfert de puissance maximum. Les ***conditions de premier défaut*** *dans un réseau régulateur selon le point b) 3) de Q.1.1 sont appliquées dans ces conditions maximales de courant et de puissance.*

Tableau Q.1 – Limites pour les sources à puissance limitée par construction

Tension de sortie [a] U_{oc}		Courant de sortie [b d] I_{sc}	Puissance apparente [c d] S
V c.a.	V c.c.	A	VA
$U_{oc} \le 30$	$U_{oc} \le 30$	≤8,0	≤100
–	$30 < U_{oc} \le 60$	≤150/U_{oc}	≤100

[a] U_{oc}: Tension de sortie mesurée conformément à B.2.3 avec tous les circuits de charge déconnectés. Les tensions sont pour des signaux en courant alternatif essentiellement sinusoïdal et en courant continu sans ondulation. Pour les signaux en courant alternatif non sinusoïdal et en courant continu avec une ondulation supérieure à 10 % de la valeur crête, la tension crête ne doit pas dépasser 42,4 V.

[b] I_{sc}: Courant de sortie maximal avec charge non capacitive, y compris un court-circuit.

[c] S (VA): Puissance maximale de sortie en VA avec charge non capacitive.

[d] Les mesures de I_{sc} et S sont effectuées 5 s après l'application de la charge si la protection est assurée par un circuit électronique, et 60 s dans le cas d'un dispositif CTP ou dans les autres cas.

Tableau Q.2 – Limites pour les sources à puissance non limitée par construction (nécessité d'un dispositif de protection contre les surintensités)

Tension de sortie [a] U_{oc}		Courant de sortie [b d] I_{sc}	Puissance apparente [c d] S	Valeur assignée du courant du dispositif de protection contre les surintensités [e]
V c.a.	V c.c.	A	VA	A
≤20	≤20	≤1 000/U_{oc}	≤250	≤5,0
$20 < U_{oc} \le 30$	$20 < U_{oc} \le 30$			≤100/U_{oc}
–	$30 < U_{oc} \le 60$			≤100/U_{oc}

[a] U_{oc}: Tension de sortie mesurée conformément à B.2.3 avec tous les circuits de charge déconnectés. Les tensions sont pour des signaux en courant alternatif essentiellement sinusoïdal et en courant continu sans ondulation. Pour les signaux en courant alternatif non sinusoïdal et en courant continu avec une ondulation supérieure à 10 % de la valeur crête, la tension crête ne doit pas dépasser 42,4 V.

[b] I_{sc}: Courant de sortie maximal avec charge non capacitive, y compris un court-circuit, mesuré 60 s après l'application de la charge.

[c] S (VA): Puissance maximale de sortie en VA avec charge non capacitive, mesurée 60 s après l'application de la charge.

[d] Les impédances de limitation de courant dans les équipements restent dans le circuit pendant la mesure; en revanche, les dispositifs de protection contre les surintensités sont contournés.

La raison pour laquelle les dispositifs de protection contre les surintensités sont contournés pendant les mesures est que cela permet de déterminer la quantité d'énergie qui est disponible et susceptible de provoquer une surchauffe pendant le délai de fonctionnement des dispositifs de protection contre les surintensités.

[e] Les valeurs assignées du courant des dispositifs de protection contre les surintensités sont basées sur des fusibles et des disjoncteurs qui coupent le circuit dans un délai de 120 s avec un courant égal à 210 % de la valeur assignée du courant indiquée dans le tableau.

Q.2 Essai des circuits externes – câble conducteur à paires

Les équipements qui alimentent un câble conducteur à paires d'un ***circuit externe*** *destiné à être connecté au câblage d'un bâtiment doivent être vérifiés comme suit:*

Si la limitation en courant est due à l'impédance inhérente de la source d'énergie, le courant de sortie dans une charge résistive, y compris un court-circuit, est mesuré. La limite de courant ne doit pas être dépassée après 60 s d'essai.

Si la limitation en courant est assurée par un dispositif de protection contre les surintensités ayant une caractéristique temps/courant spécifiée:

- *la caractéristique courant-durée doit indiquer que le courant égal à 110 % de la limite de courant est interrompu dans un délai de 60 min; et*
- *le courant de sortie dans une charge résistive, y compris un court-circuit, avec le dispositif de protection contre les surintensités contourné, mesuré après 60 s d'essai, ne doit pas dépasser 1 000/U où U est la tension de sortie mesurée selon B.2.3, tous les circuits de charge étant déconnectés.*

Si la limitation en courant est assurée par un dispositif de protection contre les surintensités qui n'a pas de caractéristique courant-durée spécifiée:

- *le courant de sortie dans une charge résistive, y compris un court-circuit, ne doit pas dépasser la limite de courant après 60 s d'essai, et*
- *le courant de sortie dans une charge résistive, y compris un court-circuit, avec le dispositif de protection contre les surintensités en dérivation, mesuré après 60 s d'essai, ne doit pas dépasser 1 000/U où U est la tension de sortie mesurée selon B.2.3, tous les circuits de charge étant déconnectés.*

Annexe R
(normative)

Essai de court-circuit limité

R.1 Généralités

La présente annexe décrit la procédure d'essai et les critères de conformité pour l'essai de court-circuit limité. Cet essai démontre qu'un **conducteur de liaison de protection** utilisé dans des circuits protégés par un dispositif de moins de 25 A, est adapté au courant de défaut permis par le dispositif de protection contre les surintensités et, ce faisant, il vérifie l'intégrité d'une **protection supplémentaire**.

R.2 Montage d'essai

*La source utilisée pour effectuer l'essai de court-circuit limité doit être mise en court-circuit au niveau de ses bornes de sortie et le courant mesuré pour s'assurer qu'elle peut fournir une intensité d'au moins 1 500 A. Il peut s'agir d'une prise murale de courant alternatif, un générateur, une alimentation ou une **batterie**.*

Si l'équipement est muni d'un dispositif de protection contre les surintensités, alors ce dernier est utilisé pour l'essai.

Pour les sources à courant alternatif où un seul dispositif de protection contre les surintensités est monté dans l'équipement et où la prise est non polarisée, le dispositif de protection de l'installation du bâtiment est utilisé pour l'essai et le dispositif interne de protection contre les surintensités est contourné. Le fabricant doit spécifier dans les consignes de sécurité de l'équipement le dispositif utilisé pour effectuer l'essai

En l'absence de dispositif de protection dans l'équipement, un dispositif de protection contre les surintensités adapté doit être choisi. Ce dispositif de protection contre les surintensités doit être tel qu'il ne coupe pas le courant de défaut avant l'accomplissement d'un demi-cycle. Le dispositif de protection contre les surintensités dans l'installation du bâtiment pour les sources de courant continu, ou celui spécifié pour être installé à l'extérieur de l'équipement pour les sources de courant alternatif, est utilisé pour l'essai. Le fabricant doit alors spécifier dans les consignes de sécurité de l'équipement le dispositif utilisé pour effectuer l'essai.

R.3 Méthode d'essai

*La source doit être appliquée à l'EUT via le câble du **réseau d'alimentation** fourni ou spécifié par le fabricant de l'équipement. Si aucun câble n'est fourni ou spécifié, un câble de 1 m de long et d'une section de 2,5 mm^2 ou du type 12 AWG doit être utilisé. Pour les sources de courant continu, le câble doit être dimensionné pour le courant d'entrée assigné maximal de l'équipement.*

Pour effectuer cet essai, un court-circuit dans l'équipement à la connexion de terre de l'équipement doit être introduit. Le point auquel ce défaut est appliqué dépend de l'équipement. Après examen de la construction et des schémas de circuits de l'équipement, le court-circuit doit être introduit entre le conducteur de phase, au point le plus près de l'entrée (le point d'impédance la plus faible), et le chemin de liaison de protection considéré. Il est possible qu'il existe plus d'un point auquel on peut appliquer ce court-circuit afin de déterminer le cas le plus défavorable.

*Le **conducteur de liaison de protection** est connecté à une source capable de fournir un courant alternatif ou continu, selon l'EUT, de 1 500 A en régime de court-circuit, et en utilisant* *une tension source égale à la* ***tension assignée*** *ou à toute tension comprise dans la* ***plage de tensions assignées*** *de l'équipement. Lorsque le courant de court-circuit présumé observé par l'équipement est connu, alors la source utilisée pour l'essai doit pouvoir fournir ce courant en régime de court-circuit. Le fabricant doit spécifier le courant de court-circuit présumé qui a été utilisé durant l'évaluation dans les consignes de sécurité. Le dispositif de protection contre les surintensités protégeant le circuit en question (conformément à l'Article R.2) est maintenu en série avec le* ***conducteur de liaison de protection****. Le cordon ou câble d'alimentation, s'il est fourni ou spécifié, doit rester connecté lorsque l'essai est effectué.*

L'essai de court-circuit limité pour les ***conducteurs de liaison de protection*** *dans un ensemble enrobé ou recouvert d'un revêtement enrobant est effectué sur un échantillon enrobé ou recouvert d'un revêtement.*

L'essai est effectué deux autres fois (pour un total de trois fois, sur un échantillon différent sauf si le fabricant consent à effectuer l'essai sur le même échantillon). L'essai est poursuivi jusqu'à ce que le dispositif de protection contre les surintensités fonctionne.

R.4 Critères de conformité

A la fin de l'essai, la conformité est vérifiée par examen de la façon suivante.

Il ne doit y avoir:

– *aucun dégât causé au* ***conducteur de liaison de protection****,*

– *aucun dégât causé à l'****isolation principale****, à l'****isolation supplémentaire*** *ou à l'****isolation renforcée****,*

– *aucune réduction des* ***distances dans l'air****,* ***des lignes de fuite*** *et des distances à travers l'isolation,*

– *aucun délaminage de la carte imprimée.*

Annexe S
(normative)

Essais de résistance à la chaleur et au feu

NOTE Des gaz toxiques sont émis pendant les essais. Les essais sont généralement réalisés sous une hotte de ventilation ou dans une pièce bien ventilée, mais sans courant d'air pouvant invalider les essais.

S.1 Essai d'inflammabilité de l'enveloppe ignifuge et des matériaux de barrières ignifuges des équipements où la puissance en régime constant ne dépasse pas 4 000 W

*L'**enveloppe ignifuge (contre le feu)** et les matériaux de barrière contre le feu sont soumis à essai conformément à la CEI 60695-11-5.*

Les exigences supplémentaires suivantes s'appliquent aux articles spécifiés de la CEI 60695-11-5:2004.

Article 6 de la CEI 60695-11-5:2004 – Eprouvette

*Pour les **enveloppes ignifuges (contre le feu)** et les barrières contre le feu, chaque éprouvette consiste en une **enveloppe ignifuge (contre le feu)** entière ou une barrière contre le feu ou une section de l'**enveloppe ignifuge (contre le feu)** ou de la barrière contre le feu représentant l'épaisseur de paroi significative la plus fine et incluant toute ouverture de ventilation.*

Article 7 de la CEI 60695-11-5:2004 – Degrés de sévérité

Les valeurs de la durée d'application de la flamme d'essai sont les suivantes:

– *la flamme d'essai est appliquée pendant 10 s;*
– *si l'inflammation ne dépasse pas 30 s, la flamme d'essai est immédiatement réappliquée pendant 1 min au même endroit;*
– *si, à nouveau, l'inflammation ne dépasse pas 30 s, la flamme d'essai est immédiatement réappliquée pendant 2 min au même endroit.*

Article 8 de la CEI 60695-11-5:2004 – Conditionnement de l'éprouvette

Préalablement aux essais, les échantillons sont conditionnés dans un four à circulation d'air pendant une période de 7 jours (168 h), à une température 10 K supérieure à la température maximale de la partie mesurée lors de l'essai de 5.4.1.4 ou 70 °C, la valeur la plus élevée étant retenue, puis refroidis à la température ambiante.

Pour les cartes imprimées, un préconditionnement de 24 h à une température de 125 °C ± 2 °C dans un four à circulation d'air suivi d'une période de refroidissement de 4 h à la température ambiante dans un dessiccateur contenant du chlorure de calcium anhydre sont à appliquer.

Paragraphe 9.2 de la CEI 60695-11-5:2004 – Application du brûleur-aiguille

La flamme d'essai est appliquée sur une surface interne de l'éprouvette en un point jugé susceptible d'être enflammé à cause de sa proximité avec une source d'inflammation.

Si une partie verticale est impliquée, la flamme est appliquée à un angle d'environ 45° par rapport à la verticale.

Si des ouvertures de ventilation sont impliquées, la flamme est appliquée à un bord de l'ouverture, sinon à une surface solide. Dans tous les cas, l'extrémité de la flamme est tenue d'être en contact avec l'éprouvette.

L'essai est répété sur les deux autres éprouvettes. Si une partie soumise à essai est proche d'une source d'inflammation à plusieurs endroits, chaque éprouvette est soumise à essai avec la flamme appliquée à un endroit différent proche de la source d'inflammation.

Article 11 de la CEI 60695-11-5:2004 – Evaluation des résultats d'essai

Le texte existant est remplacé par ce qui suit.

Les éprouvettes doivent être conformes à toutes les informations suivantes:

– *après chaque application de la flamme d'essai, l'éprouvette ne doit pas se consumer complètement; et*
– *après toute application de la flamme d'essai, toute flamme autoalimentée doit s'éteindre dans un délai de 30 s; et*
– *il ne doit pas se produire de brûlure de la couche spécifiée ou du* ***papier mousseline****.*

S.2 Essai d'inflammabilité pour vérifier l'intégrité de l'enveloppe ignifuge et de la barrière ignifuge

*La conformité de l'intégrité de l'****enveloppe ignifuge (contre le feu)*** *et de la barrière contre le feu est vérifiée conformément à la CEI 60695-11-5.*

Pour les besoins de la présente norme, les exigences supplémentaires suivantes s'appliquent aux articles indiqués de la CEI 60695-11-5:2004.

Article 6 de la CEI 60695-11-5:2004 – Eprouvette

Pour les ***enveloppes ignifuges (contre le feu)*** *et les barrières contre le feu, chaque éprouvette consiste en une* ***enveloppe ignifuge (contre le feu)*** *entière et une barrière contre le feu ou une section de l'****enveloppe ignifuge (contre le feu)*** *ou de la barrière contre le feu représentant l'épaisseur de paroi significative la plus fine et incluant toute ouverture de ventilation.*

Article 7 de la CEI 60695-11-5:2004 – Degrés de sévérité

La valeur de la durée d'application de la flamme d'essai est la suivante:

– *la flamme d'essai est appliquée pendant 60 s.*

Article 8 de la CEI 60695-11-5:2004 – Conditionnement de l'éprouvette

Préalablement aux essais, les échantillons sont conditionnés dans un four à circulation d'air pendant une période de 7 jours (168 h), à une température 10 K supérieure à la température maximale de la partie mesurée lors de l'essai de 5.4.1.4 ou 70 °C, la valeur la plus élevée étant retenue, puis refroidis à la température ambiante.

Pour les cartes imprimées, un préconditionnement de 24 h à une température de 125 °C ± 2 °C dans un four à circulation d'air suivi d'une période de refroidissement de 4 h à la température ambiante dans un dessiccateur contenant du chlorure de calcium anhydre sont à appliquer.

Paragraphe 9.2 de la CEI 60695-11-5:2004 – Application du brûleur-aiguille

La flamme d'essai est appliquée sur une surface interne de l'éprouvette en un point jugé susceptible d'être enflammé à cause de sa proximité avec une source d'inflammation.

Si une partie verticale est impliquée, la flamme est appliquée à un angle d'environ 45° par rapport à la verticale.

Si des ouvertures de ventilation sont impliquées, la flamme est appliquée à un bord de l'ouverture, sinon à une surface solide. Dans tous les cas, l'extrémité de la flamme est tenue d'être en contact avec l'éprouvette.

L'essai est répété sur les deux autres éprouvettes. Si une partie soumise à essai est proche d'une source d'inflammation à plusieurs endroits, chaque éprouvette est soumise à essai avec la flamme appliquée à un endroit différent proche de la source d'inflammation.

Article 11 de la CEI 60695-11-5:2004 – Evaluation des résultats d'essai

Le texte existant est remplacé par ce qui suit.

Les éprouvettes doivent être conformes aux informations suivantes:

Après l'application de la flamme d'essai, l'éprouvette ne doit pas présenter de trous supplémentaires.

S.3 Essais d'inflammabilité du fond d'une enveloppe ignifuge (contre le feu)

S.3.1 Montage des échantillons

*Un échantillon du fond complet fini de l'**enveloppe ignifuge (contre le feu)** est porté solidement dans une position horizontale. De l'**étamine** blanchie d'environ 40 g/m^2 est placée dans l'une des couches d'un bac non profond et à fond plat environ 50 mm sous l'échantillon. Elle a une taille suffisamment importante pour couvrir entièrement le modèle d'ouvertures dans l'échantillon mais n'est toutefois pas assez large pour récupérer l'huile qui coule par-dessus les bords de l'échantillon ou sinon ne passe pas à travers les ouvertures.*

*Il est recommandé d'utiliser un écran métallique ou une **enveloppe** de verre-armé autour de la zone d'essai.*

S.3.2 Méthode d'essai et critères de conformité

Une petite louche métallique (de préférence n'ayant pas plus de 65 mm de diamètre) munie d'un bec verseur et d'une longue poignée dont l'axe longitudinal reste à l'horizontale durant le déversement, est remplie partiellement avec 10 ml de gazole. La louche contenant le gazole est chauffée; on enflamme le gazole et on le laisse brûler pendant 1 min, après quoi on déverse tout le gazole chaud enflammé, à un débit constant de 1 ml/s approximativement, sur le centre géométrique de l'ensemble des ouvertures à partir d'une position située à environ 100 mm au-dessus de celles-ci.

NOTE Le "gazole" est considéré comme similaire au mazout distillé semi-volatil ayant une masse volumique comprise entre 0,845 g/ml et 0,865 g/ml, un point d'éclair compris entre 43,5 °C et 93,5 °C et un pouvoir calorifique moyen de 38 MJ/l.

*L'essai est répété deux fois à 5 min d'intervalle, en utilisant de l'**étamine** propre.*

*Lors de ces essais, l'**étamine** ne doit pas s'enflammer.*

S.4 Classe d'inflammabilité des matériaux

Les matériaux sont classifiés selon le comportement au feu et leur capacité à s'éteindre s'ils sont allumés. Les essais sont réalisés avec le matériau dans l'épaisseur significative la plus fine utilisée.

Les hiérarchies des classes d'inflammabilité des matériaux sont données dans le Tableau S.1, le Tableau S.2 et le Tableau S.3.

Tableau S.1 – Matériaux plastiques cellulaires

Classe d'inflammabilité des matériaux	Norme ISO
HF-1 considéré mieux que **HF-2**	ISO 9772
HF-2 considéré mieux que **HBF**	ISO 9772
HBF	ISO 9772

Tableau S.2 – Matériaux rigides

Classe d'inflammabilité des matériaux	Norme CEI
5VA considéré mieux que **5VB**	CEI 60695-11-20
5VB considéré mieux que **V-0**	CEI 60695-11-20
V-0 considéré mieux que **V-1**	CEI 60695-11-10
V-1 considéré mieux que **V-2**	CEI 60695-11-10
V-2 considéré mieux que **HB40**	CEI 60695-11-10
HB40 considéré mieux que **HB75**	CEI 60695-11-10
HB75	CEI 60695-11-10

Tableau S.3 – Matériaux très fins

Classe d'inflammabilité des matériaux	Norme ISO
VTM-0 considéré mieux que **VTM-1**	ISO 9773
VTM-1 considéré mieux que **VTM-2**	ISO 9773
VTM-2	ISO 9773

Lorsque des matériaux très fins (VTM) sont utilisés, il convient également de considérer les exigences électriques et mécaniques adaptées.

Du bois et un matériau à base de bois d'une épaisseur d'au moins 6 mm sont considérés comme satisfaisant à l'exigence **V-1**. Un matériau à base de bois est un matériau dont l'élément principal est du bois naturel usiné associé à un liant.

NOTE Des exemples de matériaux à base de bois sont des matériaux incorporant de la sciure ou des copeaux de bois, tels que panneaux de fibres comprimées ou panneaux en copeaux comprimés.

S.5 Essai d'inflammabilité des matériaux d'enveloppes ignifuges (contre le feu) de l'équipement avec une puissance en régime constant qui dépasse 4 000 W

*Les matériaux d'**enveloppes ignifuges (contre le feu)** sont soumis à essai conformément à la CEI 60695-11-20:1999, en utilisant la procédure en plaque de la CEI 60695-11-20:1999, 8.3.*

Pour les besoins de la présente norme, les exigences supplémentaires suivantes s'appliquent à la CEI 60695-11-20:1999 spécifiée.

Article 7 de la CEI 60695-11-20:1999 – Eprouvettes, essai sur produits finis

*Pour les **enveloppes ignifuges (contre le feu)**, chaque éprouvette consiste en une **enveloppe ignifuge (contre le feu)** entière ou une section de l'**enveloppe ignifuge (contre le feu)** représentant l'épaisseur de paroi significative la plus fine et incluant toute ouverture de ventilation (procédure en plaque).*

Paragraphe 8.1 de la CEI 60695-11-20:1999 – Conditionnement

Préalablement aux essais, les échantillons sont conditionnés dans un four à circulation d'air pendant une période de 7 jours (168 h), à une température 10 K supérieure à la température maximale de la partie mesurée lors de l'essai de 5.4.1.4 ou 70 °C, la valeur la plus élevée étant retenue, puis refroidis à la température ambiante.

Paragraphe 8.3 de la CEI 60695-11-20:1999 – Procédure en plaque

La flamme d'essai est appliquée sur une surface interne de l'éprouvette en un point jugé susceptible d'être enflammé à cause de sa proximité avec une source d'inflammation.

Si une partie verticale est impliquée, la flamme est appliquée à un angle d'environ 20° par rapport à la verticale.

Si des ouvertures de ventilation sont impliquées, la flamme est appliquée à un bord de l'ouverture, sinon à une surface solide. Dans tous les cas, l'extrémité de la flamme est tenue d'être en contact avec l'éprouvette.

Les valeurs de la durée d'application de la flamme d'essai sont les suivantes:

- *la flamme d'essai est appliquée pendant 5 s puis retirée pendant 5 s;*
- *l'application et le retrait de la flamme d'essai sont répétés quatre fois supplémentaires au même endroit (total de cinq applications de flamme).*

Paragraphe 8.4 de la CEI 60695-11-20:1999 – Classification

Le texte existant est remplacé par ce qui suit.

Les éprouvettes doivent être conformes à toutes les informations suivantes:

- *après chaque application de la flamme d'essai, l'éprouvette ne doit pas se consumer complètement; et*
- *après la cinquième application de la flamme d'essai, toute flamme doit s'éteindre en moins de 1 min.*

*Il convient qu'aucune brûlure de l'indicateur de coton spécifié ou du **papier mousseline** ne se produise.*

Annexe T
(normative)

Essais de résistance mécanique

T.1 Généralités

En général, la présente annexe décrit différents essais mentionnés dans la présente norme. Les critères de conformité sont spécifiés dans l’article qui mentionne un essai particulier.

Aucun essai n’est réalisé sur les poignées, leviers, boutons, l’avant des tubes cathodiques ou sur les capots transparents ou translucides des dispositifs de mesure ou d’indication, à moins que des parties à ES3 soient **accessibles** lorsque la poignée, le levier, le bouton ou le capot sont ôtés.

T.2 Essai de force constante, 10 N

Une force constante de 10 N ± 1 N est appliquée sur le composant ou la partie considéré(e) pendant une courte durée d’environ 5 s.

T.3 Essai de force constante, 30 N

L’essai est réalisé au moyen d’une version droite et sans articulation de la sonde d’essai applicable de la Figure V.1 ou Figure V.2, appliquée avec une force de 30 N ± 3 N pendant une courte durée d’environ 5 s.

T.4 Essai de force constante, 100 N

*L’essai est réalisé en soumettant les **enveloppes** externes à une force constante de 100 N ± 10 N sur une surface plane circulaire de 30 mm de diamètre pendant une courte durée d’environ 5 s, appliquée tour à tour sur le dessus, le dessous et les côtés.*

T.5 Essai de force constante, 250 N

*L’essai est réalisé en soumettant les **enveloppes** externes à une force constante de 250 N ± 10 N sur une surface plane circulaire de 30 mm de diamètre pendant une courte durée d'environ 5 s, appliquée tour à tour sur le dessus, le dessous et les côtés.*

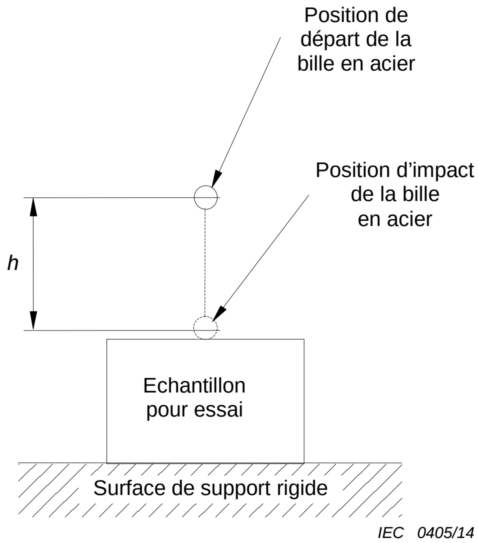
T.6 Essai de choc sur l’enveloppe

*Un échantillon constitué d’une **enveloppe** complète ou d’une portion de celle-ci, représentant la zone non renforcée la plus grande, est porté dans sa position normale. Une sphère en acier poli plein, de 50 mm ± 1 mm de diamètre et d'une masse de 500 g ± 25 g, est utilisée pour réaliser les essais suivants:*

– *sur les surfaces horizontales, la sphère nécessite de tomber librement de la position de repos, d’une hauteur de 1 300 ± 10 mm sur l’échantillon (voir Figure T.1);*
– *sur les surfaces verticales, la sphère est suspendue par une corde et balancée telle un pendule pour appliquer un choc horizontal, tombant d’une hauteur de 1 300± 10 mm sur l’échantillon (voir Figure T.1).*

*Pour évaluer une partie qui sert uniquement d'**enveloppe ignifuge,** l'essai est effectué comme ci-dessus, mais la distance verticale est de 410 mm ± 10 mm.*

En variante, des chocs horizontaux peuvent être simulés sur des surfaces verticales ou inclinées en montant l'échantillon à 90 ° par rapport à sa position normale et en appliquant l'essai de choc vertical au lieu de l'essai du pendule.



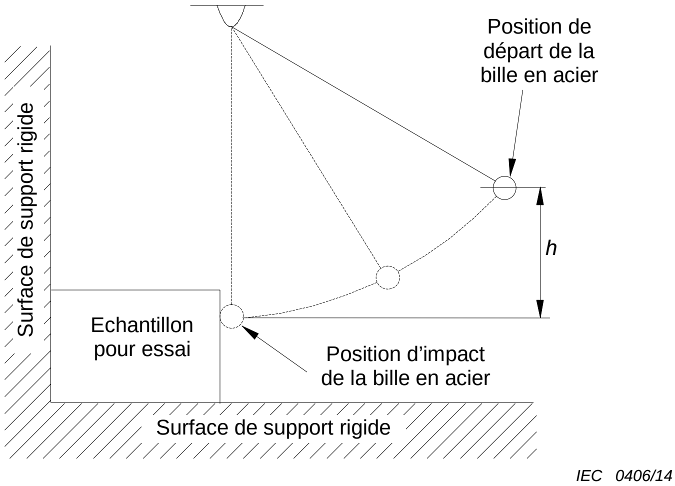


Figure T.1 – Essai de choc utilisant une sphère

T.7 Essai de chute

Un échantillon de l'équipement complet est soumis à trois impacts provoqués par leur chute sur une surface horizontale dans les positions susceptibles de générer les résultats les plus défavorables.

La hauteur de chute doit être:

– *750 mm ± 10 mm pour les équipements à poser sur un bureau ou sur une table et les **équipements mobiles**;*

– *1 000 mm ± 10 mm pour les **équipements portatifs**, les **équipements à enficher directement** et les **équipements transportables**.*

– *500 mm ± 10 mm pour une partie qui sert uniquement **d'enveloppe ignifuge** pour les équipements à poser sur une table et les **équipements mobiles***

– *350 mm ± 10 mm pour une partie qui sert uniquement d'**enveloppe ignifuge** pour les **équipements portatifs**, les **équipements à enficher directement** et les **équipements transportables.***

La surface horizontale est en bois dur d'au moins 13 mm d'épaisseur et montée sur deux couches de contreplaqué ayant chacune une épaisseur de 18 mm ± 2 mm, le tout étant posé sur un sol en béton ou en matériau non élastique équivalent.

T.8 Essai de relâchement des contraintes

Le relâchement des contraintes est vérifié par l'essai de relâchement des contraintes de moulage de la CEI 60695-10-3, par la procédure d'essai décrite ci-dessous ou par l'examen de la construction et des données disponibles selon le cas.

*Un échantillon constitué de l'équipement complet, ou de l'**enveloppe** complète avec toutes les structures de support est placé dans un four à circulation d'air à une température supérieure de 10 K à la température maximale observée sur l'échantillon pendant l'essai de chauffage de 5.4.1.4.2, mais non inférieure à 70 °C, pendant une durée de 7 h, puis refroidi à la température ambiante.*

*Pour les équipements de grandes dimensions où est impossible de traiter l'**enveloppe** complète, il est possible d'utiliser une partie de l'**enveloppe**, représentative de l'ensemble complet eu égard à l'épaisseur, à la forme et à la présence éventuelle de pièces mécaniques de support.*

NOTE Il n'est pas nécessaire de maintenir une humidité relative à une valeur spécifique lors de l'essai.

T.9 Essai de choc

L'échantillon pour essai est soutenu sur toute sa surface et doit être soumis à un unique choc spécifié dans le Tableau T.1. Si l'échantillon est en verre, le choc doit être appliqué à un emplacement représentant le centre du verre.

Le choc spécifié doit être provoqué par la chute d'une bille en acier poli plein, de 50 mm ± 1 mm de diamètre et d'une masse de 500 g ± 25 g, lâchée en chute libre sur une distance à la verticale, au moins égale à celle indiquée au Tableau T.1, comme cela est représenté à la Figure T.1 en partant du repos et heurtant l'échantillon avec l'énergie spécifiée, dans une direction perpendiculaire à la surface de l'échantillon.

Tableau T.1 – Force de l'impact

Partie	Résultat	Energie J	Hauteur m
Sauf spécification contraire ci-dessous, tout verre utilisé comme **protection** contre les sources d'énergie de classe 3	Sources d'énergie de classe 3	3,5	714
Verre sur équipements posés au sol	Coupures de la peau	3,5	714
Verre sur équipements portatifs, équipements de table et équipements montés à demeure	Coupures de la peau	2	408
Verre agissant uniquement comme une **enveloppe ignifuge**	Source d'énergie de puissance (PS)	1	204
Lentilles de verre fournies pour l'atténuation du rayonnement UV	Exposition au rayonnement UV	0,5	102

Afin d'appliquer le choc requis, la hauteur correcte est calculée par $H = E / (g \times m)$

où

H est la distance verticale, en mètres, avec une tolérance de ± 10 mm;

E est l'énergie d'impact, en Joules;

g est l'accélération de la pesanteur de 9,81 m/s2²

m est la masse de la bille d'acier, en kilogrammes.

T.10 Essai de fragmentation du verre

L'échantillon pour essai est supporté sur toute sa surface et des mesures de précaution doivent être prises pour s'assurer que les particules ne sont pas dispersées pendant la fragmentation. Ensuite, l'échantillon pour essai est cassé par un coup situé à environ 15 mm du point milieu de l'un des plus grands côtés et vers le centre de l'échantillon pour essai. Dans un délai de 5 min après la rupture, et sans utiliser de système d'aide à la vision, excepté des lunettes si elles sont utilisées en usage normal, les particules sont comptées *dans un carré de 50 mm de côté situé approximativement au centre de la zone de rupture la plus grosse en excluant toute zone de 15 mm autour des côtés ou du trou.*

L'échantillon pour essai doit se fragmenter de manière telle que le nombre de particules dans un carré de 50 mm de côté ne soit pas inférieur à 45.

T.11 Essai pour les antennes télescopiques ou les antennes fouets

La pièce d'extrémité des antennes télescopiques ou des antennes fouets doit être soumise à une force de 20 N suivant l'axe principal de l'antenne, pendant 1 min. De plus, si la pièce d'extrémité est fixée par des pas de vis, un couple de desserrage est à appliquer à cette pièce sur cinq échantillons supplémentaires. Le couple est à appliquer progressivement, le brin de l'antenne étant fixé. Lorsque le couple spécifié est atteint, il est à maintenir pendant 15 s au maximum. La durée du maintien pour chaque échantillon ne doit pas être inférieure à 5 s et la moyenne des durées de maintien pour les cinq échantillons ne doit pas être inférieure à 8 s.

La valeur du couple est donnée au Tableau T.2.

Tableau T.2 – Valeurs du couple pour l'essai des pièces d'extrémité

Diamètre de la pièce d'extrémité mm	**Couple** Nm
< 8,0	0,3
≥ 8,0	0,6

Annexe U
(normative)

Résistance mécanique des tubes cathodiques et protection contre les effets d'implosion

U.1 Généralités

La présente annexe spécifie la résistance mécanique des tubes cathodiques (CRT, Cathode Ray Tubes), la façon de se protéger contre les effets d'une implosion et la façon dont un écran de protection peut supporter des forces mécaniques.

Si la plus grande dimension de la face du tube cathodique d'un équipement est supérieure à 160 mm, ce tube doit être intrinsèquement protégé contre les risques d'implosion et contre les chocs mécaniques; sinon l'**enveloppe** de l'équipement doit assurer une protection adéquate contre les effets d'une implosion du tube cathodique.

La face d'un tube cathodique qui n'est pas intrinsèquement protégé doit être pourvue d'un écran efficace ne pouvant être retiré à la main. Si on utilise un écran séparé en verre, ce dernier ne doit pas être en contact avec la surface du tube cathodique.

Le tube cathodique, autre que sa face intrinsèquement protégée, ne doit pas être **accessible** à une **personne ordinaire**.

Un film protecteur, fixé sur la dalle du tube à images comme partie du système de protection contre les implosions, doit être recouvert sur tous les bords par l'**enveloppe** de l'équipement.

Si l'équipement est équipé d'un tube cathodique avec un film protecteur, fixé à la dalle comme partie du système de protection contre les implosions, la **protection par instructions** doit être fournie conformément à l'Article F.5:

– élément 1a: non disponible.
– élément 2: "Avertissement" ou énoncé ou texte équivalent.
– élément 3: "Risque de blessure" ou texte équivalent.
– élément 4: "Le tube cathodique à l'intérieur de cet équipement utilise un film protecteur sur l'avant. Ce film ne doit pas être retiré dans la mesure où il remplit une fonction de sécurité et son retrait augmente le risque de blessure" ou texte équivalent.

La **protection par instructions** doit être fournie dans les instructions.

La conformité est vérifiée par examen, par des mesures et par l'exécution des essais prévus:

– *dans la CEI 61965 dans le cas des tubes cathodiques intrinsèquement protégés, y compris les tubes pourvus d'un écran protecteur intégré;*
– *dans les Articles U.2 et U.3 dans les cas des équipements ayant des tubes cathodiques non intrinsèquement protégés;*
– *dans l'Annexe V pour l'application des sondes sur l'**enveloppe**.*

NOTE 1 Un tube cathodique à images est considéré comme étant intrinsèquement protégé contre les effets d'une implosion si, lorsqu'il est correctement monté, aucune protection supplémentaire n'est nécessaire.

NOTE 2 Pour faciliter les essais, le fabricant de tubes cathodiques est sensé indiquer la zone la plus vulnérable sur les tubes à soumettre à essai.

U.2 Méthode d’essai et critères de conformité pour les tubes cathodiques non intrinsèquement protégés

On place l’équipement, avec le tube cathodique et l'écran de protection en place, sur un support horizontal à une hauteur de (750 ± 50) mm au-dessus du sol, ou directement sur le sol s'il s'agit d’un équipement manifestement prévu pour être placé sur le sol.

*On fait imploser le tube cathodique à l’intérieur de l’***enveloppe** *de l’équipement par la méthode suivante.*

Des fissures sont provoquées dans l’enveloppe de chaque tube. On raye avec une pointe en diamant une certaine surface sur le côté ou sur l’avant de chaque tube cathodique, et on refroidit cette surface de façon répétée à l'aide d'azote liquide ou d'un autre produit similaire, jusqu'à ce qu'une fêlure se produise. Pour éviter que le liquide de refroidissement ne se répande en dehors de la surface d'essai, il convient d’utiliser un anneau de pâte à modeler ou de tout autre matière convenable.

NOTE Des modèles de rayures adaptés sont proposés dans la Figure 6 de la CEI 61965:2003.

Après cet essai, moins de 5 s après la rupture initiale, aucune particule (un morceau de verre ayant une masse supérieure à 0,025 g) ne doit avoir franchi une barrière de 250 mm de haut, placée sur le sol, à 500 mm de la projection de l’avant de l’équipement.

U.3 Ecran de protection

Un écran de protection doit être fixé de manière appropriée et résistant aux forces mécaniques.

La conformité est vérifiée par les essais de l'Article T.3, sans fêlure de l’écran de protection ou desserrage de son montage.

Annexe V
(normative)

Détermination des parties accessibles

V.1 Parties accessibles de l'équipement

V.1.1 Généralités

Une partie **accessible** d'un équipement est une partie qui peut être touchée par une partie du corps. Afin de déterminer si une partie est **accessible**, une partie du corps est représentée par une ou plusieurs sondes spécifiques.

Les parties **accessibles** d'un équipement peuvent inclure des parties situées derrière une porte, un panneau, un couvercle amovible, etc. pouvant être ouverts sans l'aide d'un **outil**.

Les parties **accessibles** n'incluent pas les parties qui deviennent **accessibles** lorsque l'équipement posé au sol et ayant une masse supérieure à 40 kg est incliné.

Pour les équipements destinés à être encastrés ou montés dans des baies, ou pour les sous-ensembles et dispositifs semblables destinés à être intégrés dans un équipement de plus grande taille, les parties **accessibles** n'incluent pas les parties qui ne sont pas **accessibles** lorsque l'équipement ou le sous-ensemble est installé selon la méthode de montage ou d'installation spécifiée dans les instructions d'installation.

Une partie est considérée comme **accessible** si les instructions ou les marquages destinés à être suivis impliquent qu'une personne entre en contact physique avec cette partie. Ceci s'applique sans essai et qu'un **outil** soit nécessaire ou non pour accéder.

V.1.2 Méthode d'essai 1 – Surfaces et ouvertures soumises à essai avec sondes d'essai articulées

Pour les surfaces et les ouvertures, la sonde d'essai articulée suivante est appliquée, sans force appréciable et dans toutes les positions possibles, aux surfaces et ouvertures de l'équipement:

– *la sonde d'essai de la Figure V.1 pour les équipements qui sont susceptibles d'être* ***accessibles*** *aux enfants;*

NOTE 1 Les équipements destinés à être utilisés dans les maisons, écoles et lieux publics et semblables sont généralement considérés comme des équipements **accessibles** aux enfants, voir également l'Article F.4.

– *la sonde d'essai de la Figure V.2 pour les équipements qui ne sont pas susceptibles d'être* ***accessibles*** *aux enfants.*

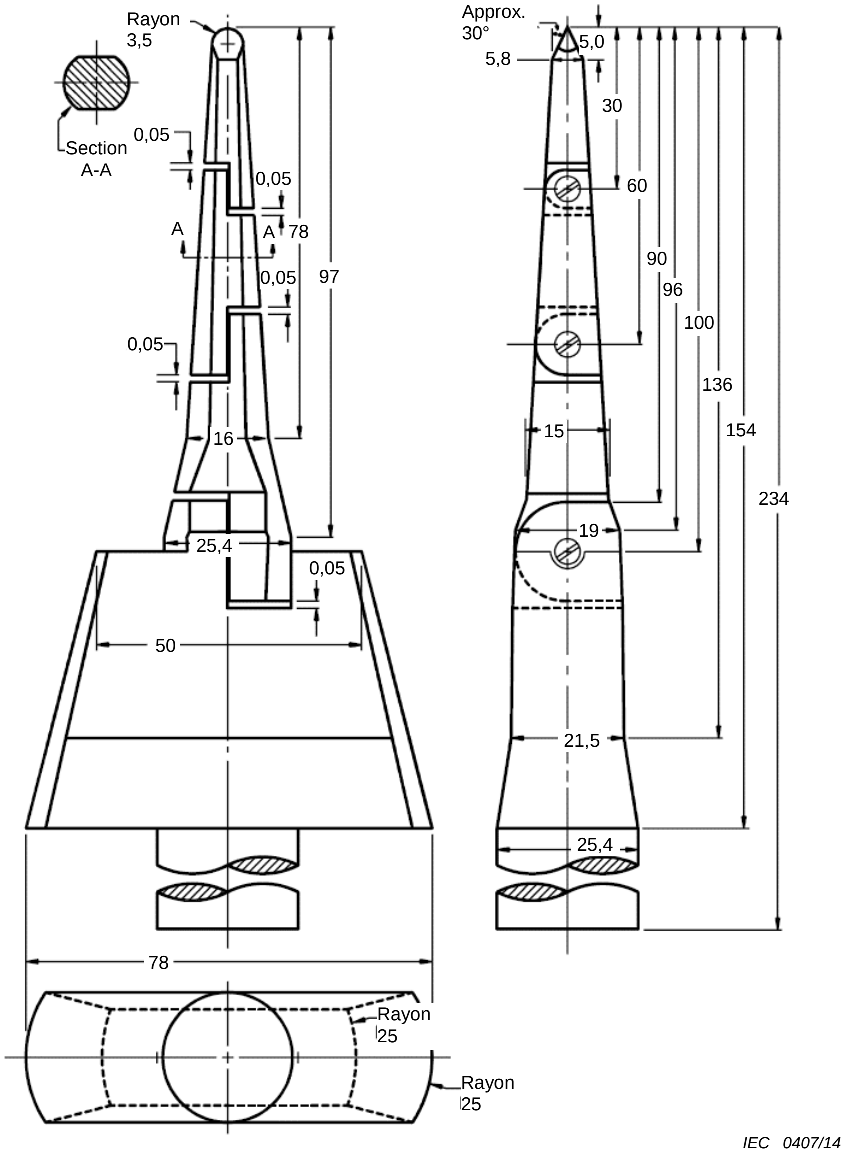
Lorsque l'accès derrière une porte, un panneau, un couvercle amovible, etc. est possible sans l'aide d'un ***outil*** *ou lorsque l'accès est indiqué par les instructions du fabricant ou un marquage, avec ou sans l'aide d'un* ***outil****, la sonde d'essai est appliquée aux surfaces et ouvertures dans ces zones.*

Lorsque toute la sonde passe par une grande ouverture (autorisant l'entrée d'un bras mais pas d'une épaule), la sonde doit être appliquée à toutes les parties situées dans un hémisphère de 762 mm de rayon. La poignée de la sonde doit être dirigée le long d'un chemin vers la grande ouverture afin de simuler la main au bout du bras tendue dans la grande ouverture. Le plan de l'hémisphère doit être le plan extérieur de l'ouverture. Toute partie en dehors de l'hémisphère de 762 mm de rayon est considérée comme non ***accessible****.*

NOTE 2 L'équipement peut être démonté pour réaliser l'essai.

V.1.3 Méthode d'essai 2 – Ouvertures soumises à essai avec sondes d'essai droites et inarticulées

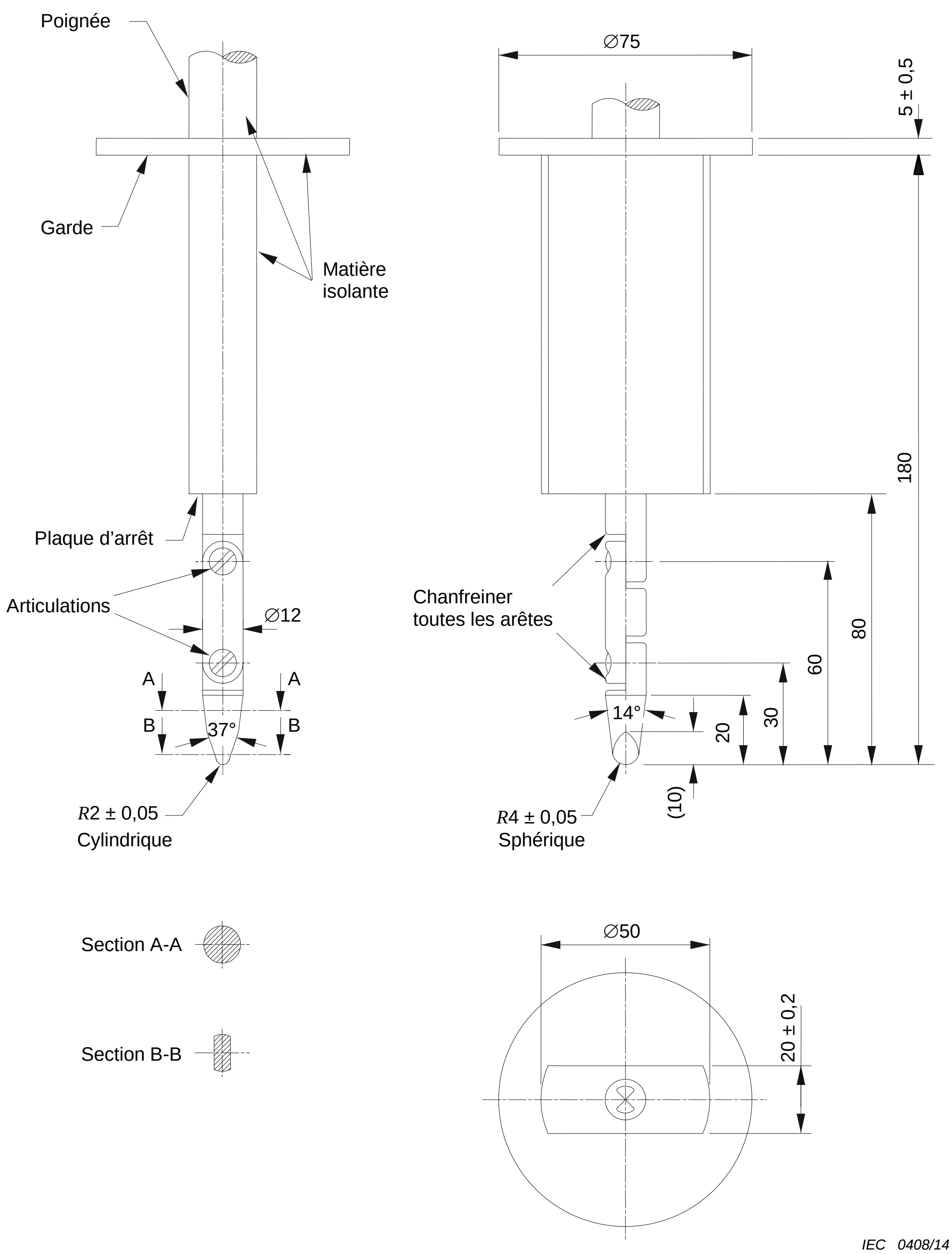
Les ouvertures empêchant l'accès à une partie par la sonde d'essai articulée de la Figure V.1 ou de la Figure V.2 sont soumises à essai plus en détail grâce à une version droite et inarticulée de la sonde d'essai en question, appliquée avec une force de 30 N. Si la sonde inarticulée pénètre dans les ouvertures, la méthode d'essai 1 est répétée, sauf que la version articulée appropriée de la sonde d'essai est poussée à travers l'ouverture avec la force nécessaire allant jusqu'à 30 N.



Dimensions en millimètres

Tolérances sur les dimensions sans tolérances spécifiques:
angles: ± 15'
rayons: ± 0,1 mm
Tolérances sur les dimensions linéaires sans tolérances spécifiques:
≤15 mm: $^{0}_{-0,1}$ mm
>15 mm ≤ 25 mm: ±0,1 mm
>25 mm: ±0,3 mm
Matériau du doigt d'essai: Acier traité thermiquement, par exemple.

Figure V.1 – Sonde d'essai articulée pour équipements susceptibles d'être accessibles aux enfants



Dimensions linéaires en millimètres

Tolérances sur les dimensions sans tolérances spécifiques:

– angles de 14° et 37°: ±15′

– rayons: ±0,1 mm

– dimensions linéaires:

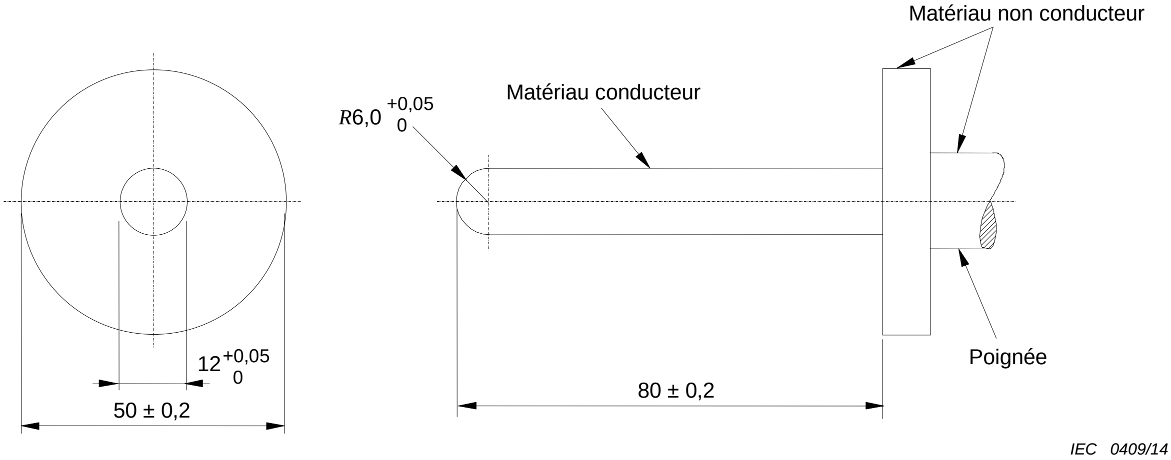
≤15 mm:	$^{0}_{-0,1}$ mm
>15 mm ≤ 25 mm:	±0,1 mm
<25 mm:	±0,3 mm

NOTE Cette sonde d'essai articulée est tirée de la Figure 2, sonde d'essai B de la CEI 61032:1997.

Figure V.2 – Sonde d'essai articulée pour équipements non susceptibles d'être accessibles aux enfants

V.1.4 Méthode d'essai 3 – Fiches, jacks, connecteurs

Le calibre d'essai de la Figure V.3 est appliqué sans force appréciable et dans toutes les positions possibles aux parties spécifiées.

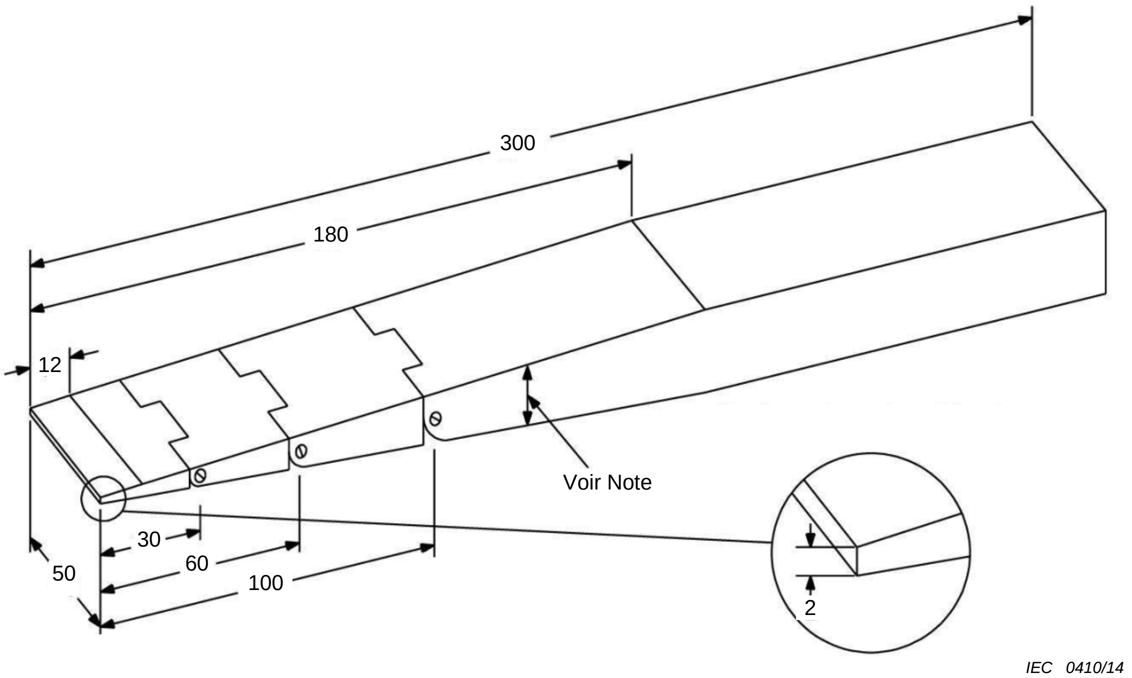


Dimensions en millimètres

Figure V.3 – Calibre d'essai

V.1.5 Méthode d'essai 4 – Ouvertures fentes

La sonde en coin de la Figure V.4 est appliquée comme spécifié.



Dimensions en millimètres

Tolérances sur les dimensions linéaires sans tolérances spécifiques:

≤25 mm: ±0,13 mm

>25 mm: ±0,3 mm

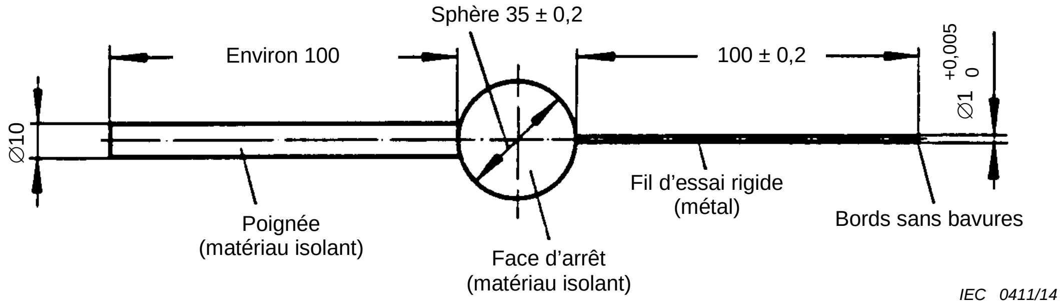
NOTE L'épaisseur de la sonde varie linéairement avec des changements d'inclination aux endroits suivants de la sonde:

Distance du bout de la sonde mm	**Epaisseur de la sonde** mm
0	2
12	4
180	24

Figure V.4 – Sonde en coin

V.1.6 Méthode d'essai 5 – Dispositifs de connexion extérieure conçus pour être utilisés par une personne ordinaire

Le fil rigide d'essai de la sonde d'essai de la Figure V.5 est inséré dans l'ouverture applicable avec une force de 1 N ± 0,1 N et avec une longueur limitée à 20 mm ± 0,2 mm. Tout en étant insérée, la sonde est déplacée selon n'importe quel angle avec une force minimale.



Dimensions en millimètres

NOTE Cette sonde est tirée de la Figure 4, CEI 61032:1997.

Figure V.5 – Sonde de dispositif de connexion extérieure

V.2 Critère de la partie accessible

*Si une partie peut être touchée par la sonde spécifiée, alors la partie est **accessible**.*

Annexe W
(informative)

Comparaison des termes présentés dans la présente norme

W.1 Généralités

La présente norme présente de nouveaux termes de sécurité associés à de nouveaux concepts de sécurité.

Cette annexe identifie les termes correspondants à la présente norme et, si différents, les compare aux termes équivalents des publications de sécurité de base du TC 64 de la CEI[5] et des autres publications de sécurité correspondantes.

Les termes qui n'apparaissent pas dans les tableaux ci-dessous sont les mêmes ou sensiblement les mêmes que ceux utilisés dans les autres normes CEI.

W.2 Comparaison des termes

Dans les Tableaux ci-dessous, le texte tiré d'une norme CEI est écrit en police normale. Les remarques concernant la CEI 62368-1 sont en *italique*.

Tableau W.1 – Comparaison des termes et définitions de la CEI 60664-1:2007 et de la CEI 62368-1

CEI 60664-1:2007	CEI 62368-1
3.2 **distance dans l'air** distance la plus courte dans l'air entre deux parties conductrices	**3.3.12.1** **distance dans l'air** distance la plus courte dans l'air entre deux parties conductrices
3.3 **ligne de fuite** distance la plus courte, le long de la surface d'un isolant solide, entre deux parties conductrices	**3.3.12.2** **ligne de fuite** distance la plus courte, le long de la surface d'un matériau isolant, entre deux parties conductrices
3.4 **isolation solide** matériau isolant solide interposé entre deux parties conductrices	**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
3.5 **tension de service** valeur efficace la plus élevée de la tension en courant alternatif ou continu à travers n'importe quelle isolation qui peut apparaître lorsqu'un matériel est alimenté sous la tension assignée	**3.3.14.9** **tension de service** tension la plus élevée appliquée à travers n'importe quelle isolation 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**

5 CEI/TC 64: Installations électriques et protection contre les chocs électriques. Cliquez sur le site Web de la CEI pour une liste des publications du TC 64.

CEI 60664-1:2007	CEI 62368-1
3.9 **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	**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
3.13 **degré de pollution** nombre caractérisant la pollution prévue du microenvironnement	**3.3.6.5** **degré de pollution** nombre caractérisant la pollution prévue du microenvironnement
3.19.1 **essai de type** essai effectué sur un ou plusieurs dispositifs réalisés selon une conception donnée pour vérifier que cette conception répond à certaines spécifications	**3.3.6.11** **essai de type** essai réalisé sur un échantillon représentatif avec l'objectif de déterminer si, tel que conçu et fabriqué, il peut répondre aux exigences de la présente norme
3.9.2 **tension assignée de tenue aux chocs** valeur de tension de tenue aux chocs fixée par le fabricant aux matériels ou à une partie d'entre eux caractérisant la capacité de tenue spécifiée de son isolation contre des surtensions transitoires	**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 sur le **réseau d'alimentation**
3.17.1 **isolation fonctionnelle** isolation entre parties conductrices qui est uniquement nécessaire au bon fonctionnement du matériel	**3.3.5.3** **isolation fonctionnelle** isolation entre parties conductrices qui est uniquement nécessaire au bon fonctionnement du matériel
3.17.2 **isolation principale** isolation des parties actives dangereuses qui assure la protection principale	**3.3.5.1** **isolation principale** isolation assurant une **protection principale** contre les chocs électriques
3.17.3 **isolation supplémentaire** isolation indépendante prévue, en plus de l'isolation principale, en tant que protection en cas de défaut	**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
3.17.4 **double isolation** isolation comprenant à la fois une isolation principale et une isolation supplémentaire	**3.3.5.2** **double isolation** isolation comprenant à la fois une **isolation principale** et une **isolation supplémentaire**
3.17.5 **isolation renforcée** isolation des parties actives dangereuses assurant un degré de protection contre les chocs électriques équivalant à une double isolation	**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**
3.19.2 **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	**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
3.19.3 **essai sur prélèvement** essai effectué sur un certain nombre de dispositifs prélevés au hasard dans un lot	**3.3.6.8** **essai sur prélèvement** essai effectué sur un certain nombre de dispositifs prélevés au hasard dans un lot

Tableau W.2 – Comparaison des termes et définitions de la CEI 61140:2001 et de la CEI 62368-1

CEI 61140:2001	CEI 62368-1
3.1.1 protection principale protection contre les chocs électriques en l'absence de défaut	*Pour des raisons de cohérence, tout au long de la norme, le terme "*protection*" est employé pour désigner un dispositif ou un plan qui assure une protection contre une source d'énergie.* **3.3.11.1** **protection principale** **protection** assurée dans les **conditions normales** et **anormales de fonctionnement** lorsqu'une source d'énergie susceptible de provoquer une douleur ou une blessure est présente dans l'équipement
3.10.2 isolation supplémentaire isolation indépendante prévue, en plus de l'isolation principale, en tant que protection en cas de défaut	**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**
3.4 **partie active** conducteur ou partie conductrice destiné à être sous tension en service normal, y compris le conducteur de neutre, mais par convention, excepté le conducteur PEN, le conducteur PEM ou le conducteur PEL NOTE 1 Ce concept n'implique pas nécessairement un risque de choc électrique. NOTE 2 Pour les définitions des conducteurs PEM et PEL, voir VEI 195-02-13 et 195-02-14.	*Le terme* **partie active** *n'est pas utilisé.* *Conformément à la définition de la CEI 61140, ES1, ES2 et ES3 sont toutes des parties actives.*
3.5 **partie active dangereuse** partie active qui peut provoquer, dans certaines conditions, un choc électrique nuisible NOTE En haute tension, une tension dangereuse peut être présente à la surface d'une isolation solide. Dans ce cas, la surface est considérée comme une partie active dangereuse.	*Le terme* **partie active dangereuse** *n'est pas utilisé.* *Conformément à la définition de la CEI 61140, une source ES3 est une partie active dangereuse.*
3.26 **très basse tension** **TBT** toute tension ne dépassant pas les limites spécifiées dans la CEI/TS 61201	*Aucun terme équivalent. Voir ES1.*
3.26.1 **réseau TBTS** réseau électrique dont la tension ne peut pas dépasser la valeur de la TBT – dans des conditions normales et – dans des conditions de défaut, y compris les défauts à la terre dans les autres circuits	**ES1** *ES1 est une tension ne dépassant pas la limite de tension applicable spécifiée dans la CEI/TS 61201 ou un courant ne dépassant pas la limite de courant applicable spécifiée dans la CEI/TS 60479-1* - *dans les conditions normales, et* - *dans les* ***conditions de premier défaut***

CEI 61140:2001	CEI 62368-1
3.28 **source à courant limité** dispositif fournissant de l'énergie électrique alimentant un circuit électrique – présentant une séparation de protection vis-à-vis des parties actives dangereuses, et – assurant que le courant de contact en régime établi et la charge sont limités à des niveaux non dangereux en fonctionnement normal ou dans des conditions de défaut	**ES1** *ES1 est une tension ne dépassant pas la limite de tension applicable spécifiée dans la CEI/TS 61201 ou un courant ne dépassant pas la limite de courant applicable spécifiée dans la CEI/TS 60479-1* - *dans les conditions normales, et* - *dans les* ***conditions de premier défaut***
5.1.6 Limitation du courant de contact en régime établi et de la charge électrique La limitation du courant de contact en régime établi et de la charge électrique doit empêcher les personnes ou les animaux d'être soumis à des valeurs dangereuses ou perceptibles de ces paramètres. NOTE Pour les personnes, les valeurs suivantes (valeurs en courant alternatif jusqu'à la fréquence de 100 Hz) sont données pour information: – Un courant de régime établi s'écoulant entre des parties conductrices simultanément accessibles au travers d'une résistance de 2 000 Ω ne dépassant pas le seuil de perception; des valeurs de 0,5 mA en courant alternatif et de 2 mA en courant continu sont recommandées. – Des valeurs ne dépassant pas le seuil de la douleur, 3,5 mA en courant alternatif ou 10 mA en courant continu, peuvent être spécifiées.	*La limite de courant de ES1 est de 0,5 mA en courant alternatif et de 2 mA en courant continu.* *La limite de courant de ES2 est de 5 mA en courant alternatif et de 25 mA en courant continu (ces valeurs sont issues de la CEI/TS 60479-1).*
Aucun terme équivalent	**3.3.11.12** **protection** partie physique, système ou instruction spécifiquement prévu(e) pour réduire la probabilité de blessure ou, en cas d'incendie, pour réduire la probabilité d'inflammation ou de propagation du feu
Aucun terme équivalent. D'après la double isolation	**3.3.11.2** **double protection** **protection** comprenant une **protection principale** et une **protection supplémentaire**
Aucun terme équivalent. D'après l'isolation renforcée	**3.3.11.11** **protection renforcée** **protection** unique qui est opérationnelle dans: – les **conditions normales de fonctionnement**, – les **conditions anormales de fonctionnement**, et – les **conditions de premier défaut**
Aucun terme équivalent. A peu près équivalent à un avertissement	**3.3.11.5** **protection par instructions** instruction impliquant un comportement spécifié afin d'éviter le contact ou l'exposition à une source d'énergie de classe 2 ou 3

CEI 61140:2001	CEI 62368-1
Aucun terme équivalent	**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**
Aucun terme équivalent	**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
Le terme "condition normale" est utilisé dans la CEI 61140 mais n'est pas défini	**3.3.7.4** **condition normale de fonctionnement** mode de fonctionnement qui reflète le mieux les conditions d'utilisation normale les plus rigoureuses qu'il est raisonnable d'attendre
Aucun terme équivalent	**3.3.7.1** **condition anormale de fonctionnement** condition de fonctionnement temporaire qui n'est ni une **condition normale de fonctionnement**, ni une **condition de premier défaut** de l'équipement proprement dit
Le terme "défaut simple" est utilisé dans la CEI 61140 mais n'est pas défini	**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

Tableau W.3 – Comparaison des termes et définitions de la CEI 60950-1:2005 et de la CEI 62368-1

CEI 60950-1:2005	CEI 62368-1
1.2.8.8 **circuit TBTS** circuit secondaire conçu et protégé de telle manière que, dans des conditions normales de fonctionnement et dans des conditions de premier défaut, les tensions ne soient pas supérieures à une valeur sûre	**5.2.1.1** **ES1** ES1 est une source d'énergie électrique de classe 1 avec des niveaux ne dépassant pas les limites 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 dépassant pas les limites ES2 dans les **conditions de premier défaut**. NOTE ES1 peut être **accessible** à une **personne ordinaire**
1.2.8.11 **circuit TRT** circuit qui est dans le matériel et dont la surface de contact accessible est limitée et qui est conçu et protégé de telle manière que, dans les conditions normales de fonctionnement et les conditions de premier défaut (voir 1.4.14 de la CEI 60950-1:2005), les tensions ne dépassent pas les valeurs limites spécifiées un circuit TRT est considéré comme étant un circuit secondaire au sens de la présente norme	**5.2.1.2** **ES2** ES2 est une source d'énergie de classe 2 avec des niveaux ne dépassant pas les limites ES2 dans les **conditions normales de fonctionnement**, les **conditions anormales de fonctionnement** et les **conditions de premier défaut** , mais n'équivaut pas à ES1. NOTE ES2 peut être **accessible** à une **personne avertie**,
1.2.8.12 **circuit TRT-1** circuit TRT – dont les tensions normales de fonctionnement ne dépassent pas les limites pour un circuit TBTS dans les conditions normales de fonctionnement et – sur lequel des surtensions venant des réseaux de télécommunications et des systèmes de distribution par câbles sont possibles	ES 1 sur lequel les transitoires conformément aux numéros d'identification 1, 2 et 3 du Tableau 14 sont possibles NOTE Les caractéristiques électriques ne sont pas identiques aux circuits TRT mais présentent un niveau de sécurité équivalent.
1.2.8.13 **circuit TRT-2** circuit TRT – dont les tensions normales de fonctionnement dépassent les limites pour un circuit TBTS dans les conditions normales de fonctionnement et – qui n'est pas sujet à des surtensions venant des réseaux de télécommunications	ES2 NOTE Les caractéristiques électriques ne sont pas identiques aux circuits TRT mais présentent un niveau de sécurité équivalent.

CEI 60950-1:2005	CEI 62368-1
1.2.8.14 **circuit TRT-3** circuit TRT – dont les tensions normales de fonctionnement dépassent les limites pour un circuit TBTS dans les conditions normales de fonctionnement et – sur lequel des surtensions venant des réseaux de télécommunications et des systèmes de distribution par câbles sont possibles	ES 2 sur lequel les transitoires conformément aux numéros d'identification 1, 2 et 3 du Tableau 14 sont possibles NOTE Les caractéristiques électriques ne sont pas identiques aux circuits TRT mais présentent un niveau de sécurité équivalent.
1.2.13.6 **utilisateur** toute personne autre que le personnel de maintenance Le terme utilisateur dans la présente norme est le même que le terme opérateur et les deux termes peuvent s'utiliser indifféremment	**3.3.8.2** **personne ordinaire** personne qui n'est ni une **personne qualifiée** ni une **personne avertie**
1.2.13.7 **opérateur** voir **utilisateur** (1.2.13.6 de la CEI 60950-1:2005)	*Voir 3.3.8.2.*
1.2.13.8 **réseau de télécommunications** moyen de transmission à terminaison métallique destiné à la communication entre matériels qui peuvent être placés dans des bâtiments différents, à l'exclusion: – des réseaux de production, transport et distribution de l'énergie électrique utilisés comme vecteur de transmission pour les télécommunications; – des systèmes de distribution par câbles; – des circuits TBTS connectant les unités d'un matériel de traitement de l'information NOTE 1 L'expression réseau de télécommunications est définie en termes de sa fonctionnalité, non de ses caractéristiques électriques. Un réseau de télécommunications n'est pas lui-même défini comme étant soit un circuit TBTS soit un circuit TRT. Seuls les circuits à l'intérieur du matériel sont classés ainsi. NOTE 2 Un réseau de télécommunications peut être – public ou privé: – soumis à des surtensions transitoires dues à des décharges atmosphériques et à des défauts dans les systèmes de distribution de l'énergie: – soumis à des tensions longitudinales (mode commun) induites par les lignes d'énergie ou les lignes de traction électrique dans le voisinage. NOTE 3 Exemples de réseaux de télécommunications: – un réseau téléphonique public commuté; – un réseau de données public; – un réseau numérique à intégration de services (RNIS);	**3.3.1.1** **circuit externe** circuit électrique qui est externe à l'équipement et n'est pas un **réseau d'alimentation** NOTE Les **circuits externes** concernés sont identifiés dans le Tableau 14.

CEI 60950-1:2005	CEI 62368-1
– un réseau privé avec des caractéristiques d'interface électriques similaires à celles des réseaux ci-dessus.	
Aucun	**3.3.8.1** **personne avertie** personne formée ou encadrée par une **personne qualifiée** en sources d'énergie et qui peut utiliser les **protections** des équipements et les **protections de précaution** de manière responsable par rapport à ces sources d'énergie
1.2.13.5 **personnel de maintenance** personne ayant une formation technique appropriée et l'expérience nécessaire pour être consciente des dangers auxquels elle peut être exposée en effectuant une tâche et des mesures à prendre pour minimiser les risques pour elle-même ou d'autres personnes	**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
1.2.13.14 **système de distribution par câbles** moyen de transmission à terminaison métallique utilisant du câble coaxial principalement destiné à la transmission des signaux vidéo et/ou audio entre des bâtiments séparés ou entre une antenne extérieure et des bâtiments, à l'exclusion: – des systèmes d'alimentation, de transmission et de distribution du réseau électrique, s'ils sont utilisés comme vecteur de transmission de communication; – des réseaux de télécommunications; – des circuits TBTS connectant les unités d'un matériel de traitement de l'information NOTE 1 Exemples de systèmes de distribution par câbles: – des réseaux câblés locaux, par exemple des systèmes de réseaux communautaires de télévision et des systèmes d'antennes collectives fournissant une distribution de signaux audio et vidéo; – des antennes extérieures, y compris les paraboles satellites, les antennes de réception et d'autres dispositifs similaires. NOTE 2 Les systèmes de distribution par câbles peuvent être soumis à des transitoires plus importants que ceux des réseaux de télécommunications.	**3.3.1.1** **circuit externe** circuit électrique qui est externe à l'équipement et n'est pas un **réseau d'alimentation** NOTE Les **circuits externes** concernés sont identifiés dans le Tableau 14.

Tableau W.4 – Comparaison des termes et définitions de la CEI 60728-11 et de la CEI 62368-1

CEI 60728-11	CEI 62368-1
3.1.3 **réseaux par câbles (pour signaux de télévision, signaux de radiodiffusion sonore et services interactifs)** terme général utilisé pour définir les réseaux de télévision par câble et d'antennes collectives, les réseaux de télévision par satellite à antenne collective et de réception individuelle; ces réseaux peuvent être utilisés en amont et en aval **3.1.4** **télévision par câble** réseau conçu pour délivrer des signaux de télévision, de radiodiffusion sonore ainsi que des signaux de services interactifs à la population **3.1.20** **réseau de télévision à antenne collective** réseau conçu pour délivrer des signaux de télévision, de radiodiffusion sonore ainsi que des signaux de services interactifs aux foyers dans un ou plusieurs bâtiments **3.1.31** **réseaux de télévision par satellite à antenne collective** réseau conçu pour délivrer des signaux de télévision, de radiodiffusion sonore ainsi que des signaux de services interactifs reçus par des antennes à réception satellite éventuellement combinées à des signaux de télévision terrestre et/ou de radiodiffusion sonore, à des foyers dans un ou plusieurs bâtiments	**3.3.1.1** **circuit externe** circuit électrique qui est externe à l'équipement et n'est pas un **réseau d'alimentation** NOTE Les **circuits externes** concernés sont identifiés dans le Tableau 14.

Tableau W.5 – Comparaison des termes et définitions de la CEI 62151 et de la CEI 62368-1

CEI 62151	CEI 62368-1
3.1.3 **réseau de télécommunications** moyen de transmission à terminaison métallique destiné à la communication entre matériels pouvant être placés dans des bâtiments différents à l'exclusion: – des réseaux de production, de transport et de distribution de l'énergie électrique, s'ils sont utilisés comme vecteur de transmission pour les communications; – des systèmes de télédiffusion utilisant des câbles. NOTE 1 Le terme réseau de télécommunications est défini selon de sa fonctionnalité, non selon ses caractéristiques électriques. Un réseau de télécommunications n'est pas lui-même défini lui-même comme un circuit TRT. Seuls les circuits à l'intérieur du matériel sont classés ainsi. NOTE 2 Un réseau de télécommunications peut être – public ou privé; – soumis à des surtensions transitoires dues à des décharges atmosphériques et à des défauts dans les systèmes de distribution de l'énergie; – soumis à des tensions permanentes longitudinales (mode commun) induites par les lignes d'énergie ou les lignes de traction électriques situées à proximité. NOTE 3 On peut citer comme exemples de réseaux de télécommunications – un réseau téléphonique public commuté; – un réseau de données public; – un réseau numérique à intégration de services (RNIS); – un réseau privé avec des caractéristiques d'interface électriques similaires à celles des réseaux ci-dessus.	**3.3.1.1** **circuit externe** circuit électrique qui est externe à l'équipement et n'est pas un **réseau d'alimentation** NOTE Les **circuits externes** concernés sont identifiés dans le Tableau 14.
3.5.4 **circuit TRT-0** circuit TRT: – dont les tensions normales de fonctionnement ne dépassent pas une valeur sûre dans les conditions normales de fonctionnement et les conditions de premier défaut; – qui n'est pas sujet à des surtensions venant des réseaux de télécommunications NOTE Les valeurs limites de tension dans les conditions normales de fonctionnement et dans les conditions de premier défaut sont spécifiées en 4.1.	**5.2.1.1** **ES1** ES1 est une source d'énergie électrique de classe 1 avec des niveaux ne dépassant pas les limites ES1 dans les **conditions normales de fonctionnement** et les **conditions anormales de fonctionnement** et ne dépassant pas les limites ES2 dans les **conditions de premier défaut**. NOTE 1 ES1 peut être **accessible** à une **personne ordinaire.** NOTE 2 Les caractéristiques électriques ne sont pas identiques, mais présentent un niveau de sécurité équivalent.

CEI 62151	CEI 62368-1
3.5.3 **circuit TRT** circuit qui est dans le matériel et dont la surface de contact accessible est limitée (sauf dans le cas d'un circuit TRT-0) et qui est conçu et protégé de telle manière que, dans les conditions normales de fonctionnement et dans les conditions de premier défaut, les tensions ne dépassent pas les valeurs limites spécifiées Un circuit TRT est considéré comme un circuit secondaire au sens de la présente norme. NOTE Les relations de tension entre les circuits TRT sont indiquées dans le Tableau 1.	**5.2.1.2** **ES2** ES2 est une source d'énergie électrique de classe 2 avec des niveaux ne dépassant pas les limites ES2 dans les **conditions normales de fonctionnement**, les **conditions anormales de fonctionnement** ou les **conditions de premier défaut** , mais n'équivaut pas à ES1. NOTE 1 ES2 peut être **accessible** à une **personne avertie.** NOTE 2 Les caractéristiques électriques ne sont pas identiques aux circuits TRT, mais présentent un niveau de sécurité équivalent.

Tableau W.6 – Comparaison des termes et définitions de la CEI 60065 et la CEI 62368-1

CEI 60065	CEI 62368-1
2.2.12 **appareil professionnel** appareil utilisé dans le cadre d'activités commerciales, professionnelles ou industrielles et qui n'est pas destiné à être vendu au public NOTE Il convient que le fabricant spécifie la désignation.	Aucun terme équivalent.
2.4.3 **directement connecté au réseau d'alimentation** connexion électrique au réseau d'alimentation établie de sorte qu'une connexion à l'un des pôles du réseau d'alimentation engendre dans cette connexion un courant permanent égal ou supérieur à 9 A, les dispositifs de protection dans l'appareil n'étant pas court-circuités NOTE Un courant de 9 A est retenu comme courant minimal de coupure d'un fusible 6 A.	Aucun terme équivalent. Conformément à la définition de la CEI 60065, une source ES3 serait considérée comme directement connectée au **réseau d'alimentation**.
2.4.4 **conductivement connecté au réseau d'alimentation** connexion électrique au réseau d'alimentation établie de sorte qu'une connexion par une résistance de 2 000 Ω à l'un des pôles du réseau d'alimentation engendre dans cette résistance un courant permanent supérieur à 0,7 mA (de crête), l'appareil n'étant pas connecté à la terre	Aucun terme équivalent. Conformément à la définition de la CEI 60065, une source ES3 ou ES2 peut être considérée comme conductivement connectée au réseau d'alimentation.

CEI 60065	CEI 62368-1
2.4.7 **réseau de télécommunications** moyen de transmission à terminaison métallique destiné à la communication entre matériels qui peuvent être placés dans des bâtiments différents, à l'exclusion: – des réseaux de production, transport et distribution de l'énergie électrique utilisés comme vecteur de transmission pour les télécommunications; – des systèmes de distribution par câbles; NOTE 1 L'expression réseau de télécommunications est définie en termes de sa fonctionnalité, non de ses caractéristiques électriques. Un réseau de télécommunications n'est pas lui-même défini comme étant soit un circuit TBTS soit un circuit TRT. Seuls les circuits à l'intérieur du matériel sont classés ainsi. NOTE 2 Un réseau de télécommunications peut être – public ou privé: – soumis à des surtensions transitoires dues à des décharges atmosphériques et à des défauts dans les systèmes de distribution de l'énergie: – soumis à des tensions longitudinales (mode commun) induites par les lignes d'énergie ou les lignes de traction électrique dans le voisinage. NOTE 3 Exemples de réseaux de télécommunications: – un réseau téléphonique public commuté; – un réseau de données public; – un réseau numérique à intégration de services (RNIS); - un réseau privé avec des caractéristiques d'interface électriques similaires à celles des réseaux ci-dessus	**3.3.1.1** **circuit externe** circuit électrique qui est externe à l'équipement et qui n'est pas un **réseau d'alimentation** NOTE Les **circuits externes** concernés sont identifiés dans le Tableau 14.
2.6.10 **actif dangereux** état électrique d'un objet dont un courant de contact dangereux (choc électrique) peut être tiré (voir 9.1.1)	Le terme "actif dangereux" n'est pas utilisé. Conformément à la définition de la CEI 60065, une source ES3 est active dangereuse
2.8.6 **personne avertie** personne informée ou encadrée de manière adaptée par des personnes qualifiées qui lui permettent d'éviter les dangers et les risques que peut créer l'électricité	**3.3.8.1** **personne avertie** personne avertie ou encadrée par une personne qualifiée en sources d'énergie et qui peut utiliser les **protections de l'équipement** et les **protections de précaution** de manière responsable par rapport à ces sources d'énergie [VEI 826-18-02, modifiée] NOTE Encadré, tel qu'utilisé dans la définition, signifie qui dirige et surveille les performances des autres.

CEI 60065	CEI 62368-1
2.8.11 **source potentielle d'incendie** défaut possible susceptible d'initier un incendie si la tension en circuit ouvert mesurée au niveau d'une interruption ou contact défectueux dépasse une valeur de 50 V, valeur de crête c.a. ou c.c. et le produit de la valeur de crête de cette tension avec le courant efficace mesuré dans les conditions normales de fonctionnement dépasse 15 VA. Un contact défectueux ou interruption de ce type dans une connexion électrique comprend les éléments susceptibles de se produire dans les réseaux de conducteurs sur les cartes imprimées NOTE Un circuit de protection électronique peut être utilisé pour empêcher qu'un défaut ne devienne une source potentielle d'incendie.	**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.

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CEI 61558-2-6, *Sécurité des transformateurs, bobines d'inductance, blocs d'alimentation et produits analogues pour des tensions d’alimentation jusqu'à 1 100 V – Partie 2-6: Règles particulières et essais pour les transformateurs de sécurité et les blocs d’alimentation incorporant des transformateurs de sécurité*

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